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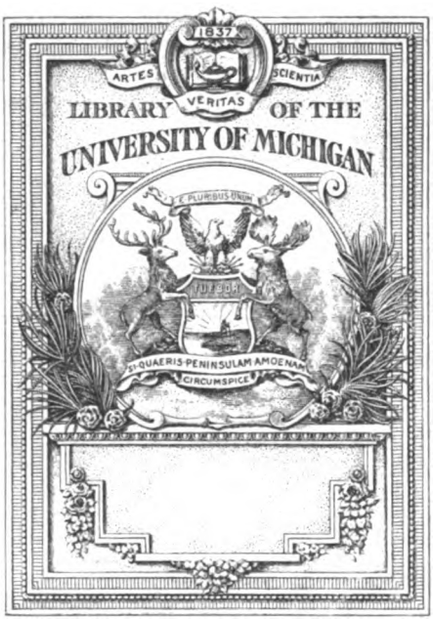


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# THE ELECTRICIAN:

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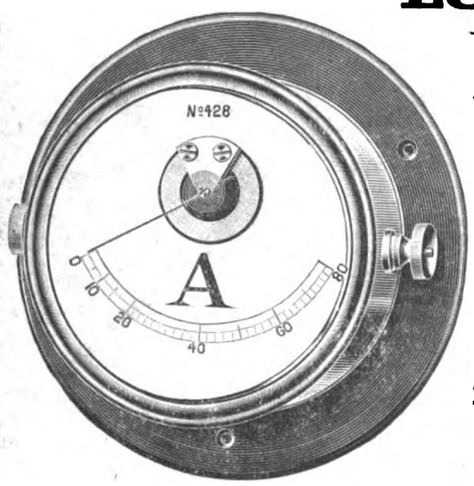


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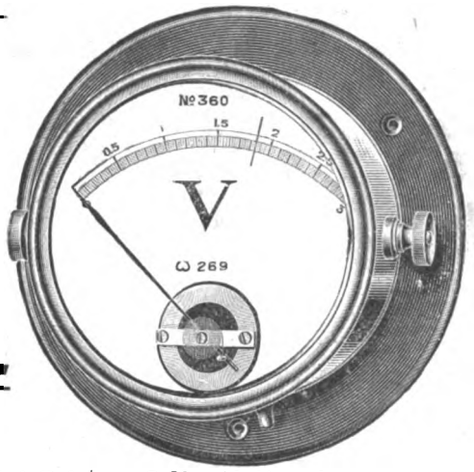


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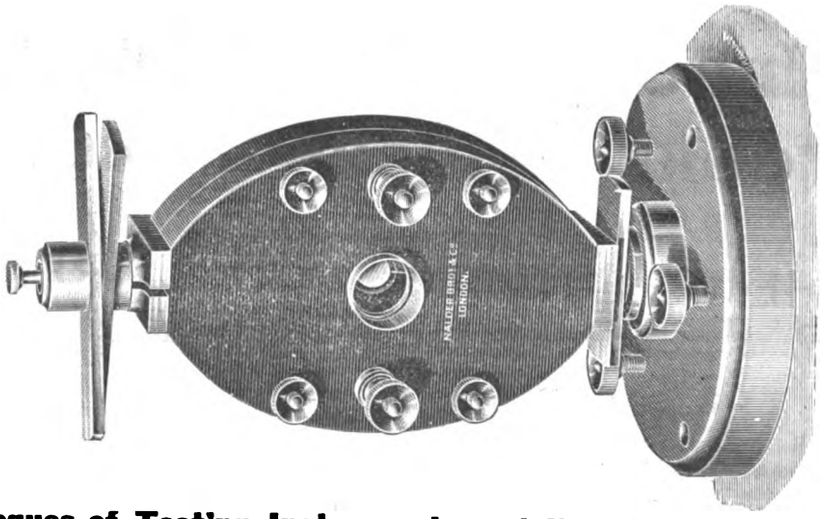


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By order, A. G. BRODRICK, Secretary.

50, Old Broad-street, London, E.C., April 24th, 1896.

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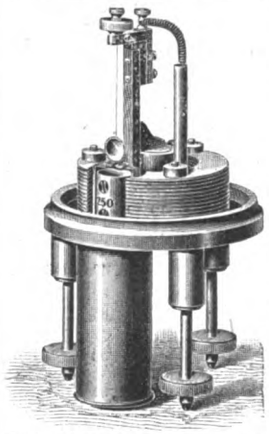

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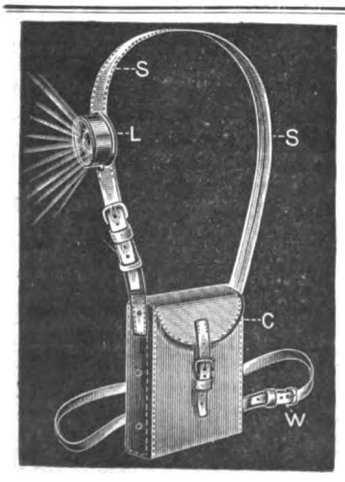


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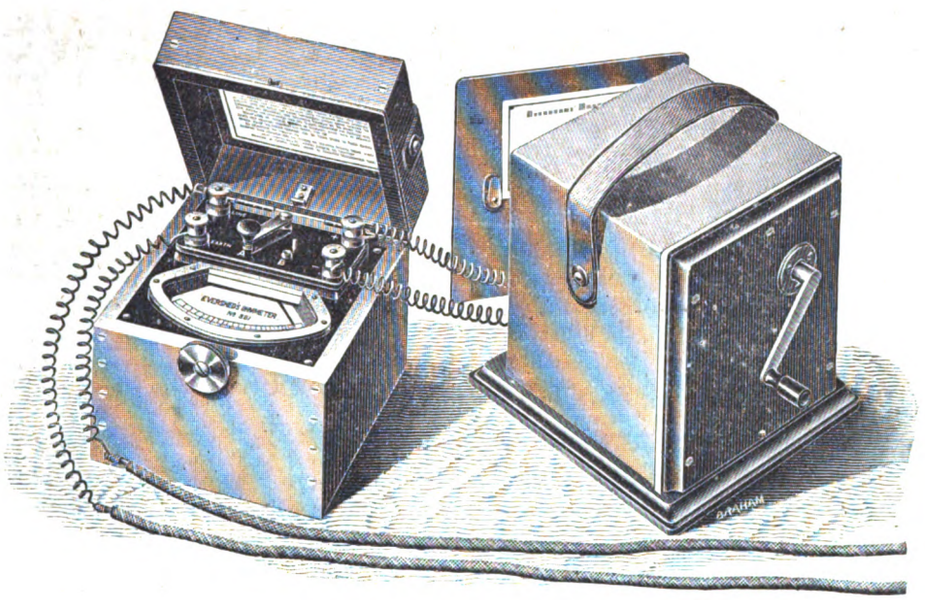

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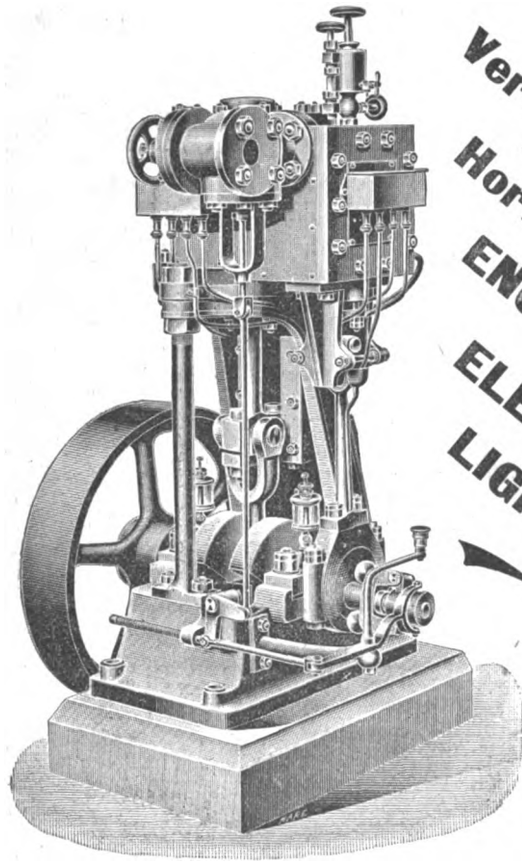

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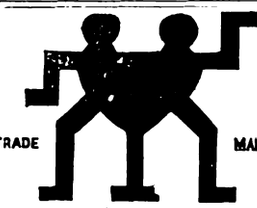


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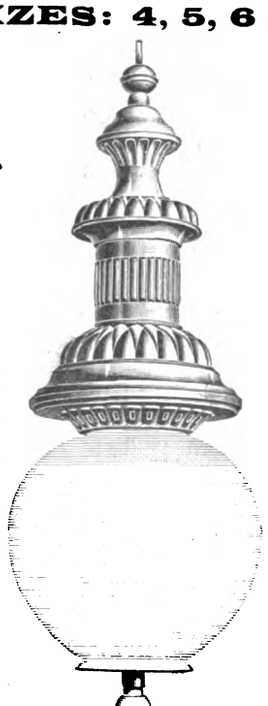

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**Irish News and Belfast Morning News.**—"The Lamp which has been fitted up outside 'The Ivesagh' seems to possess all the advantages claimed for the 'Jandus.' It gives a brilliant illumination without glare or flickering, and has a real artistic effect."

### TESTIMONIALS.

**Messrs. The DE LAVALS ELEKTRISKA BLOCK-BELYSNING, Stockholm** (The De Lavals House-to-House Electric Supply Company).—"The 35 Lamps you have sent us during the last six months have proved highly satisfactory in steadiness, economy and efficiency.

"We are so pleased with the lamp that we have decided to purchase the rights for the Scandinavian countries, and commence the manufacture of lamps there."—Signed for the Company by JOHN HAMMAR, M.I.E.E. (by power of attorney).

**Messrs. G. E. BELLIS & CO., Birmingham.**

"The Lamp we have is still working satisfactorily, and now burns about 195 hours."

**Messrs. A. WHITELAW & SON, Edinburgh.**

"We are highly pleased with the results given by the Jandus Lamp. It burns perfectly steady, and the trimming is simplicity itself."

**Messrs. BRISCOE & SHAW, Blackburn.**

"The Jandus Lamps supplied to us are burning with every success. Our clients at the paper mill are highly pleased with their Lamp, and inform us it is splendid for getting shades with. The Corporation Gas Committee are well pleased with the Lamp. Our client, Mr. Till, thanks us for advising him to use the Jandus Arc Lamp, so far being well satisfied."

**Messrs. JULES CHAGOT et CIE., Monceau-les-Mines.**

"Il résulte des essais que nous avons faits avec la première lampe Jandus que vous nous avez fournie, que la durée d'une paire de charbons, sur 4 amperes, est d'environ 220 heures."

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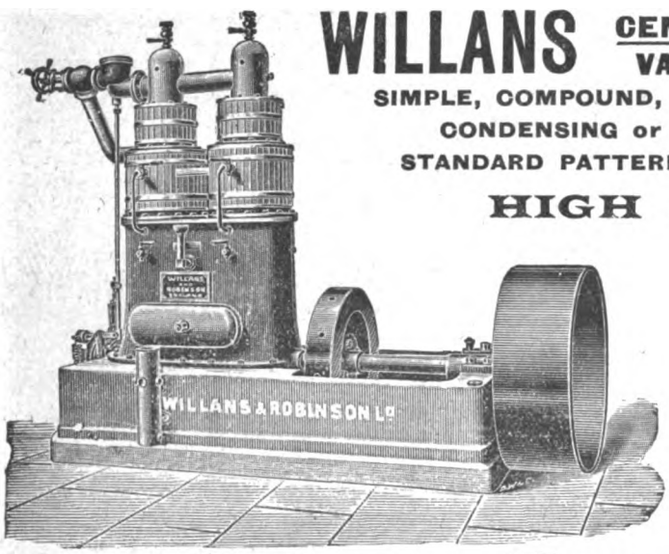


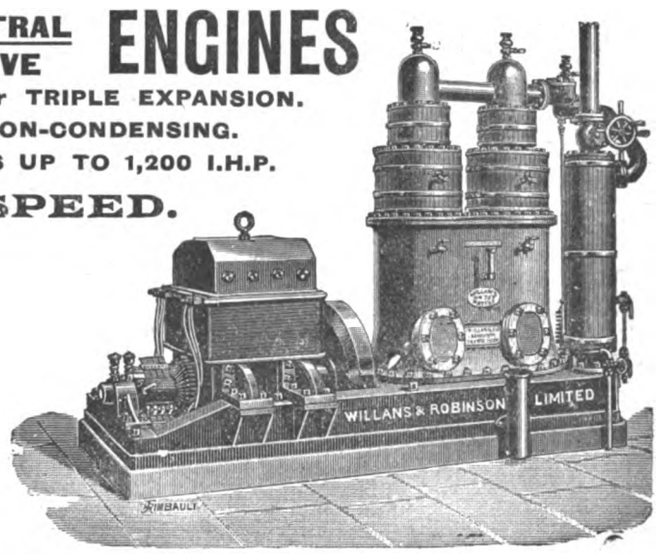


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*Crompton & Co., Ltd.* — *See Important Announcement on page xxxi.*

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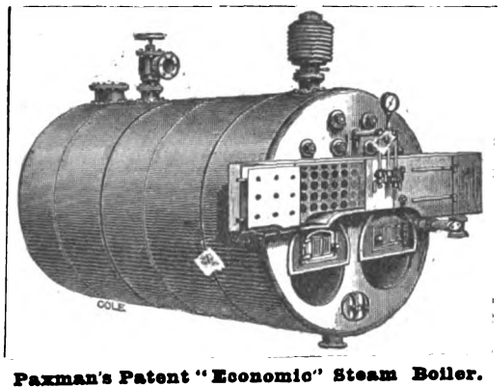

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 937. [Vol. No. 1. XXXVII.] FRIDAY, MAY 1, 1896. PRICE SIXPENCE.


## NOTES.

THE patent No. 15,286 of 1885, granted to CARL AUER VON WELSBACH, of No. 63, Gumpendorfer Strasse, in the city of Vienna, Doctor of Philosophy, on the "MANUFACTURE OF AN ILLUMINANT APPLIANCE FOR GAS AND OTHER BURNERS," a patent the substantial validity of which was recently vindicated in the Queen's Bench Division, is one which has its interest for members of the electrical industry. The misfortunes of even our best friends are said to be a source of subtle satisfaction, and the spectacle of our good friends the gas engineers wasting their substance in patent litigation connected with an incandescent lamp, a method of spending money once so much affected by electrical engineers, is not without a peculiar relish of its own.

ANOTHER feature of interest in connection with this Welsbach case is that it affords a conspicuous instance of the comparative vulnerability of a patent, even when it is for an undoubted invention, and when it is drawn up with extreme care and skill. The ambit of the patent was purposely narrowed to an illuminating hood made of particular substances in a particular way, and the consequence is that the Sunlight Incandescent Gas Lamp Company, to use the words of Mr. Justice WILLS, "are taking a very valuable process bodily from WELSBACH without any remuneration."

THE Welsbach case, again, has afforded not only the daily papers, but a scientific contemporary, a text upon which to preach some extremely edifying sermons on the depravity of the expert witness. We ourselves have in our time said some hard things of the species, but we have never found it in our hearts to say anything quite so unkind as *The Times* has done. Doubtless anyone who takes to the calling of expert witness wears his reputation upon his sleeve for daws to peck at, and it must be admitted that in most instances the daws have good cause to peck; the clever fencing of an eminent witness anxious to be at once veracious, consistent and helpful to his clients, leaving upon the mind a decidedly painful impression of misplaced ingenuity. It is, however, the system rather than the individual who is to blame. Under the Patents, Designs and Trade Marks Act of 1883 either side can insist on the judge being assisted by an assessor. But, notwithstanding, this oft-recommended step is rarely taken by litigants. Why, we know not. Moreover, our pragmatic contemporaries could scarcely have chosen a worse example for the purpose of villifying the unfortunate expert witness than the one under consideration. Mr. Justice WILLS was most lavish with his encomiums. Of one witness (Mr. BALLANTYNE) he said:—"He is one of the most truthful and fairest-minded men I have seen in the witness box." Of another witness (Mr. SWINBURNE), the judge remarked that he answered a certain question "with that perfect frankness, truth and indifference to consequences which marked every answer that he gave, and made him the perfect idea of what a scientific witness should be." We feel sure that these certificates of virtue were thoroughly well deserved, and that Mr. Justice WILLS's ideal is the right one; but, alas, it is not the common one. Here we have Mr. G. F. EMERY in his recently published book on patent law, delivering himself of the following pleasantry:—" . . . . it is generally supposed that experts are not always strictly truthful; an ideal expert witness is a man who is unlikely to be entrapped by the wiles of the opposing counsel into admitting anything which will injure the side on which he is called." It is the too frequent realism of *this* ideal that brings the expert witness into such bad odour that hasty newspaper writers do not even think it necessary to glance at a patent case before they draw up an indictment against an entire species.

IN an article which we published on January 31st we criticised the design of the Melbourne municipal lighting station, in which, it will be remembered, a system of countershafting with ropes and belts is used to connect four engines to some 20 dynamos. A letter which we publish this week gives the reasons the Melbourne municipal electrical engineer, Mr. A. J. ARNOT, believes to have justified the particular design adopted. The letter is a curious commentary on the imperfect engineering facilities of the Victorian colony. It is surprising that at a hotel in Sydney in 1889 it was possible to use direct-coupled engines, while in Melbourne in 1891 the facilities for getting this type of plant were so completely absent that the best that could be done was to use countershafting. Nor is it any less surprising that a progressive colony should be blind to the mischievousness of the policy of imposing a 35 per cent. duty on machinery imported from the mother country, especially in regard to machinery which it is admitted the labour element in the colony is incapable of turning out. Such things are not to be defended, but they certainly support Mr. ARNOT's claim that the best that was possible in the circumstances was done.

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Mr. Arnot, however, goes further than merely to advance this claim, and a considerable portion of his interesting communication is nothing else than a defence of the Melbourne system *per se*. No doubt, a coal consumption of "5·3lb. per unit generated" is a fair result for the Melbourne station; but when it is remembered that this is solely a public lighting station, and consequently works at steady full load, it is evidently unfair to compare this achievement with those of ordinary supply stations in this country. Mr. Arnot has cited Prof. Unwin as having said that "taking only the largest and best stations (in the United Kingdom) the consumption of coal varies in different cases from 7 to 12lb. per unit generated." That was for the year 1894. In that year, however, the coal bill of one of the London companies amounted to only 0·63d. per unit *delivered*; so that, assuming 20 per cent. of the units generated to have been used in the works and wasted in transmission, the cost per unit generated was only 0·5d. If this station had consumed so much as from 7lb. to 12lb. of coal per unit generated, the price paid for the coal could not have exceeded from 7s. 9d. to 13s. 4d. per ton, figures far below the price actually paid for good coal in London. Take another instance. At an important station in the South of England, where the plant is wholly direct-coupled, the average weight of coal per unit *sold* was well below 7lb., and the maximum at any time did not exceed 7·5lb., throughout 1895. The minimum weight was about 5·75lb. per unit sold. In this station the average consumption per unit generated could hardly have exceeded 5·8lb., and the minimum about 5lb., on the most liberal estimate. During the past twelve months many provincial stations have touched figures as low as 0·29d., 0·37d., 0·38d. and thereabouts per unit generated, and we very much doubt if any of these figures represent a consumption equivalent to 12lb. of good coal per unit generated. With unstinted admiration for the degree of success which the Melbourne station has attained under Mr. Arnot's management, we feel sure a still greater measure of success would have crowned his efforts had he been able to adopt arrangements more closely approximating to English practice of to-day.

In connection with the "Notes on Some American Alternating Current Machinery," which are commenced in our columns this week, we would call attention to one interesting development which has taken place in the United States. American engineers are now building alternators, the E.M.F. wave forms of which are specially adapted to the particular class of work intended to be done. Thus, low-frequency flat-topped and simple periodic waves are used for long-distance power transmission, while "saw-tooth" waves of higher frequency are more commonly used on distribution circuits. The General Electric Company of America seems to prefer the sine wave pure and simple for long-distance transmission, as this is said to give rise to less resonance than with any complex wave, whether flat-topped or peaked. We should have thought that in any but very long-distance transmission it would pay to make some concession to the transformers, and to use more peaky waves than the simple sine form. Curiously enough, too, the American experts—or, at any rate, some of them—seem to regard a flat-topped wave of *electromotive force* as being most efficient for supplying to transformers, whereas in this country it is the peaky wave of E.M.F., and the flat-topped wave of magnetising current that are considered best. The arguments put forward by the American experts in favour of their choice seem to us to confirm the correctness of English ideas.

The British Consul at New Orleans may or may not be an American, in any case he has been bitten with the transatlantic mania for figure juggling. Thus in his report to the Foreign Office he says: "A year or two ago the mule-car system was in force, by which much time was lost, as only five miles per hour could be made; now that the transit is by electric car a speed of 12 miles an hour is obtained. In New Orleans, with an average saving to each passenger of 12 minutes, there is an economy of 10,000,000 hours a year, equivalent to 1,250,000 days' labour of eight hours. If time is money, and one day's labour is worth 4s., which it certainly is at New Orleans, the electric cars are saving the city £250,000 a year in time." We should very much like to know on what grounds 12 minutes is taken to represent the time saved to each passenger by the new mode of traction. To assess the value of a day's labour in New Orleans at 4s. is also just a trifle sweeping and arbitrary. That is the beauty of this style of statistic spinning. Immense savings can be worked out on paper on the basis of tremendous assumptions that may or may not be warranted by the facts. However, so long as the sum saved sticks in the public mind whilst the chain of argument leading up to it is quickly forgotten, the arrow shot at a venture has hit its mark and, at any rate, one individual has done a good day's work. But electric traction no longer needs such adventitious aids; facts based on actual experience are now sufficiently numerous and sufficiently convincing, and flights into the realms of fancy are quite uncalled for.

We had thought the use of cast iron for live steam pipes was practically obsolete, and were surprised when we heard of the explosion, last January, of such a pipe at so modern a station as that at Dundee. The pipe in question, it appears from a recent Board of Trade inquiry, was a short bend forming part of a branch leading from the main steam range, and was so fixed that the expansion and contraction of the main could not but set up severe stresses in the bend. Moreover, the metal was of a spongy nature, through faulty casting. It is only to be wondered at that the pipe held out for three years. Engineers should remove any cast iron live steam pipes from their stations as speedily as possible; for if not, the pipes are practically certain to do as the Dundee one has done.

We commence this week the publication of a series of articles on a matter of considerable current interest, "The Localisation of Faults in Electric Light Mains." After discussing the various methods of testing the insulation resistance of high and low-pressure networks during working, the author will deal with the localisation of faults in electric

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light systems, paying special attention to the ingenious automatic signalling and localising devices worked out by Herr KALLMANN of Berlin. Apart from possible future Board of Trade requirements in the matter of insulation tests and fault localisation, electrical engineers will not be living up to their reputation for scientific thoroughness unless they succeed in evolving reliable methods of automatically indicating and rapidly locating the leaks that occur on their mains. To this end Mr. RAPHAEL'S series of articles may prove helpful.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique..... ..... | December 19, 1895. |
| Ceara—Maranham ..... | April 28, 1896. |

**Masonic Honours.**—We learn that the Grand Lodge of Freemasons has appointed Bro. T. A. Bullock, the popular London superintendent of the Eastern Telegraph Company, Past Grand Swordbearer.

**Pacific Cable Conference.**—A Reuter's telegram, dated Ottawa, April 27th, states that Sir Mackenzie Bowell and Sir Donald Smith will sail on May 9th for London as delegates to the Cable Conference. They will be accompanied by Mr. Sandford Fleming as expert adviser.

**Post Office Appointment.**—The Postmaster-General has made the following appointment: Mr. J. C Lamb, C.B., C.M.G., to be Third Secretary to the Post Office, in succession to Mr. Herbert Joyce, C.B., retired (Mr. Lamb will remain in charge of the Telegraph Branch).

**English as she is Spoke.**—While reading a translation from a German work describing a Continental electric supply station, we came across the following choice specimen of "English":—

"Everything which could have seduced the constructor to an experimental risk in order to supply with the demands of an extravagant electrical order, has been carefully avoided, and an engine was chosen whose working was, from a multitude of cases, known to be a satisfactory one."

**An Early Electrical Patent.**—On Sunday next, the 3rd inst., will terminate the 14 years' period which Patent No. 2,092, of 1882, granted to Charles Lever for his arc lamp, would have run had it not prematurely become void. The patent relates to "IMPROVEMENTS IN ELECTRIC LIGHT APPARATUS," and the claims are for a lamp in which the carbons are held apart when not in action, the feeding and regulation of the lamp being controlled by a shunt coil. The working of a number of such lamps in series is also claimed.

**Halifax-Bermuda Cable.**—According to the *Electrical Engineer* of New York it has been decided by the Bermuda Cable Company to keep secret the position of their cable from Halifax to Bermuda. According to the same authority Mr. D Budge, superintendent of the Halifax and Bermuda Cable Company, has gone to Ottawa to ask the Government for a subsidy to enable his company to extend its present cable from Bermuda to Jamaica.

**Berlin Industrial Exhibition.**—The supply of electrical energy at this exhibition will be in the hands of a syndicate, consisting of 12 of the leading German engineering firms. The total capacity of the generating plant will be over 4,600 H.P., made up of 22 units, ranging from 100 H.P. to 340 H.P. The current will be employed for lighting and power. There will be 500 arc lamps in the main hall, and 350 in the exhibition grounds. Electric energy will also be used for working a circular railway and some hundred electric motors. The generators will supply continuous and polyphase currents at low and high pressure.

**Cable Communication with the West Indies.**—In the House of Commons last week Mr. Chamberlain, in answer to Mr. Tomlinson, said he had received communications from the West India Colonies, representing the importance of establishing a through telegraphic communication between this country and those colonies, for the purpose of Imperial defence, as well as for commercial purposes. He had no reason to think that there were any insuperable constructive difficulties in effecting any such communication. Proposals on the subject were under consideration, and he hoped they would result in a cable being laid at no distant date.

**High Pressure Currents and Water Jets.**—An experiment to ascertain whether a high-pressure alternating current can be sent from a conductor to earth by means of a jet of water from the hose of a fire engine, and also whether the current can be transmitted to the firemen under such circumstance, was made a little time ago by Prof. Slaby, of Berlin. The overhead conductors of the Eichberg-Grünberg three-phase 10,000 volt transmission of power plant was used for the experiment. A voltmeter was connected between the metal mouthpiece of the water hose and the earth. On turning the water on to the three live conductors no flow of current to earth was noticeable.

**The P.Q. Atlantic Cable.**—We understand that the French cable steamer "François Arago," which has been engaged on the repair of this cable, has returned to France disabled, after experiencing very bad weather in the Atlantic. The Compagnie Française des Cables Télégraphiques has entrusted the repair of their Brest–Penzance and Penzance–St. Pierre sections to the Telegraph Construction and Maintenance Company, whose vessel, the "Seine," has just left England to undertake this work. As was mentioned recently in our columns the "François Arago" succeeded in recovering and buoying the St. Pierre end of the main cable in deep water. An engineer accompanies the "Seine" on behalf of the Compagnie Française.

**Applied Electro-Chemistry.**—Mr. Swinburne, in his first Cantor lecture on this subject at the Society of Arts on Monday evening, dealt merely with the elementary phenomena of electrolysis, though in a decidedly original manner. Grotthuss' hypothesis, Thomson's law, Helmholtz's law, Arrhenius' dissociation theory were discussed and caustically criticised, and a number of experiments were shown. In Lecture II. (May 4th) Mr. Swinburne will explain, "in a manner to be understanded of the people," the electrolytic production of caustic soda and bleach, and the electrolytic refining of copper. In Lecture III. he will deal with aluminium, sodium and "fused electrolysis," and in the concluding lecture, on May 18th, calcium carbide, aluminium and miscellaneous processes will be dealt with.

**The Government and the Telephone Trunk Wires.**—On the report this week of the financial resolution appropriating £300,000 for telegraph advances, Mr. Dalziel said that the House of Commons was entitled to a detailed statement as to the way in which the money was being spent. Mr. Hanbury said no portion of the money would go to the National Telephone Company, which had already received about £450,000 out of the £1,000,000 provided in the former Bill. The rest of that sum had gone to purchase wires for the trunk lines. The additional sum asked for was in order to complete the purchase of wires. Considerable discussion ensued, and an amendment was moved. Finally the amendment was withdrawn and the report agreed to. The Telegraphs (Advances) Bill was then brought in by Mr. Hanbury and read a first time.

**Iron and Steel Institute.**—In accordance with previous announcements, the autumn meeting of the Iron and Steel Institute will be held at Bilbao in September next. To convey the members to Bilbao, and to serve as a floating hotel, the ss. "Ormuz," 6,031 tons register, 8,500 H.P., one of the finest of the Australian liners belonging to the Orient Steam Navigation Company, has been detailed. The steamer will leave London (Tilbury) on August 29th, 1896. The routine of meals will be maintained in port, and communication with the shore will be provided without extra charge. The passage money is 20 guineas, which includes board on the steamer while in port, and is payable, one half on engaging passage and the balance three days before embarking, except as regards a few cabins. Passages may be engaged on and after May 7th, on application to the managers of the Orient Company, Messrs. Anderson, Anderson and Co., 5, Fenchurch-avenue, London, E.C.

**A Useful Engine Slide Rule.**—We have recently seen a useful and handy form of slide rule for the computation of

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steam, gas and oil engine quantities. The slide rule is made of stiff cardboard, and measures about 6in. by 2½in. There are two sliders, placed side by side in the centre, and the working capacity of the instrument may be judged from the fact that the scales include indicated horse-power, brake horse-power, efficiency, firing or working strokes per minute, revolutions per minute, stroke, mean effective pressure, cylinder diameter, &c. All these quantities can be worked out without having to pull out and reverse the sliders, as in some other slide rules, which is a distinct advantage in respect of convenience, speed of working and durability. Among the useful things which can readily be accomplished with this slide rule are the following:—The computation of indicated horse-power from the quantities usually observed on an indicator trial, of brake horse-power from a brake trial, of the dimensions of an engine for any given indicated horse-power or brake horse-power and mean effective pressure, the mechanical efficiency, speed ratios of pulleys, velocities of belts or ropes, and the ubiquitous but useful "areas of circles." The range of use will be judged from the fact that the power scale is from 4 H.P. to 400 H.P., and may be indirectly reduced to 0·4 H.P. or raised to 4,000 H.P. The other scales are similarly of sufficient scope to cover a wide range of practice. We have carefully tested this slide rule with a number of examples, and find it accurate (to three figures with ease), expeditious and thoroughly practical over a wide range of engine quantities. We can confidently recommend it, and engineers will find it a great boon in undertaking tests, &c. Science teachers, too, would find it handy in checking class problems. Accompanying the slide rule is a card of instructions for use. This is the same shape and size as the slide rule, and both are contained in a stout case. The instrument is the invention of Mr. C. N. Pickworth, of Fallowfield, Manchester, from whom it may be obtained.

**Obituary.**—The death is announced of Mr. H. J. Vose, M.Inst.E.E., of Cardiff, Superintending Engineer of the Post Office Telegraphs for the South Wales District. Mr. Vose passed practically the whole of his official career in the engineering department of the telegraphs. He joined the staff of the late Mr. Edward Graves in 1871 Mr. Graves was then divisional engineer of the old north-western district, with headquarters at Birmingham. On Mr. Graves's promotion to the position of engineer-in-chief, in 1878, Mr. Vose followed him to London, and acted as his confidential assistant, with a short break, until Mr. Graves's death in November, 1892. Mr. Vose was then appointed, on the recommendation of the present engineer-in-chief, Mr. W. H. Preece, to the superintending engineership at Cardiff, in succession to Mr. J. Gavey, who removed to London on promotion as principal technical officer on the head office staff. Mr. Vose possessed in a marked degree the attributes that make a man a charming personal companion; but he was none the less an excellent man of business. He carried out the many delicate and important duties entrusted to him with admirable skill and tack; and he had the interests of the department he served very much at heart. He had been in failing health for a considerable time past, and for at least 12 months his condition had been such as to cause much anxiety to his friends and colleagues. But throughout the long course of the insidious disease from which he suffered, he never once lost heart. It was hoped that his comparative youth would eventually enable him to throw off the disorder, and recent reports of his condition favoured this view, but on Sunday last he suffered a severe relapse, and passed peacefully away on Tuesday morning. Mr. Vose was in his 46th year, and he leaves a widow and three children to mourn his loss. He will be greatly missed by his brother officers and by innumerable personal friends both within and without electrical circles. He was an enthusiastic Freemason.

**Recent Chemical Progress.**—In his second lecture on this subject at the Royal Institution Prof. Dewar commenced by describing the characteristic properties of acetylene, illustrating his remarks by experiments. This substance is one of those peculiar bodies, which, like arsenic, pass into the gaseous state at the ordinary atmospheric pressure without first liquefying. Acetylene is a most important body, as from it can be obtained ethylene, benzol, the cyanides, and in fact a whole range of organic bodies. Another product of the electric furnace whose application is daily extending, is aluminium. The Deville process gave us pure aluminium, but at a very high price, as it required the use of sodium, itself a costly metal. Then came the Cowles process which yielded it in greater quantities, but alloyed with other metals. To get it pure the metallurgist had to resort to the plan adopted by Sir Humphry Davy in the case of potassium and sodium, *i.e.*, separating the metal from one of its salts by electrolysis. As aluminium will not separate from oxygen except at a very high temperature, it is necessary to get a bath of some aluminium compound, such as cryolite, in a molten state. This is the process carried out at the works at Foyers, where the aluminium bath is kept molten in a large electric furnace, and the current at the same time separates the metal, which is tapped off at the bottom of the crucible. Now that aluminium can be cheaply produced, it is likely to be of great use, not only in the arts on account of its lightness and the beauty of its alloys, but also in metallurgical processes on account of its great reducing properties. Vautin has always employed it for purifying tungsten and other metals, examples of which were exhibited. Prof Dewar also showed the formation of an alloy of copper and aluminium. In this experiment he threw lumps of cold aluminium into a crucible of molten copper, the result being that the mass, instead of being cooled as one would have expected, was raised from the bright red heat of the molten copper to almost white heat, owing to the immense generation of heat produced by the union of the two metals to form the well-known alloy. At the temperature of the electric furnace silicon also forms a carbide, known commonly as carborundum, which is in the form of greenish crystals, and is coming largely into use as an abrasient.

**Contemporary Electrical Science.**—Mr. D. A. GOLDHAMMER, the distinguished Kasan physicist, throws in the weight of his opinion against the longitudinal vibration theory of the X-rays in a short Paper appearing in *Wiedemann's Annalen*. He pleads that all the peculiar properties of these rays are consistent with the assumption that they are very short ultra-violet waves. Such waves would be too small to be reflected by ordinary reflecting surfaces owing to roughnesses in polish. For the same reason they could not be polarised. But it would appear that this could be easily tested by trying reflection from *liquid* surfaces, which would need no polishing. Mr. Goldhammer gives no reason against the longitudinal character of these waves, but simply points out that in several theories of dispersion there is no deviation of infinitely small waves—which would account for the absence of refraction. The question of electrostatic discharge, so successfully tackled by Jaumann with the aid of the longitudinal theory, is left untouched by Goldhammer.—In the same number C. CHRISTIANSEN continues his disquisition on contact electricity. He has found that, among gases, oxygen and hydrochloric acid are about the only ones capable of producing a difference of potential between mercury and amalgams. But in any case, some gas is necessary.—FRANZ STREINTZ demolishes all experiments made to determine the polarisation of an electrolytic cell by the proof that the "resistance" of the cell is an indefinite function of the current intensity, and the polarisation, even if determinable, would be incapable of logical defination on the basis of present conceptions. The only solution is to abandon the idea of ohmic resistance as applied to a cell capable of polarisation.——An experimental proof of the truth of the theorem that an ellipsoid will be uniformly magnetised throughout in a uniform magnetic field has been attempted by O. GROTRIAN. He employed the ballistic method, using coils of different sizes to surround the ellipsoid in varying sections along the axis. But it was found impossible to make coils to fit ellipsoids, so he employed an iron sphere instead, which may be regarded as the limiting case of an ellipsoid. He then found that the theoretical conclusion was very closely verified. No influence of the direction of the "grain" of wrought iron could be discovered.——KARL L. SCHAEFER appears at last to have found a fairly strict means of measuring sound intensity. He uses a telephone adjusted to various sensibilities conveying a constant ticking sound from a clock which it is made just to "cover." He finds the law of inverse squares not to be strictly true.

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# THE CROMPTON POTENTIOMETER: ITS USE AND CAPABILITIES.—VI.*

BY W. C. FISHER, ASSOC.MEM.INST.C.E.

*Resistance Standards.*

The system of measurement under description, in which the potentiometer itself forms but the main and most important item, would be very limited and curtailed in its usefulness and capabilities were it not for the necessary Standards of Resistance, inasmuch as current measurement and comparisons of E.M.F. of any reasonable range are impossible without them; it is, therefore, requisite thatsome description of their construction be given.

The demand for commercial standard resistances for the measurement of currents by means of the fall of potential over the same, more especially for large or heavy currents, is of comparatively recent growth, and might be said to be coincident with the growth of commercial electric lighting—that is to say, within the past six or eight years. Prior to that time there were naturally but few in use; and probably the first makers of such standards for heavy currents were Messrs. Crompton, for, having adopted the potentiometer system of measurement at their works, such standards were imperative to them as adjuncts that system. Some of these standards, relics of early days, are still in existence, and consist of one or many strips of thin platinoid sheet, sweated into heavy copper thimble connections, to which were attached both main and potential leads. They were satisfactory as things went in those days, but with increased accuracy and refinement in the main instrument an investigation into their behaviour revealed several defects in construction, as well as in the alloys used; these

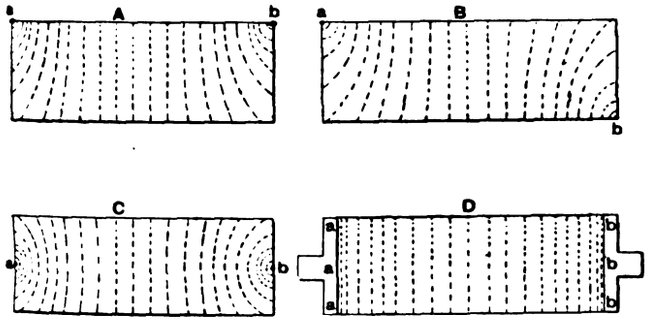


FIG 36.

have now respectively been remedied and abandoned. The two main points observed as defective were: First, the potential points were not sufficiently defined; and secondly, the alloys then in use were not sufficiently reliable. In the case of the first it was found impossible to obtain concordant and definite values unless the potential point was placed well within the area of the alloy itself, and *not* on the copper terminals.

During this investigation it was thought advisable to plot out on a given sheet of alloy the actual equipotential surface under given conditions. Some of the results or curves so obtained are shown in Fig. 36, in which the sheets A, B and C have the currents led in and out at the points *a* and *b*, with the result that the equipotential curves arrange themselves radially as shown, whilst in the case of D, having heavy copper connections extending the whole width of the sheet, they become parallel lines from end to end. These curves are only what one would expect, yet they serve to show strikingly that the shape of the main terminal and the position of the potential point are of considerable importance when great accuracy is desired; these curves were obtained and plotted upon actual sheets of alloy at the expenditure of much time and patience by Mr. A. C. Heap and some idea of the work involved may be obtained from the fact that the sheets measured approximately 20in. by 8in., and the curves were on an average about ½in. apart.

For a short time the potential terminals themselves were sweated on to the sheets, but as this was not deemed entirely satisfactory a change was sought in a small tapped hole and screw connection; but, as was pointed out by Prof. Viriamu Jones, the unscrewing of the screw and rescrewing of the same again in the plate was productive of an alteration in value; it afterwards proved, however, that without the necessity for unscrewing a change in value with time took place, which was due apparently to the formation of partial films of oxidation upon the surface or circumference of the screw. Prof. Jones also, at a British Association meeting, suggested the adoption of a peninsular-like projection, joined by a very narrow isthmus to the side of the sheet for the attachment of the potential terminal, as a method least likely to distort the equipotential surface, &c.; but this being somewhat impractical, the method shown at A B (Fig. 37) was adopted and is still in use; when this is suitably proportioned the cross-section of the sheet is but very slightly reduced, the equipotential surface is practically not disturbed, and by placing the V-cut at each end in the same direction a ready means of adjustment is obtained.

In the design and construction of such standards the first and chief point to be considered is their current capacity and consequent cross-section. In the early forms, as has already been stated, it was customary to construct them of very thin strips of alloy, having a considerable extent of radiating surface and leading naturally to economy in weight of material, but the extensive area exposed to atmospheric influence with its more or less chemical action upon the alloy employed, dependent upon the thickness of the strip, speedily alters its value by reducing the sectional area, &c. This, together with the fact that such standards being subject at times to rough usage, rendering mechanical strength a not unimportant consideration, has led to the adoption of considerably thicker sheets with consequent increased weight. So constructed these standards have a much longer life, and are in every way more reliable. Whilst using thin sheets recourse was had to gold plating as a protection from atmospheric influence, but in the case of large surfaces this led to considerable expense, and was abandoned in favour of japanning, enamelling, and flexible varnish.

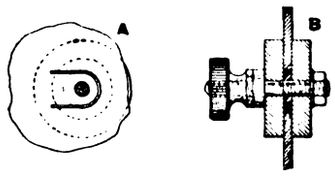


FIG. 37.

The current capacity and consequent size of such standards is, of course, variable from the ohm used for measuring currents up to one ampere, down to the lowest submultiples capable of carrying the largest currents; two samples of the latter were recently constructed for use at Kensington Court, being adopted by Mr. Miller for recording the total output of the station, having a maximum capacity of 6,000 amperes each.

No attempt is made here to describe pure laboratory standards with values that one is now fairly climatised to seeing defined by a stately row of ciphers carried on to attenuity, with perfect impunity, for the exact conditions under which they were obtained cannot possibly be repeated with any certainty, and proof of the inaccuracy of the last few figures accordingly need never be feared. Engineers do not ask for, do not want, and probably if they had, would doubt this degree of accuracy, and its uselessness as an unnecessary refinement to them is perfectly apparent when one considers the circumstances under which commercial standards are worked—amidst wide differences in temperature, mechanical upset, acid spray, and in some instances a chemical atmosphere, together with other causes that one does not usually obtain in a laboratory. One is not surprised therefore at the satisfaction expressed at a guaranteed accuracy within one-tenth per cent. in individual measurements of current or E.M.F., or even one-quarter per cent. in the measurement of power.

In a recently-published article upon foreign practice in the construction of standards the method of winding the standard coil high and then bringing it down to correct value by means of a fine wire shunt was described. This method was

* For previous articles see *The Electrician*, November 29th, December 6th, January 17th, January 31st, and March 13th. *Copyright.*

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adopted in the calibration of potentiometer coils some years ago and abandoned, for the following reasons: the whole safety of the calibration of the coil was dependant upon the weak link of a fine wire, it was perfectly possible for this wire to be injured or severed without anything indicating the same, in fact as actually happened, it was possible for the coil to test up all right, and yet in the very act of removing it from the test table a disconnection of the fine wire to take place. The device is mechanically weak, therefore, in practice, it is far preferable to wind the coil—of substantial bare wire—slightly under value, and then by the mechanical process of removing metal by scraping or rubbing bring it up to its proper value. In this manner standards up to 10 ohms or more can be easily made and calibrated, and it is found more useful if necessary to wind between the convolutions of a standard coil, in place of the shunt described, a fine platinum wire to be used as a means of ascertaining the true temperature of the coil.

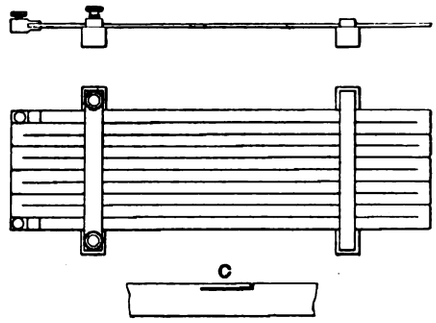


FIG. 38.

Fig. 38 is representative of the type of standard resistance used for the measurement of current up to 150 or 300 amperes. It consists of a sheet having alternate saw cuts from either end; the main terminals are fixed as shown, whilst the whole is braced with battens, the alloy being of sufficient thickness to stand knocking about. The potential is taken off a tongue, slit at the side of one of the limbs, as shown enlarged at C.

Fig. 39 is a type consisting of a single sheet (in some instances double), and is made to carry up to 1,500 amperes, the potential terminal in this case being fixed, as has already been described in Fig. 37, by being screwed into the tag shewn and secured by a lock nut, two ebonite washers ($a$, $b$) being interpolated.

Some remarkable inquiries with reference to standards might be here mentioned as being somewhat amusing. In one case a quotation was asked for a particular standard to be constructed

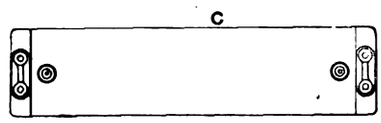


FIG. 39.

in solid alloy. The superficial area of this sheet when worked out, allowing it to be $\frac{1}{10}$in. in thickness, came to over 25 square yards; the dimensions when supplied proved sufficient. Another case which caused some surprise occurred with reference to a standard ohm, which was to be of somewhat large gauge platinum silver wire. Upon running out as a preliminary the probable cost, the wire alone came to between £70 and £80; this standard ohm was not made.

With reference to the question of alloys out of which such standards may be constructed, in the early days one had to be content with German silver or platinoid; but now, what with manganin, constantan, nickeline, rheotan, Krupp metal, and many others, one has infinite choice. In the case of German silver and platinoid, neither might be said to have been a success, the former becoming useless in a very short time, the latter becoming also, in course of time, very uncertain. Large currents appear to have a most demoralising effect upon both alloys, with the result that their values were never constant, varying in some cases day by day to a considerable extent, this being very marked if accidentally or unavoidably they were allowed to become very heated.

Constantan might be said to be fairly true to its name, and with it might be classed those members of the German silver family, nickeline and rheotane, whilst Krupp metal, with its abnormally high specific resistance of 86 microhms per cubic centimetre, and reputed virtue of remaining constant and unimpaired after being heated to 400°C., has the grave fault of quickly becoming oxidised and exceedingly "short" if subjected to atmospheric influences, more especially if there be a trace of acid vapour or spray present. Writing after an

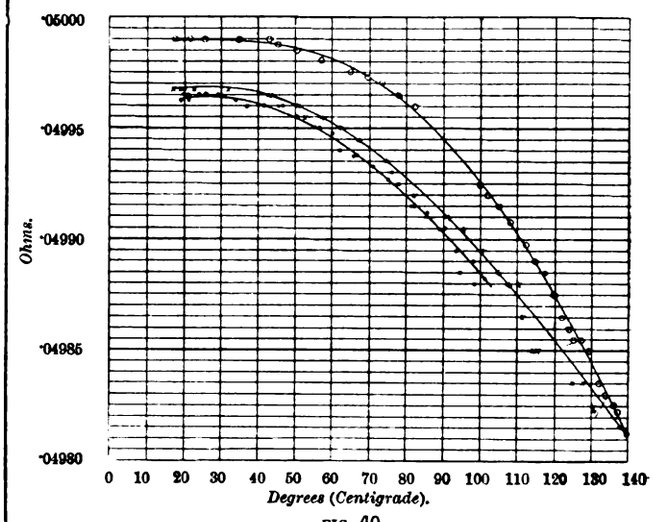


FIG. 40.

experience dating from its first introduction into this country, and after trial of all the known alloys, manganin is undoubtedly the best and most reliable of alloys that can be used for standards of the description in question, provided it is obtained in fit and proper condition. Complaints have from time to time appeared as to the difficulty in obtaining successive deliveries having identical electrical qualifications. When first placed upon the market such complaints were certainly just, for the specific resistances of successive batches varied by as much as several per cent.; but this difficulty seems to have been got over, and it is now possible to obtain specific

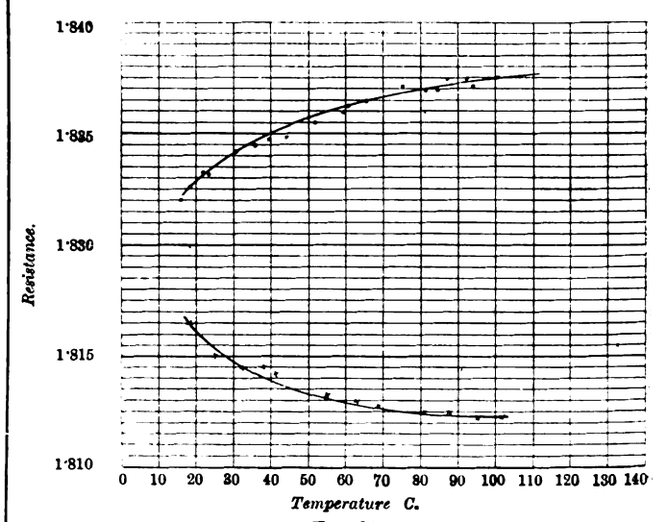


FIG. 41.

guarantees within reasonable limits. In any case, this complaint may to a certain extent be obviated by ordering large quantities at a time; but this is not always convenient. It is, however, certain that if this alloy be properly and consistently dealt with there is absolutely no difficulty in constructing reliable standards either of sheets in mass or of fine wires.

Fig. 40 gives the characteristic cycle of annealing and "ageing" curves common to the many tests made of sheet resistances, not one of which has been known to materially differ. At top we have the annealing curve when the resis-

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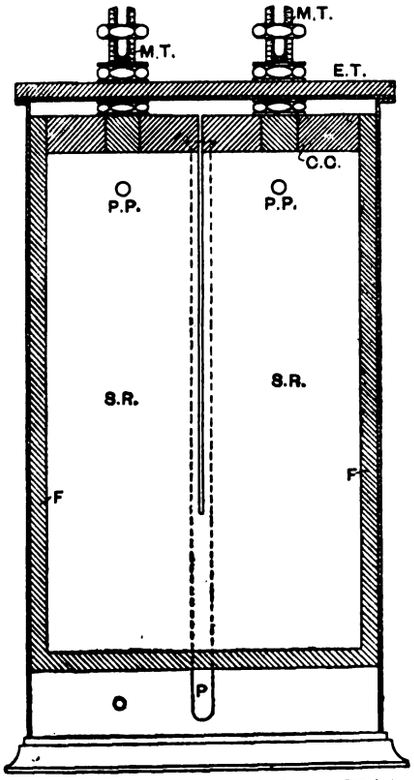
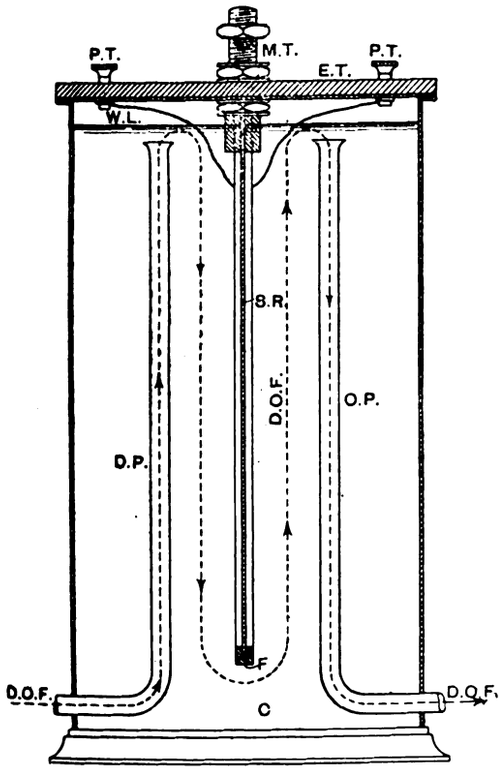
tance is heated from normal temperature up to 140°C. Next the consequent natural cooling curve, whilst the lowest is a curve common to three or four "ageing" runs up to 100°C and down again. From this last curve it may be observed that the extreme




M. T., Main Terminals; C.C., Copper Clamps; P.P., Potential Points; S.R., Standard Resistance; F., Frame (Insulation); C., Case; P., Pipes; E.T., Ebonite Top.




P.T., Potential Terminals; D.P. Delivery Pipe; O.P., Outlet Pipe; D.O.F., Direction of Flow of Water; W.L., Water Level.

FIG. 42.

variation amounts to 0·15 per cent. approximately, or a mean over the whole of 0·00176 per cent. per degree, but in the early part of the curve the alteration is very slight, from 15deg. to 30deg. being practically unmeasurable and amounting, even when heated up to 50deg., to less than 0·0125 per cent. or 0·000356 per cent per degree.

This might very well be said to be all that is necessary in a commercial standard, and in a single alloy is not likely to be very much improved, but it is possible by the combination of two different alloys to construct a compound or compensating resistance standard having a temperature error which even between the extremes of normal and 100°C, may be neligible. The possibility of this is shown by Fig. 41, which gives the characteristic temperature curves of two alloys having respectively a negative and positive error, and from which it is seen that by combination in suitable proportions such a standard resistance as that described may be made, having a very small temperature error over a considerable range.

The demand for standards of high ohmic value, to carry a large and ever-increasing range of current, led to the adoption of such methods of construction as would not only decrease their weight but size also. Prof. Eric Gérard, at Liege, obtained this

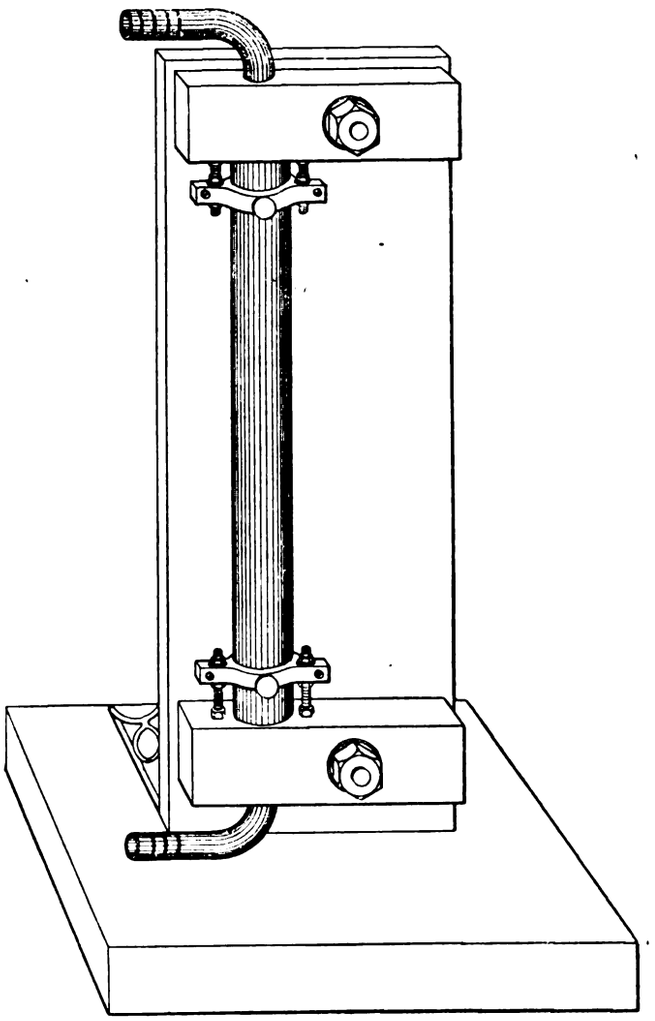


FIG. 43.—Perspective View of a Water Tube Resistance.

effect to a certain degree by plunging the standards in a tank of ever-flowing water. Several standards were made in this manner, but this method of construction was not deemed sufficiently practical or compact, added to which the amount of surface to be enamelled or protected from attack through electrolysis was still so great as to almost defy its being done efficiently, so that constant watching and overhauling was necessary. Experiments were then made to ascertain whether efficient and durable standards could not be made of tubular section, through which a constant stream of water could be maintained as a means of carrying off the heat generated by the current passing through the small section of conductor used. These proving satisfactory, this type of resistance was adopted, and is used wherever convenience or the exigencies of the case demand it. The tubes used are very thin, and are effectually protected inside by a thick coat of flexible enamel, and prove very efficient, even with a current density of something like 35,000 amperes to the square inch,

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the flow of water required being no more than that obtained from the ordinary house service. At first thought it may be considered inadvisable to connect such a standard up to any earthed electric system on account of leakage and consequent electrolysis and shocks, but no danger need be anticipated provided an india-rubber connecting pipe of reasonable length be used, as from tests made it may be roughly taken that 30ft. of $\frac{3}{4}$in.-bore rubber hose pipe filled with water is equivalent in resistance to about 1 megohm. Such standards as are here described are represented by Figs. 42 and 43, the former being an ordinary standard placed in a bath of water, the latter one in which water is passed through the standard. It is somewhat curious to note that the latter cannot be worked in any other manner than vertical, as if the tube be placed inclined or horizontally air bubbles collect upon the sides, with consequent considerable local heating; it is also advisable, in order to prevent the standard accidentally acting as a fuse, to let the water enter from below and leave by the top orifice, also to run the water through in a preliminary manner the moment the standard is *in situ*, as then, even though the water may be cut off again, there will be a sufficient quantity within the tube to prevent accidental injury in the event of the current being turned on unexpectedly.

## THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

### Insulation Testing of Low-Pressure Networks During Working.

*Permanently Earthed Networks.*

When one main of a network is permanently earthed throughout its length, it is impossible to test the fault resistance of the other main or mains during working. Such networks should preferably be provided with "fault-signalling networks,"† to be described later. Otherwise, it is only possible to discover the existence of faults through abnormal increases of current, drops of voltage, blown fuses, &c.

At some central stations one of the mains is permanently earthed at the station end through an ammeter, being insulated at every other point. On a fault suddenly occurring in any part of the network, there will be a sudden variation in the current flowing through this testing ammeter. But, except in the case of a fault thus suddenly appearing, the reading of the ammeter is not a sufficient indication of the state of the insulation of the network, although it is usually considered so. Suppose, for instance, that the ammeter earthing the middle wire of a three-wire network shows a current flowing towards earth, and that during a certain week this reading gradually decreases. The cause of this may be a decrease in the leakage from the negative main, or else the development of a fault on the positive main or of a bad fault on the middle wire, so that the engineer-in-charge would not be justified in assuming that something was wrong. A fault occurring on the middle wire must be very bad to occasion an appreciable alteration in the deflection of the ammeter. Moreover, if the fault resistances of the positive and negative mains were equal in a three-wire network (or if the equation $\frac{2}{f_1}+\frac{1}{f_2}=\frac{1}{f_4}+\frac{2}{f_5}$ were satisfied in a five-wire network), no current would pass through the ammeter, however good or bad the condition of the middle wire might be.

The current in amperes flowing from the middle wire to earth through the testing ammeter is, in fact, given by the formula

$$C=\frac{\frac{1}{f_d}-\frac{1}{f_b}}{\frac{1}{F}+\frac{1}{g}}\cdot\frac{V}{g} \text{ for a three-wire network, . . . (1)}$$

$$\text{or } C=\frac{\left(\frac{2}{f_e}+\frac{1}{f_d}\right)-\left(\frac{1}{f_b}+\frac{2}{f_a}\right)}{\frac{1}{F}+\frac{1}{g}}\cdot\frac{V}{g} \text{ for a five-wire network, . . . . (2)}$$

F being the fault resistance of the whole network in ohms;

$f_a$, $f_b$, $f_c$, $f_d$ and $f_e$ being the fault resistances of the several mains respectively from + to −;

$\left(\frac{1}{F}\right.$ is, therefore, $\frac{1}{f_a}+\frac{1}{f_b}+\frac{1}{f_c}+\frac{1}{f_d}+\frac{1}{f_e}$ in a five-wire network, or $\left.\frac{1}{f_b}+\frac{1}{f_c}+\frac{1}{f_d}\text{ in a three-wire network}\right)$;

V the difference of potential in volts between any two adjacent mains (between $a$ and $b$ or $b$ and $c$, &c.), and

$g$ the resistance of the ammeter in ohms.

In a two-wire network whose negative wire is earthed through an ammeter

$$C=-\frac{\frac{1}{f_b}}{\frac{1}{F}+\frac{1}{g}}\cdot\frac{V}{g}=-\frac{\frac{1}{f_b}}{\frac{1}{f_b}+\frac{1}{f_c}+\frac{1}{g}}\cdot\frac{V}{g}, \quad . \quad . \quad . \quad (3)$$

where $f_b$ and $f_c$ are the fault resistances of the positive and negative mains respectively.

This ammeter can thus only partially be depended upon as an indicator of faults, but as such it is better than none at all. The instrument should be of a type whose pointer deflects to different sides of the zero for currents of different directions, or it should be provided with a second needle to indicate the direction of the current. If a current flowing through it *from* the middle wire *to* earth be considered to give a + deflection, then a + deflection indicates that the positive side of the network is the better insulated, and a − deflection indicates that the negative side is the better insulated.

There is still another kind of permanently-earthed network—viz., that whose middle wire is earthed at the feeding points only. These networks—as, in fact, any which are permanently earthed—should in preference have "fault-signalling networks," as described later; but if these latter have not been provided, it is also possible to use the earthed-ammeter method of testing just described. At one feeding point, which is conveniently accessible, an ammeter of a fraction of an ohm resistance is permanently connected between the middle wire and earth. At the other feeding points the middle wire is not directly earthed, but is earthed in each case through a resistance coil of the same resistance as the ammeter. These resistances being so low, the advantages of earthing at the feeding points are still secured. The ammeter should be read each day, and the same inferences drawn from its readings as in the previous case considered.

The equations connecting the current through the ammeter with the fault resistance of the network will now be

$$C=\frac{\frac{1}{f_d}-\frac{1}{f_b}}{\frac{1}{F}+\frac{n}{g}}\cdot\frac{V}{g} \text{ for a three-wire network, . . . (4)}$$

$$\text{and } C=\frac{\left(\frac{2}{f_e}+\frac{1}{f_d}\right)-\left(\frac{1}{f_b}+\frac{2}{f_a}\right)}{\frac{1}{F}+\frac{n}{g}}\cdot\frac{V}{g} \text{ for a five-wire network, . . (5)}$$

where $n$ is the number of earthed feeding points.

For a two-wire system whose negative wire is earthed at the feeding points as above described,

$$C=-\frac{\frac{1}{f_b}}{\frac{1}{F}+\frac{n}{g}}\cdot\frac{V}{g} \text{ or } -\frac{\frac{1}{f_b}}{\frac{1}{f_b}+\frac{1}{f_c}+\frac{n}{g}}\cdot\frac{V}{g}; \quad . \quad . \quad . \quad (6)$$

$f_b$ and $f_c$ are in this equation the fault resistances of the positive and negative mains respectively.

*Networks which are not Permanently Earthed.*

The insulation resistance of a network should be tested frequently—say once a day—by one of the four following

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

† See *The Electrician*, Vol. XXXI. p. 105, or *Elektrotechnische Zeitschrift*, March 17, 1893.

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methods, and a record of the readings should be kept. A variation in the readings indicates a change in the insulation resistance of the mains.

*Method 1.**—An ammeter or voltmeter, which gives readings on both sides of zero, has one terminal connected to earth, and the other terminal is connected in turn to each main.

If $d_1$ and $d_2$ be the readings obtained from two adjacent mains (*i.e.*, for instance, between the middle wire and one of the outer wires in the case of a three-wire network); if V be the working pressure between these two mains, in volts, and $g$ the resistance of the testing ammeter or voltmeter, in ohms, the insulation resistance of the whole network in ohms is given by the simple formula

$$F = \frac{V}{d_1 - d_2} - g, \text{ if an ammeter be used for the test,} \quad . \quad (7)$$

$$\text{and } F = g\left(\frac{V}{d_1 - d_2} - 1\right), \text{ if a voltmeter be used.} \quad . \quad . \quad . \quad (8)$$

In a two-wire network the fault resistance of *each* main may also be calculated from these readings:—

If an ammeter be used—

$$\left.\begin{aligned} f_1 &= \frac{V - g(d_1 - d_2)}{-d_2} \\ \text{and} \quad f_2 &= \frac{V - g(d_1 - d_2)}{d_1} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

If a voltmeter be used—

$$\left.\begin{aligned} f_1 &= \frac{g\{V - (d_1 - d_2)\}}{-d_2} \\ \text{and} \quad f_2 &= \frac{g\{V - (d_1 - d_2)\}}{d_1} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

The expression $(d_1 - d_2)$ in all the above formulæ is the algebraical difference between the two readings—that is to say, if the deflections are to opposite sides of the scale, they must be added.

It is not absolutely necessary to use instruments which give deflections on both sides of the scale, though it is more convenient. For example, if $d_1$, $d_2$ and $d_3$ are the readings obtained from the mains of a three-wire network,

$$d_1 - d_2 = d_2 - d_3.$$

And in a five-wire network

$$d_1 - d_2 = d_2 - d_3 = d_3 - d_4 = d_4 - d_5.$$

It is thus easy to see what sign to give to the reading.

In a two-wire network the two readings are always on opposite sides of zero, and they must therefore be added.

Also, in a two-wire network the readings $d_1$ and $d_2$ are proportional to the relative insulation resistances of the two mains, so that, on a fault occurring, it is at once apparent in which main it is. In a three or five-wire system, if one of the outer mains has developed a fault, there will be a considerable change in the reading from the middle main. In the case of a fault of the same resistance on the middle wire, the reading from the middle wire itself will not alter so much, the change in the readings from the other mains causing the increase in the value of $(d_1 - d_2)$. This can be seen by studying the examples which follow.

The instrument to choose for the test should have as low a resistance as practicable, but this must be made to depend to a certain extent on the normal insulation resistance of the network. In a large network, whose normal resistance is only a few ohms, an ammeter of very low resistance would take too much current, whereas a voltmeter would have too high a resistance. In such a case a good plan is to first decide the maximum testing current to be allowed, and then to procure an ammeter reading to this current, and to use a resistance in series with it if necessary. The coils of an ordinary Wheatstone's bridge resistance box are not suitable for this, as they would be heated by the current. Coils of bare copper or iron wire do very well for the purpose; the size of the wire must be so large that it does not get heated. The value of $g$ is then the resistance of the instrument *plus* the resistance of the coil.

* This method was first described by Gustav Frisch, of Vienna. *Zeitschrift für Elektrotechnik*, May 1, 1889.

If the approximate fault resistances of the mains be known, a value of $g$ can be chosen so as to give suitable values to $d_1$, $d_2$ and $d_3$ in the following equations:—

$$\left.\begin{aligned} d_1 &= \frac{V}{g}\left(\frac{\frac{1}{f_3} - \frac{1}{f_1} - \frac{1}{g}}{\frac{1}{F} + \frac{1}{g}} + 1\right) = \frac{V}{g}\left(\frac{\frac{1}{f_2} + \frac{2}{f_3}}{\frac{1}{F} + \frac{1}{g}}\right) \\ d_2 &= \frac{V}{g}\left(\frac{\frac{1}{f_3} - \frac{1}{f_1}}{\frac{1}{F} + \frac{1}{g}}\right) \\ d_3 &= \frac{V}{g}\left(\frac{\frac{1}{f_3} - \frac{1}{f_1} + \frac{1}{g}}{\frac{1}{F} + \frac{1}{g}} - 1\right) = -\frac{V}{g}\left(\frac{\frac{1}{f_2} + \frac{2}{f_1}}{\frac{1}{F} + \frac{1}{g}}\right) \end{aligned}\right\}, \quad (11)$$

where $f_1$, $f_2$ and $f_3$ are the fault resistances of the positive, neutral and negative mains respectively, and F is the insulation resistance of the whole network, $\frac{1}{F}$ being $= \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$.

For a five-wire system the equations are:—

$$\left.\begin{aligned} d_1 &= \frac{V}{g}\left(\frac{h - \frac{2}{g}}{\frac{1}{F} + \frac{1}{g}} + 2\right) \\ d_2 &= \frac{V}{g}\left(\frac{h - \frac{1}{g}}{\frac{1}{F} + \frac{1}{g}} + 1\right) \\ d_3 &= \frac{V}{g}\left(\frac{h}{\frac{1}{F} + \frac{1}{g}}\right) \\ d_4 &= \frac{V}{g}\left(\frac{h + \frac{1}{g}}{\frac{1}{F} + \frac{1}{g}} - 1\right) \\ d_5 &= \frac{V}{g}\left(\frac{h + \frac{2}{g}}{\frac{1}{F} + \frac{1}{g}} - 2\right) \end{aligned}\right\}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$h$ being $\frac{2}{f_5} - \frac{2}{f_1} + \frac{1}{f_4} - \frac{1}{f_2}$,

and $f_1$, $f_2$, $f_3$, $f_4$, $f_5$ being the fault-resistances of the several mains, in order from the outer positive to the outer negative.

For a two-wire network:—

$$\left.\begin{aligned} d_1 &= \frac{V}{g}\,\frac{\frac{1}{f_2}}{\frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{g}} \\ d_2 &= -\frac{V}{g}\,\frac{\frac{1}{f_1}}{\frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{g}} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

For networks of somewhat higher insulation—perhaps from 40 or 50 ohms upwards—large currents can no longer be obtained between the mains and earth; then there is no necessity to put a resistance in series with the ammeter, though a resistance of a few ohms may be put in series with it as a safeguard. For still higher insulation resistances the testing currents get smaller, and either milliampere-meters or *low*-resistance voltmeters should be employed. The latter are not at present obtainable from instrument makers, as, for usual central-station practice the higher the resistance of the switchboard voltmeter the better. There is, however, no reason



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why special instruments should not be made, wound with low-resistance coils for this purpose. A hot-wire voltmeter (such as the Cardew) having a lower resistance, will serve to give indications of faults, but it will not give an accurate measurement of the insulation resistance, as its resistance is not constant, but depends on the reading. An ordinary voltmeter, which has, as a rule, a resistance of about 1,000 ohms, should only be used for testing networks whose insulation resistances are at least over 100 ohms. When used for lower insulation resistances, changes in the fault-resistance of the middle wire produce but small changes in the voltmeter readings (*see* Example 4). Moreover, a small error in reading the instrument will cause a large error in the calculated value of the insulation resistances. For instance, on a network of 50 ohms insulation resistance, in which V is 100 volts, an error of half a volt in the reading $d_1 - d_2$ produces an error of about 10 per cent.

For small networks whose insulation resistances are 1,000 ohms or more, an ordinary electromagnetic voltmeter will give very good results, or a high-resistance galvanometer may be employed. As this latter would not read directly in volts, it must first be connected across the mains to give V in terms of the galvanometer scale readings, and then the readings $d_1$, $d_2$ and $d_3$ should be taken between each omnibus bar and earth. The insulation resistance will be then, as before,

$$F = g\left(\frac{V}{d_1 - d_2} - 1\right),$$

V, $d_1$ and $d_2$ being the galvanometer readings and not necessarily volts. An extra refinement would be to use a galvanometer with a shunt box with compensating resistances (*see* "Kempe's Handbook of Electrical Testing," p. 84). But it has already been shown above, and it is also apparent from the examples which follow, that measurements of sufficient accuracy can be made with ordinary and less expensive instruments.

The ideal way to use Method 1 is to have a recording voltmeter connected between one of the outer mains and earth (or between each of the outer mains and earth), and to test once daily with an ammeter or voltmeter, as above described. Then, if only a slight variation in the insulation resistance—and consequently in readings of the testing ammeter or voltmeter—has occurred, it can at once be seen, by examining the recording voltmeter curve, whether this has been due to a sudden alteration in the conditions—*i.e.*, by the development of a fault—or by a gradual decrease in the insulation resistance. If the resistance of the recording voltmeter is high compared with the insulation resistance of the network, it is not necessary to disconnect it for the ammeter test.

In every case in which an instrument (whether a recording voltmeter or an ordinary voltmeter or ammeter) is connected between a main and earth, a fuse should be inserted between the instrument and the main, not between the instrument and the earth.

Instead of one voltmeter or ammeter having a wide range, two instruments may be used, having "open" scales at the parts where the readings occur. If this is done their resistances must be equal, or, if of different resistances, the lower resistance instrument must have a resistance coil in series with it to make up the difference.

A method of testing which is used very frequently in a three-wire network is to connect a high-resistance voltmeter between each of the two outer mains and earth. Then, if the readings are slightly different, the mains are pronounced to be in good condition. If one reading is considerably lower than the other, the outer main on that side is considered the culprit; and if the two readings are equal, the middle main is presumed to be faulty. The error and insufficiency of this method is evident from the foregoing and from the examples below. If the reading is 0 when the instrument is connected to the middle wire, it simply means, in a three-wire network, that the fault resistances of the positive and negative mains are equal; in a five-wire network, that

$$\frac{2}{f_1} + \frac{1}{f_2} = \frac{1}{f_4} + \frac{2}{f_5} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

**Example I.**—*This shows Stages in the Development of a Fault in the Middle Wire of a Three-wire Network.*

V = 105 volts. $g$ = 1 ohm.

| *a.* (Normal Readings.) | *b.* | *c.* | *d.* |
|---|---|---|---|
| | Amp. | Amp. | Amp. |
| From positive main, $d_1$ = | +4·0 | +4·5 | +7·3 | $d_1$ off scale + |
| From middle main, $d_2$ = | +0·25 | +0·25 | +0·25 | $d_2$ +0·15 amp. |
| From negative main, $d_3$ = | −3·5 | −4·0 | −6·9 | $d_3$ off scale − |
| $F = \frac{V}{d_1 - d_2} - g$ (or $\frac{V}{d_2 - d_3} - g$) | | | | |
| $= \frac{105}{3·75} - 1 = 27$ ohms. | | F = 24 ohms. | F = 13·8 ohms. | F about 2 ohms. |

**Example II.**—*Example of the Development of a Fault in the Positive Wire of the Same Network.*

V = 105 volts. $g$ = 1 ohm.

| *a.* (Normal Readings.) | *b.* | *c.* |
|---|---|---|
| From positive main, $d_1$ = | +4·0 amp. | +3·8 amp. | +2·7 |
| From middle main, $d_2$ = | +0·25 amp. | −3·7 amp. | $d_2$ off scale − |
| From negative main, $d_3$ = | −3·5 amp. | −11·1 amp. | $d_3$ off scale − |
| F = 27 ohms. | | F = 13 ohms. | F about 2 ohms. |

**Example III.**—*An Incipient Fault in the Negative Wire of the Same Network.*

V = 105 volts. $g$ = 1 ohm.

| *a.* (Normal readings.) | *b.* |
|---|---|
| From positive main, $d_1$ = +4·0 amp. | $d_1$ = +4·6 amp. |
| From middle main, $d_2$ = +0·25 amp. | $d_2$ = +0·6 amp. |
| From negative main, $d_3$ = −3·5 amp. | $d_3$ = −3·5 amp. |
| F = 27 ohms. | F = 25 ohms. |

*Use of Voltmeter of 1,000 ohms Resistance.*

The following two examples are purposely extreme cases to show how unsuitable a voltmeter is for the test when the insulation resistance of the network is low.

**Example IV.**—*Incipient Fault in Middle Wire.*

V = 110 volts. $g$ = 1,000 ohms.

| *a.* (Normal readings.) | *b.* |
|---|---|
| From positive main, $d_1$ = +111·3 volts | $d_1$ = +111·1 volts |
| From middle main, $d_2$ = + 6·7 volts | $d_2$ = + 5·7 volts |
| From negative main, $d_3$ = − 98·0 volts | $d_3$ = − 99·8 volts |
| $F = g\left(\frac{V}{d_1 - d_2} - 1\right)$ or $g\left(\frac{V}{d_2 - d_3} - 1\right)$ | |
| $= 1{,}000\left(\frac{110}{101·6} - 1\right) = \frac{1{,}000 \times 5·4}{101·6}$ | F = 43 ohms. |
| = 52 ohms. | |

**Example V.**—*Incipient Fault in the Negative Main of the Same Network.*

V = 110 volts. $g$ = 1,000 ohms.

| *a.* (Normal readings.) | *b.* |
|---|---|
| From positive main $d_1$ = +111·3 volts | $d_1$ = +128 volts |
| From middle main $d_2$ = + 6·7 volts | $d_2$ = + 23 volts |
| From negative main $d_3$ = − 98·0 volts | $d_3$ = − 83 volts |
| | (Taking the mean between $d_1 - d_2$ and $d_2 - d_3$) |
| F = 52 ohms. | $F = 1{,}000\left(\frac{110}{105·5} - 1\right)$ |
| | $= \frac{1{,}000 \times 4·5}{105·5} = 43$ ohms. |

(*To be continued.*)

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## PHYSICAL SOCIETY.

At an ordinary meeting of the Physical Society, held on April 24, 1896, Capt. W. de W. Abney, president, in the chair, a Paper by Mr. R. A. LEHFIELD on

**"Symbolism in Thermodynamics,"**

was, in the absence of the author, read by the Secretary.

The author proposes a system of about 24 separate symbols for the different quantities in thermodynamics.

Prof. SILVANUS THOMPSON said he was not at all favourably impressed with the symbols proposed. In particular it was becoming usual to restrict the use of Greek letters to the representation of specific quantities or angles, and the author's proposal seemed, in this way, a retrograde step.

Prof. PERRY said he did not care for the suggested symbols.

Mr. ELDER thought the author's system would be a very severe tax on the memory, for he did not make use of suffixes, as was ordinarily done, which in a great measure define the symbol to which they are attached.

Mr. APPLEYARD read a Paper on

**"The Adjustment of the Kelvin Bridge."**

In a recent Paper read before the Society Mr. Reeves had described a modified form of Kelvin bridge, in which a double adjustment was necessary. The author proposes to employ two wires, stretched side by side, with a sliding contact in connection with the galvanometer on each. These contacts are rigidly connected together so that the segments into which one wire is divided necessarily bear to one another the same ratio as do the segments of the other wire. Hence a single adjustment is sufficient to give balance.

Mr. REEVES said that apparently the author had completely missed the object of his (the speaker's) Paper. For the object there aimed at was to make use of such sets of resistance coils as are always to be found in any laboratory. In the author's arrangement it would be necessary to carefully calibrate the two wires, and also, since the resistances used must necessarily be small, to determine the resistance of the contacts.

Prof. AYRTON (communicated) said the author's suggestion was ingenious, but did not obviate the necessity for much of Mr. Reeves' "addition." Further, Mr. Reeves' proposal to employ ordinary resistance boxes was not made because such resistances are absolutely necessary, but because, since they are to be found in any electrical laboratory, their use saves the expense of such a wire resistance accurately calibrated as Mr. Appleyard employed.

Mr. APPLEYARD, in his reply, said that his instrument was designed for use in a factory where the time saved in making a series of tests was of more importance than the cost of the instrument.

Mr. J. FRITH read a Paper on

**"The Effect of Wave-Form on the Alternate-Current Arc."**

The author finds that an arc has the power of modifying the wave-form in a circuit in which it is included. Thus, in the case of a dynamo for which on open circuit the curve of E.M.F. was decidedly peaked, it was found that when this dynamo was employed to feed an arc that the curve became changed to a flat-topped form. It is interesting to remember that the candle-power of the arc is greater when the wave-form is flat-topped than when it is peaked. By altering the resistance in series with the arc it is possible to alter the character of the curve, for as the resistance in series with the arc increases the arc affects the wave-form less and less. In some recent experiments described by Dr. Fleming a resistance of about 7 ohms was used in series with the arc, so that the wave-form of the generator, which is not an efficient form, was forced on the arc. In practice, however, where a resistance is not used in series with the arc, this is not the case, and the differences between the efficiency obtained for alternate-current arcs in the laboratory and that claimed in practice may thus be accounted for.

Mr. BLAKESLEY said it seemed as if the more nearly the alternate current resembles a direct current—*i.e.*, the longer in each period the the current remains constant—the greater is the efficiency of the arc.

Mr. PRICE asked what was the cause of the reaction of the arc on the wave form.

Prof. AYRTON (communicated) considered the author's suggestion of great importance as bearing on the question of the efficiency of the alternate-current arc.

Prof. S. P. THOMPSON said that the dynamo employed by the author was one in which there was a large quantity of iron in the armature, so that the self-induction was large. Was it not on account of this large coefficient of self-induction, which would tend to keep the current constant, that the arc was able to alter the wave curve? If an arc is connected to the mains of a supply station in which a number of machines in parallel are feeding a number of lamps, would the arc still be able to affect the wave form of the current?

Mr. TREMLETT CARTER asked if the author had tried the effect of replacing the arc by a resistance such that it would absorb the same volts as did the arc, and comparing the curves for the current and impressed potential difference with those obtained with the arc.

The AUTHOR, in his reply, said that the effect of the self-induction of the machine was shown in the curves. Current curves had not been taken with the arc straight on the machine. The current and self-induction were the same for all the curves, the voltage of the machine being increased by increasing the field when resistance was placed in series with the arc. When, as is commonly the case, special machines are used to supply arcs, and the load consists solely of arcs, the arcs would alter the character of the wave form. If the arc is replaced by a resistance, the wave form is of the same type as is obtained for the E.M.F. of the machine on open circuit.

The Society then adjourned till May 8th.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, May 1st.**

ROYAL INSTITUTION.

*5 p.m.* Annual Meeting.

INSTITUTION OF MECHANICAL ENGINEERS.

*7:30 p.m.* Ordinary General Meeting at 25, Great George-street, S.W. The following Papers to be read and discussed: (1) "Steel Steam Pipes and Fitting, and Benardo's Arc Welding in Connection therewith," by Samuel MacCarthy; (2) "Research Committee on the Value of the Steam Jacket; Experiment on a Locomotive Engine," by Prof. T. Hudson Beare and Bryan Donkin.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Chronographs and their Application to Gun Ballistics," by Colonel H. Watkin.

**MONDAY, May 4th.**

ROYAL INSTITUTION.

*5 p.m.* General Monthly Meeting.

SOCIETY OF ENGINEERS.

*7:30 p.m.* Ordinary Meeting at the Royal United Service Institution, Whitehall. Paper to be read: "Hydraulic Rotative Engines," by Arthur Rigg.

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture II.: "Applied Electro-Chemistry," by James Swinburne.

**TUESDAY, May 5th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture (I.): "Ripples in Air and on Water," by C. Vernon Boys, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Papers to be read with a view to discussion: (1) "American and English Methods of Manufacturing Steel Plates," by Jeremiah Head; (2) "Four American Rolling Mills," by Samuel T. Wellman. At this meeting the monthly ballot for members will be taken.

**WEDNESDAY, May 6th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "High Explosives and Smokeless Powder," by Hudson Maxim.

**THURSDAY, May 7th.**

IRON AND STEEL INSTITUTE.

*10:30 a.m.* Annual Meeting at 25, Great George-street, S.W. Various Papers to be read.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Special Meeting. Fourth "James Forrest" Lecture: "Physical Experiment in Relation to Engineering," by Dr. A. B. W. Kennedy, F.R.S.

**FRIDAY, May 8th.**

IRON AND STEEL INSTITUTE.

*10:30 a.m.* General Meeting at 25, Great George-street, S.W. Various Papers to be read and discussed.

INSTITUTION OF JUNIOR ENGINEERS.

*8 p.m.* Meeting at the Westminster Palace Hotel. Paper to be read and discussed: "Notes on Belgian Electrical Engineering Practice," by A. Anstruther-Thomson and G. C. Allingham.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Electric Shadows and Luminescence," by Prof. Silvanus P. Thompson, F.R.S.

**SATURDAY, May 9th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

Students' visit to the London Electric Supply Corporation's Station at Stowage Wharf, Deptford.

**The Telephone Trunk Wires.**—On Thursday of last week the House of Commons resolved itself into Committee on the financial resolution upon which to found a Bill authorizing the raising of £300,000 under the Telegraphs Act, with reference to the purchase of telephone trunk lines. The resolution was agreed to. We understand that this £300,000 is to be spent over and above the million sterling authorised by the Treasury Minute of May, 1892.



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## SPECIAL NOTICE.

**Last week's number of "The Electrician" completed Volume XXXVI. With this week's number is issued (Gratis) the Index to the Volume.**

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## ARCS AND WAVE-FORMS.

The various branches of electrical engineering have a curious tendency to complicate themselves by opening out from time to time into fresh ramifications and endless new developments. This, to a large extent but not wholly, is due to lack of finality. When electric supply, for example, has become crystallised into settled methods, it is only reasonable to expect that there will be fewer systems, while, on the other hand, it is scarcely probable that it will run in a single groove, as is the case with, say, water supply. There is an intrinsic versatility in things electrical, which gives us our different systems of generation and distribution, our various methods of electric traction, our continuous, alternating and polyphase currents, and, lastly, our complex array of wave-forms of periodic currents and electromotive forces. In these last examples lie recent and unusually startling complications, the discovery of which opens out new vistas of possibilities in theory and practice. The alternate-current arc, already the cause of many a battle among both theorists and practical engineers, now shows that, in certain circumstances, it possesses the remarkable power of adapting and distorting every form of alternate current wave with which it may be supplied, until it has "licked it into shape" to its own best advantage. In other words, the alternating arc can create for itself the most economical and efficient form of current wave out of any form of wave with which it may be supplied. This seems too good to be true; but if true it should be of tremendous value to the optimistic philosopher. What an argument for his "best of all possible worlds" it would have

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proved for LEIBNITZ! Nor will optimist philosophy solely reap the benefit. A new light will be thrown on alternate-arc practice, and it is possible that this mode of electric lighting may receive fresh vitality to enable it to combat its rival of the continuous current.

It is to some researches by Mr. J. FRITH, the results of which are embodied in a Paper on "The Effect of Wave Form on the Alternate-Current Arc," which he read last Friday before the Physical Society, that we are indebted for this new insight into the behaviour of the alternating arc. Incidentally we may observe that the researches deal much more with the effect of the arc on wave-form than with the contrary. To grasp the full significance of Mr. FRITH's deductions we must look back at some researches of previous investigators. Scarcely had subsided the tumult of voices which, in 1894, arose in America at the suggestion that a sine-wave alternator was not the highest *desideratum* in that class of machinery, when an important Paper was read by Herren RÖSSLER and WEDDING before the Verband Deutscher Elektrotechniker on "The Potential and Current Curves of Different Types of Alternators, and their Influence on the Candle-Power of Alternate-Current Arcs." A translation of this Paper appeared in *The Electrician*, Vol. XXXIII., pp. 523 and 539. These investigators took three different makes of alternators, giving a flat-topped, a simple periodic and a peaky wave respectively; and, so far as their researches relate to arcs, they found that the highest luminous efficiency was reached with the flat-topped wave, and the lowest with the peaky wave; while, on the other hand, the arc was much more noisy in the former than in the latter case. Only one conclusion seemed at the time to be possible—viz., that for running arc lamps the best types of alternator were those which gave flat-topped waves, and it was generally assumed that dynamo builders would take this lesson to heart and design their alternating "arc-lighters" accordingly.

The conditions of a laboratory experiment often differ so widely from those in commercial practice, that it is impossible to apply practically the conclusions to which the experiment leads. This, it would appear from Mr. FRITH's work, is the case so far as RÖSSLER and WEDDING's researches relate to public arc lighting. For in those researches a large part of the output of the alternators was absorbed by a choking coil in series with the lamp, while in practice this is not the case. We are not ignoring the fact that it is common practice to put choking coils in series with arc lamps run off ordinary supply mains. But our remarks refer more particularly to circuits specially intended for arc lighting. It is only when the arc or arcs constitute substantially the whole load on the alternators that the current wave is distorted into its most serviceable form for lighting. If there is inductive or non-inductive resistance in series with the arcs they are partially or completely crippled in their effort to distort the wave. Thus it happens that when an alternator is employed to run a load consisting wholly of arc lamps, it does not matter what form of electromotive force wave the alternator might develop on open circuit or on a load of incandescent lamps. All types of alternators appear for such a purpose to have equal efficiencies, as regards wave form. Thus, too, it must follow that in all those researches which have recently been made on alternating arcs where the arcs have been run in series with several ohms resistance, the conclusions which have been drawn as to efficiency are not the happiest nor best that might have been. As Mr. FRITH says, in reference to one particular example, a type of wave which is not the most efficient is *forced* upon the arc.

There is still, however, a considerable element of uncertainty as to the general applicability of Mr. FRITH's deductions. The alternator with which he experimented was of an iron-core type, and it is just possible that the presence of iron in the armature core gave to the alternator and arc that power of interaction which made possible the curious distortion of the current and P.D. waves. It is conceivable that in an air-core or non-iron core alternator this reaction would be impossible, or would become reduced to an insignificant magnitude. But, should it turn out that, under the same conditions of load as in Mr. Frith's case, both iron-cored and non-iron cored alternators are appreciably affected by the arcs, we may expect that some modifications of arc lighting practice will result. For example, since arcs run from transformers on a general system of distribution would be unable to twist the wave to their best advantage, while arcs in series on a separate machine would be able to do so, preference for the latter practice would be strengthened, and all the more since the flat-topped P.D. wave is the very worst with which to feed transformers. It remains, in fact, to be seen what influence this new development will exert on arc light practice, but, whether it be great or little, the interest in the development itself is more than usually deep.

## REVIEWS.

**Handy Guide to Patent Law and Practice.** By GEORGE FREDERICK EMERY, LL.M., Barrister-at-Law, &c., &c. (London: Effingham Wilson. 1896.)

The learned author of this little volume has compressed within the limits of some 300 pages all the law and procedure relating to patents, even to a table of cases, a list of fees payable, copies of the regulation Patent Office forms, and an index, commendable alike from the point of view of typography and arrangement.

In a brief introductory chapter Mr. Emery gives the simple philosophy of our now sadly-complicated patent law. He shows how from an early period the Crown has possessed the power of granting to the inventor or introducer of a new industry the sole right of carrying on that industry for a limited time; how under "good" Queen Bess that privilege was shamefully abused to the profit of Court favourites, and how, as a natural consequence, the power of the Crown was regulated and curtailed at the first opportunity, the foundation of patent law proper being 21 Jac. I., c. 3., more commonly known as the "Statute of Monopolies." The origin of our present system is further revealed by the fact that even in this year of grace the grant of a patent is nominally an act of grace on the part of the Crown.

Unlike the writers of many manuals of patent law, Mr. Emery does not hold out, directly or by implication, visions of "wealth beyond the dreams of avarice"; on the contrary, he is laudably anxious to damp the ardour of the enthusiast possessed with an evil genius for aimless inventing. "The profit arising from an invention is not proportionate to the difficulty of making it," "it is often far easier to make an invention than to make it a commercial success," are samples of the deterrents scattered up and down this little work.

In the succeeding chapters the author deals with the subject-matter of letters patent, the procedure to be observed in obtaining a patent, the draughting of specifications, the grounds of opposition to a grant, the rights of patentees and licensees, the amendment of specifications, infringement actions, threats, extension of letters patent, &c. The subject is treated with such lucidity and method throughout that it is not too much to say that a careful perusal of Mr. Emery's book cannot fail to give a reader of average intelligence and education a good working grasp of the intricacies of English patent law and practice. What these intricacies are cannot be better illustrated than by the law relating to licensees *vis-à-vis* of licensors. A licensee, we are told, "is estopped from disputing

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the validity of the patent, and, while he is paying royalties, is not at liberty to deny the title of his licensors." But he may allow his royalty payments to get in arrear, or he may repudiate his agreement, and in either event can by hook or by crook succeed in doing that from which he was originally debarred. All these turns and twists, so dear and so profitable to the legal profession are, it may be, inevitable offsets to the blessings of any system of law. The following sentence, however, which concludes the chapter on costs, tends to show that the disadvantages of law are to-day, as in the days of Justinian, in considerable danger of more than counterbalancing the advantages. "The result is that both parties often feel that it will be less onerous for them to put up with injustice than to enforce what they believe to be their just rights; the patentee allows infringement to pass unchecked, or accepts a lower royalty than he feels that he is entitled to, and the manufacturer pays royalties under what he believes to be an invalid patent, because each fears the unknown volume of extra costs which he will have to pay, even if he is completely successful in asserting his rights."

Mr. Emery has succeeded in admirably explaining this deplorable state of things; perhaps he would add to our indebtedness by suggesting a radical practical remedy.

## PUBLIC LIGHTING BY ARC LAMPS.*

BY ANDRÉ BLONDEL.

*(Continued from page 856, Vol. XXXVI.)*

### Experimental Comparison Between Different Types of Globes used in Public Lighting.

It is interesting to compare the various apparatus just described, from the point of view of the utilisation of the light of a continuous-current arc. Having regard to the restricted action of most reflectors in use, and the fact that polygonal lanterns are little used, I shall confine this comparison to that of divers types of globes. For this comparison, I have myself carried out, and also had carried out for me at the Central Electrical Laboratory, 12, Rue de Staël, [45] many series of photometric measurement, to determine the curves of distribution of the luminous intensities produced in the various directions by the arc; first, without globe, then with its globe. The arrangement invented to carry out these tests is described in another article. [46] It has the advantage of simplicity, and also avoids the errors of observation usually present in the comparison of lights of different colours. The curve of intensities has been drawn for each lamp, taking one of its intensities as a provisional unit. Then, to compare the various curves with each other, the maximum intensities of each have been compared; and, lastly the results have been reduced to a known standard by replacing the lamp under test by a carcel lamp. In this way the curves of distribution have been obtained for the naked arc, then for the arc placed in four different types of globe: roughened glass, opaline, opal, and holophane. The results thus obtained for a lamp taking 11 amperes are reproduced together in Fig. 50, I., to which has also been added the curve, recently published by M. Marechal, [47] for a 10-ampere arc in an opaline globe, but brought to the same scale as the results for lamps of 11 amperes by increasing it in the ratio 11/10. These curves give all the information necessary for the preparation of a scheme of lighting, according to the principles enunciated in the first portion of these articles. In addition, they show at a glance the widely different effects produced by different globes. To judge by the general aspect, we see that the clearest globes give the best distribution, and that the holophane globe has a form of curve which is both new and more advantageous than the others, seeing that with it the maximum is in a more oblique direction—65deg. instead of 45deg. This curve closely approximates to the type of which the advantages have previously been shown, [48] and its only fault is that it allows too much light to be sent upwards. This doubtless arises partly from the faults in the manufacture of the upper mirror, but more especially from the effect of the top opening through which the carbon-holders pass.

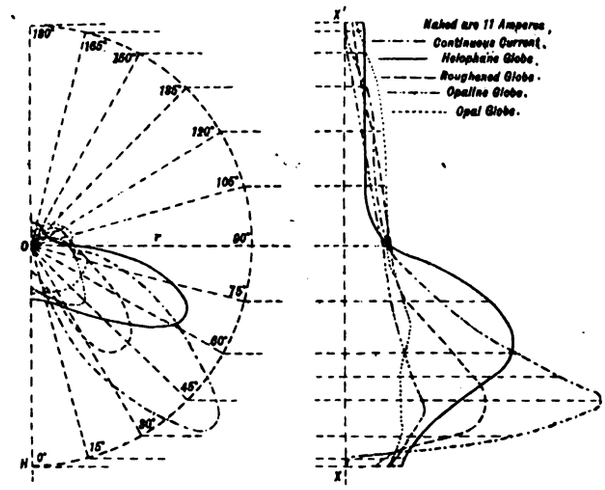


Fig. 50.—Comparison between the Photometric Curves and Curves of Flux of a Continuous-current Arc Lamp taking 11 Amperes under Different Globes. I. Photometric Curves. II. Corresponding Curves of Flux.

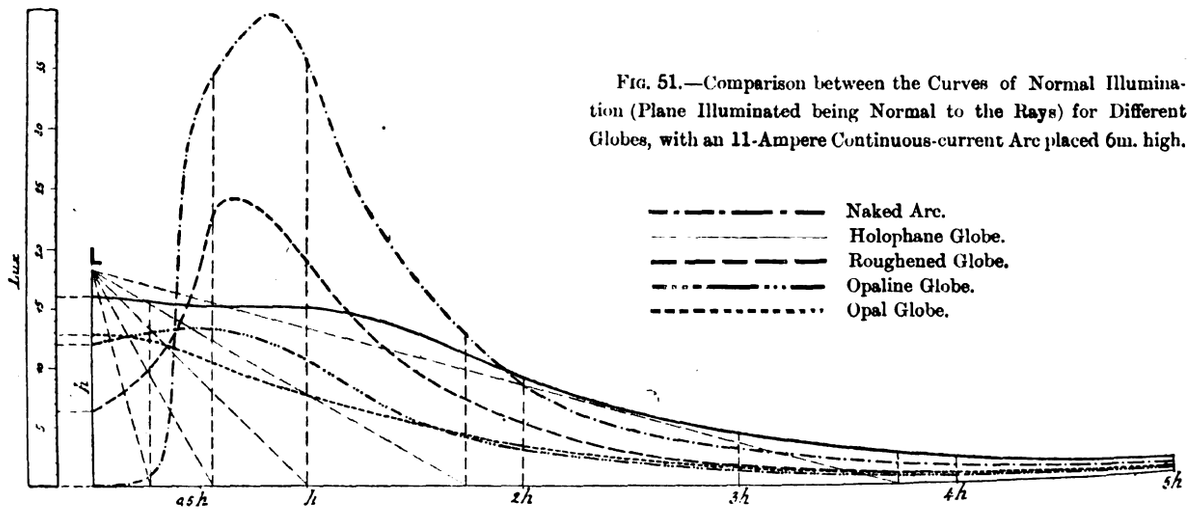


Fig. 51.—Comparison between the Curves of Normal Illumination (Plane Illuminated being Normal to the Rays) for Different Globes, with an 11-Ampere Continuous-current Arc placed 6m. high.

To make the comparison more precise, we will calculate the luminous flux and the illumination from the curves.

*Luminous Flux Utilised.*—The luminous flux is calculated by constructing the curve of flux from the curve of distribution, as explained in my "Theory of Public Lighting" (Fig. 50, II.). The abscissæ being calculated in *pyrs*, the area of the curve of flux multiplied by $\frac{2\pi}{r}$ gives the total luminous flux in *lumens* The figures in Table I. are arrived at in this manner. These results, which are closely in agreement with those of the other observers already quoted, clearly show the superiority of dioptric diffusion

* From *La Revue Technique*. Translated by Mr. John Hesketh.

[45] Thanks to the kindness of M. der Nerville, Directeur du Laboratoire, who, with the assistance of M. F. Guilbert, then chief of works, made the photometric readings relating to the holophane globe and the naked arc.

[46] "Determination de l'Intensité moyenne Sphérique des Sources de Lumière." By A. Blondel. *Eclairage Electrique*, May, &c., 1895.

[47] "L'Eclairage à Paris." By H. Marechal. Published by Baudry. 1895.

[48] "Theory of Public Lighting," Fig. 16.

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over ordinary diffusion from the point of view of absorption. We shall see that this is also the case from the point of view of distribution of the illumination.

rise to a superabundant horizontal illumination. For we may consider as useless any illumination above 10 lux. From a distance equal to the height, the illuminations decrease very unequally for

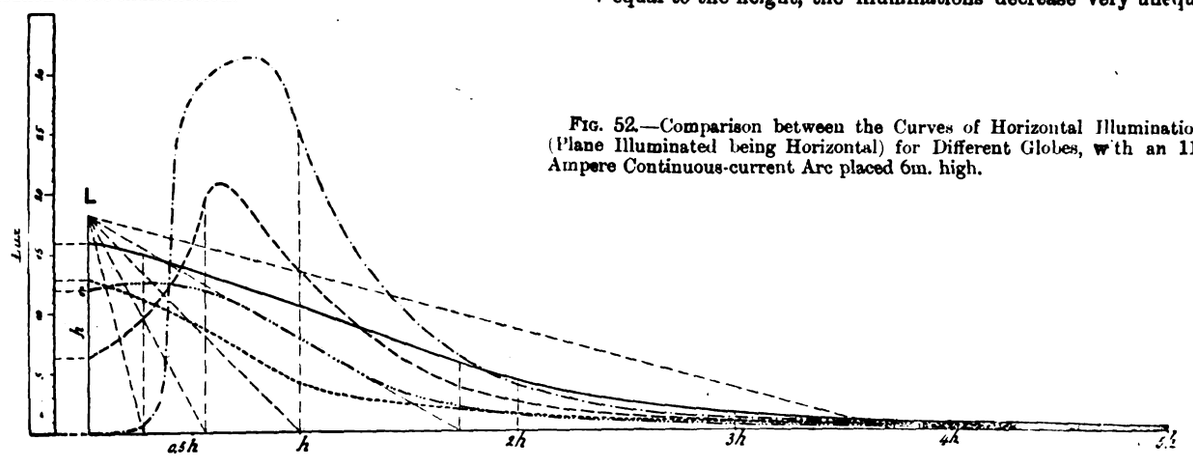


FIG. 52.—Comparison between the Curves of Horizontal Illumination (Plane Illuminated being Horizontal) for Different Globes, with an 11-Ampere Continuous-current Arc placed 6m. high.

*Curves of Illumination.*—The curves of illumination deduced from the polar curves are shown in Figs. 51, 52 and 53. In these the abscissæ are graduated in terms of the height, and a scale of illumination in lux has been drawn, corresponding to the case where

the various globes, and here the holophane globe shows a marked superiority, which increases with the distance, over the others. For instance, at the distance $3h$, the horizontal illumination, with a holophane globe, is 1·36 lux, while with the opaline and the naked

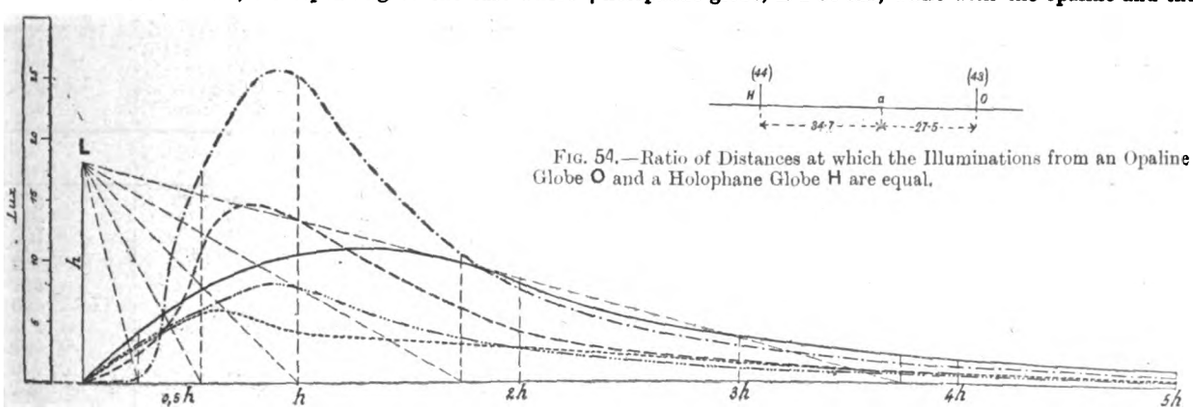


FIG. 53.—Comparison between the Curves of Vertical Illumination (Plane Illuminated being Vertical) for Different Globes, with an 11-Ampere Continuous-current Arc placed 6m. high.




FIG. 54.—Ratio of Distances at which the Illuminations from an Opaline Globe O and a Holophane Globe H are equal.

$h$=6m. In other heights, it is only necessary to alter the scales as indicated in the "General Theory of Lighting" (see *The Electrician*, November 8, 1895, p. 40). These curves all apply to 11-ampere

arc the illuminations are 0·42 and 0·98 lux respectively. This superiority has been confirmed in the experimental trials by the Edison Company with holophane globes placed between La Rue

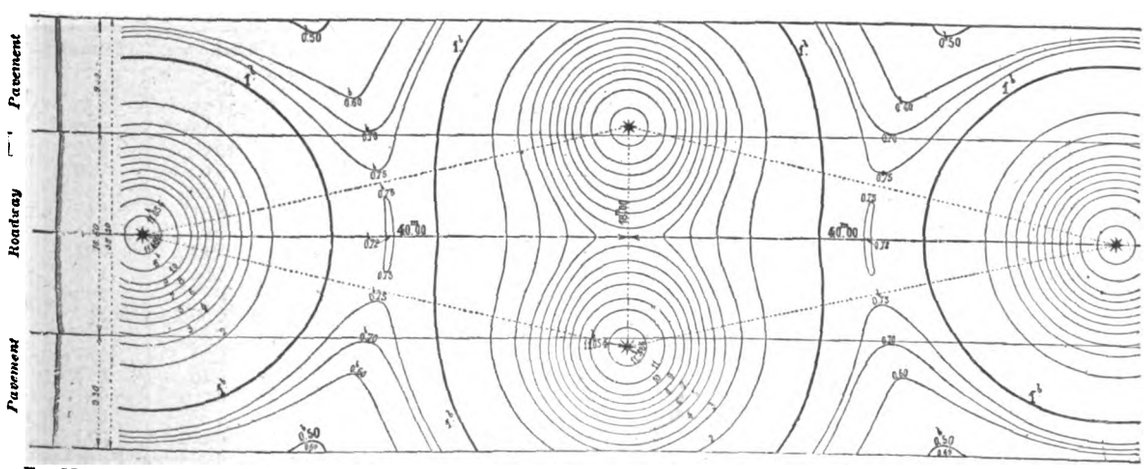


FIG. 55.—Plan of Illumination of the Grand Boulevards, Paris, with 10-Ampere-continuous Current Arcs, and Opaline Globes. Height of Arc, 5·95m. Figure taken from "L'Eclairage à Paris," by M. H. Maréchal.

lamps, placed successively in the different globes. Tables II. to VI. summarise the numerical data used in deducing these curves from the polar curves and the observed values. A separate figure has been given to each of the three illuminations, namely, that on the normal plane, that on the vertical plane, and that on the horizontal plane, which, as I have previously explained, give all the elements necessary for a scheme for lighting.

Examining these curves, we see that at short distances all classes of globes, including, despite its promises, even the holophane, give

d'Hauteville and La Porte St. Denis on the Boulevards Bonne Nouvelle and St. Denis.[49] By placing a shadow photometer between two

[49] At this moment there are 12 holophane globes in use on the Boulevards (between La Rue Hauteville and La Porte St. Denis) and on La Place de Roubaix. The Secteurs de la Transmission de la Force and the Edison Company have, in adopting these globes, given proof of a progressive spirit which is very rare in France, and does credit to the Directors. M. Weill and M. Meyer took the initiative in the matter, with the permission of M. Monmerque, the municipal engineer.

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**Table I.**—*Table of Values of the Intensities and Luminous Flux for different Globes, with the same Continuous-current Arc Lamp, taking 11 amperes.*

| — | Naked arc. | Holophane globe. | Roughened glass globe. | Opaline globe. | Opal globe. |
|---|---|---|---|---|---|
| Maximum intensities in pyrs | 2,530 | 1,640 | 1,346 | 773 | 572 |
| Mean spherical intensities in pyrs | 787 | 692 | 550 | 383 | 434 |
| Mean lower hemispherical intensity (below the horizontal) in pyrs | 1,350 | 1,188 | 854 | 578 | 541 |
| Total luminous flux (lumens) | 9,885 | 8,591 | 6,968 | 4,810 | 5,450 |
| Lower hemispherical flux (lumens) | 8,478 | 7,272 | 5,363 | 3,629 | 2,054 |
| Loss in total flux compared with the naked arc | ... | 13 % | 31 % | 51 % | 45 % |
| Loss in lower hemispherical flux compared with the naked arc | .. | 15 % | 37 % | 57 % | 60 % |

**Table II.**—*Continuous-current Naked Arc.*

| Angular direction from the foot of the vertical. $\alpha$. | Distance from the foot of post where $h=6$m. $h \tan \alpha$. | Luminous intensity in pyrs. $I\alpha$. 11 amperes. | Illumination on normal plane in lux where $h=6$m. $E_N = \frac{I_\alpha \cos^2 \alpha}{h^2}$ 11 amperes. | Illumination on horizontal plane in lux where $h=6$m. $E_H = \frac{I_\alpha \cos^3 \alpha}{h^2}$ 11 amperes. | Illumination on vertical plane in lux where $h=6$m. $E_V = \frac{I_\alpha \cos^2 \alpha \sin \alpha}{h^2}$ 11 amperes. |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 15° | 1·60 | 23 | 0·59 | 0·57 | 0·15 |
| 22° 30′ | 2·48 | 990 | 23·46 | 21·67 | 8·97 |
| 30° | 3·34 | 1,606 | 33·45 | 28·97 | 16·72 |
| 37° 30′ | 4·60 | 2,225 | 38·89 | 30·90 | 23 67 |
| 45° | 6·00 | 2,530 | 35·13 | 24·84 | 24·84 |
| 52° 30′ | 7·82 | 2,156 | 22·19 | 13·50 | 17·60 |
| 60° | 10·39 | 1,705 | 12·39 | 5·97 | 10·25 |
| 63° 30′ | 12·00 | 1,485 | 8·20 | 3·65 | 7·34 |
| 71° 34′ | 18·00 | 1,122 | 3·11 | 0·98 | 2·95 |
| 75° 58′ | 24·00 | 902 | 1·46 | 0·35 | 1·42 |
| 78° 42′ | 30·00 | 770 | 0·82 | 0·16 | 0·80 |
| 81° 28′ | 40·00 | 572 | 0·35 | 0·05 | 0·34 |
| 90° | ∞ | 363 | 0 | 0 | 0 |

**Table III.**—*Roughened Glass Globe.*

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 224 | 6·22 | 6·22 | 0 |
| 15° | 1·60 | 369 | 9·60 | 9·27 | 2·48 |
| 30° | 3·34 | 1,078 | 22·45 | 19·44 | 11·22 |
| 45° | 6·00 | 1,346 | 18·69 | 13·20 | 13·20 |
| 60° | 10·39 | 1,034 | 7·32 | 3·59 | 6·21 |
| 63° 30′ | 12·00 | 924 | 5·10 | 2·27 | 4·00 |
| 71° 34′ | 18·00 | 660 | 1·83 | 0·52 | 1·73 |
| 75° 58 | 24·00 | 570 | 0·92 | 0 27 | 0·89 |
| 78° 42′ | 30·00 | 540 | 0·57 | 0·11 | 0·56 |
| 81° 28′ | 40·00 | 506 | 0·31 | 0·04 | 0·31 |
| 90° | ∞ | 418 | 0 | 0 | 0 |

**Table IV.**—*Opaline Globe.*

| Angular direction from the foot of the vertical. | Distance from the foot of post where $h=6$m. | Luminous intensity in pyrs. $I_\alpha$. | | Illumination on normal plane in lux where $h=6$m. $E_N = \frac{I_\alpha \cos^2 \alpha}{h^2}$ | | Illumination on horizontal plane in lux where $h=6$m. $E_H = \frac{I_\alpha \cos^3 \alpha}{h^2}$ | | Illumination on vertical plane in lux where $h=6$m. $E_V = \frac{I_\alpha \cos^2 \alpha \sin \alpha}{h^2}$ | |
|---|---|---|---|---|---|---|---|---|---|
| $\alpha$ | $h \tan \alpha$. | 11 amperes. | 10 amperes. | 11 amperes. | 10 amperes. | 11 amperes. | 10 amperes. | 11 amperes. | 10 amperes. |
| 0 | 0 | 431 | 392 | 11·96 | 10·88 | 11·96 | 10·88 | 0 | 0 |
| 15° | 1·60 | 497 | 452 | 12·89 | 11·72 | 12·45 | 11·32 | 3·33 | 3·03 |
| 22° 30′ | 2·48 | 560 | 509 | 13·26 | 12·06 | 12·26 | 11·15 | 5·07 | 4·61 |
| 30° | 3·34 | 638 | 580 | 13·28 | 12·08 | 11·50 | 10·46 | 6·02 | 5·48 |
| 37° 30′ | 4·60 | 715 | 649 | 12·49 | 11·36 | 9 90 | 9·00 | 7·59 | 6·90 |
| 45° | 6·00 | 773 | 703 | 10·73 | 9·76 | 7·59 | 6·90 | 7·59 | 6·90 |
| 52° 30′ | 7·82 | 696 | 633 | 7·16 | 6·51 | 4·30 | 3·91 | 5·67 | 5·16 |
| 60° | 10·39 | 601 | 547 | 4·18 | 3·80 | 2·09 | 1·90 | 3·61 | 3·29 |
| 63° 30′ | 12·00 | 560 | 500 | 3·03 | 2·76 | 1·35 | 1·23 | 2·71 | 2·47 |
| 68° 10′ | 15·00 | 528 | 480 | 2·02 | 1·84 | 0·74 | 0·68 | 1·78 | 1·62 |
| 71° 10′ | 17·60 | 495 | 450 | 1·43 | 1·30 | 0·46 | 0·42 | 1·35 | 1·23 |
| 71° 34′ | 18·00 | 490 | 445 | 1·35 | 1·23 | 0·42 | 0·39 | 1·27 | 1·16 |
| 73° 17′ | 20·00 | 484 | 440 | 1·15 | 1·05 | 0·32 | 0·29 | 1·08 | 0·99 |
| 75° | 22·39 | 477 | 434 | 0·88 | 0·80 | 0·23 | 0·21 | 0·84 | 0·77 |
| 75° 58′ | 24 00 | 473 | 430 | 0·76 | 0·69 | 0·17 | 0 16 | 0·73 | 6·67 |
| 78° 42′ | 30·00 | 462 | 420 | 0·48 | 0·44 | 0·094 | 0·086 | 0·47 | 0·43 |
| 81° 23′ | 40·00 | 440 | 400 | 0·26 | 0·24 | 0 039 | 0·036 | 0·26 | 0·24 |
| 84° 18′ | 60·00 | 418 | 380 | 0·11 | 0 10 | 0·011 | 0·010 | 0·11 | 0·10 |
| 85° 42′ | 80·00 | 410 | 373 | 0·063 | 0·059 | 0·008 | 0·008 | 0·063 | 0·058 |
| 90° | ∞ | 376 | 342 | 0 | 0 | 0 | 0 | 0 | 0 |

lamp posts, one of which was fitted with an ordinary opaline globe, and the other with a holophane globe, a very marked increase in the illumination in favour of the latter was observed, amounting to as much as 60 per cent. in the most favourable instance (Fig. 54). A similar result was obtained at Nantes (Place du Theatre) by the Societé Nantaise d'Eclairage, &c.

To properly appreciate the effect realised by the use of the holophane globe, the most precise method is to study comparatively the distribution of light on a given street with the same lamps, but with the two different types of globe: ordinary opaline and holophane. We will take as a basis for this comparison one of the plans prepared by M. Marechal (Fig. 55) corresponding to the lighting of part of the Boulevards with 10-ampere arcs and opaline globes of the ordinary type. Let us suppose the space lighted by the same arcs, but let them be fitted with holophane globes; and let us, under these new conditions, plot out isolux curves from the

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**Table V.**—*Opal Globe.*

| Angular direction from the foot of the vertical. $\alpha$. | Distance from the foot of post where $h=6$m. $h \tan \alpha$. | Luminous intensity in pyrs $I_\alpha$. 11 amperes. | Illumination on normal plane in lux where $h=6$m. $E_N = \frac{I_\alpha \cos^2 \alpha}{h^2}$ 11 amperes. | Illumination on horizontal plane in lux where $h=6$m. $E_H = \frac{I_\alpha \cos^3 \alpha}{h^2}$ 11 amperes. | Illumination on vertical plane in lux where $h=6$m. $E_V = \frac{I_\alpha \cos^2 \alpha \sin \alpha}{h^2}$ 11 amperes. |
|---|---|---|---|---|---|
| 0 | 0 | 462 | 12·83 | 12 83 | 0 |
| 15° | 1·60 | 462 | 12·23 | 11·57 | 3·21 |
| 30° | 3·34 | 528 | 11·05 | 9·52 | 5·50 |
| 45° | 6·00 | 550 | 7·63 | 4·00 | 4·00 |
| 60° | 10·39 | 572 | 4·80 | 1 98 | 3·44 |
| 63° 30′ | 12·00 | 572 | 3·16 | 1·40 | 2·83 |
| 71° 34′ | 18·00 | 572 | 1 61 | 0·50 | 1·50 |
| 75° 58′ | 24·00 | 561 | 0·91 | 0·22 | 0·88 |
| 78 42′ | 30·00 | 540 | 0·57 | 0·11 | 0·56 |
| 81° 28′ | 40·00 | 484 | 0·29 | 0·04 | 0·29 |
| 90° | ∞ | 396 | 0 | 0 | 0 |

**Table VI.**—*Holophone Globe.*

| Angular direction from the foot of the vertical. | Distance from the foot of post where $h=6$m. | Luminous intensity in pyrs. $I_\alpha$. | | Illumination on normal plane in lux where $h=6$m. $E_N = \frac{I_\alpha \cos^2 \alpha}{h^2}$ | | Illumination on horizontal plane in lux where $h=6$m. $E_H = \frac{I_\alpha \cos^3 \alpha}{h^2}$ | | Illumination on vertical plane in lux where $h=6$m. $E_V = \frac{I_\alpha \cos^2 \alpha \sin \alpha}{h^2}$ | |
|---|---|---|---|---|---|---|---|---|---|
| $\alpha$ | $h \tan \alpha$. | 11 amperes. | 10 amperes. | 11 amperes. | 10 amperes. | 11 amperes. | 10 amperes. | 11 amperes. | 10 amperes. |
| 0° | 0 | 572 | 520 | 15·88 | 14·45 | 15·88 | 14·45 | 0 | 0 |
| 15° | 1·60 | 594 | 540 | 15·41 | 14·00 | 14·96 | 13·60 | 3·98 | 3·62 |
| 22° 30′ | 2·48 | 638 | 580 | 15·12 | 13·75 | 13·97 | 12·70 | 5·78 | 5·26 |
| 30° | 3·34 | 726 | 660 | 14·96 | 13·60 | 13·09 | 11·90 | 7·55 | 6·87 |
| 37° 30′ | 4·60 | 858 | 780 | 14·96 | 13·60 | 11·91 | 10·83 | 9·13 | 8·30 |
| 45° | 6·00 | 1,070 | 970 | 14·81 | 13·47 | 10·45 | 9·50 | 10·45 | 9·50 |
| 52° 30′ | 7 82 | 1,364 | 1,240 | 14·03 | 12·76 | 8·22 | 7·48 | 11·13 | 10·12 |
| 60° | 10·39 | 1,606 | 1,460 | 11·14 | 10·13 | 5·57 | 5·07 | 9·59 | 8·72 |
| 63° 30′ | 12·00 | 1,640 | 1,490 | 9·00 | 8·19 | 4·02 | 3·66 | 8·01 | 7·29 |
| 68° 10′ | 15·00 | 1,628 | 1,480 | 6·24 | 5·68 | 2·31 | 2·10 | 5·06 | 4·60 |
| 71° 10′ | 17·00 | 1,572 | 1,430 | 4·55 | 4·14 | 1·46 | 1·33 | 4·20 | 3·91 |
| 71° 34′ | 18·00 | 1,562 | 1,420 | 4·32 | 3·93 | 1·36 | 1·24 | 4·10 | 3·73 |
| 73° 17′ | 20·00 | 1,497 | 1,360 | 3·44 | 3·13 | 0·92 | 0·84 | 3·28 | 2·99 |
| 75° | 22·39 | 1,452 | 1,320 | 2·69 | 2·45 | 0·69 | 0·63 | 5·59 | 2·36 |
| 75° 58′ | 24 00 | 1,408 | 1,280 | 2 28 | 2·08 | 0·55 | 0·50 | 2·21 | 2·01 |
| 78° 42′ | 30·00 | 1,265 | 1,150 | 1·35 | 1·23 | 0·26 | 0·24 | 1·32 | 1·20 |
| 81° 28′ | 40 00 | 1,100 | 1,000 | 0·67 | 0·61 | 0·10 | 0 09 | 0·66 | 0·60 |
| 84° 18′ | 60·00 | 913 | 830 | 0·25 | 0·23 | 0·024 | 0·022 | 0·25 | 0·23 |
| 85° 42′ | 80·00 | 815 | 740 | 0·12 | 0·11 | 0·009 | 0 008 | 0·12 | 0·11 |
| 90° | ∞ | 440 | 400 | 0·08 | 0 | 0 | 0 | 0 | 0 |

curve of illumination of the holophane globe which is supposed to be fixed 6 metres high.[50] For this purpose it is sufficient to use the comparative curves of illumination on a horizontal plane (Figs. 57 and 58) determined for 10-ampere arcs 6 metres high with opaline and holophane globes. Fig. 56, thus obtained, gives us at a glance the effective result. The minimum illumination is raised from 0·5 to 1·25 lux, and the mean illumination from 3 35 to 5·36 lux. I have also prepared plans of comparative illuminations for the more usual case; that in which holophane globe is used on the Boulevards.[51] The curves thus obtained are reproduced in Figs. 59 and 60. The minimum illumination is raised from 0·33 lux to 0 88, and the mean illumination from 1·98 to 3 90 lux. The increase thus deduced from photometric curves is therefore seen to be very considerable.[52]

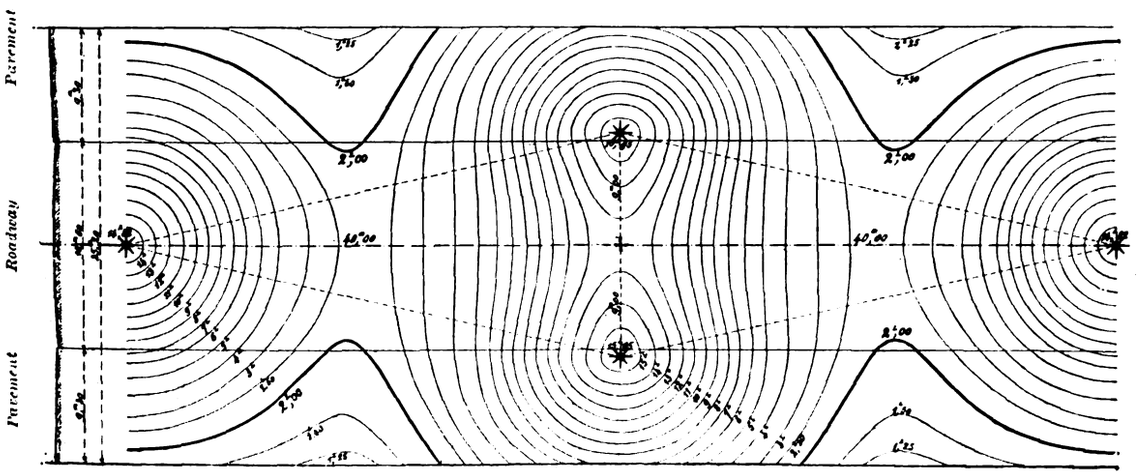


FIG. 56.—Plan of Illumination of the Grand Boulevards, Paris, with 10-Ampere Continuous-current Arcs and Holophane Globes 34cm. diameter and 6m. high.

I believe that it would be easy with dioptric globes to obtain a curve of distribution more nearly approaching uniformity; but, as

[50] The ordinates of the curve for the holophane globe have been reduced in the ratio 10/11 to bring the intensity of the lamp to the value (10 amperes) of that adopted by M. Marechal.

[51] These plans and curves of illumination have been designed by M. G. Rameau, civil engineer, who materially assisted me in the preparation of this work, and for whose excellent co-operation I wish to express my thanks.

[52] It is more difficult to appreciate the increase exactly by the eye, and on the ground; measurements should be taken with some instrument of



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it was before stated, the time has not yet come for uniform illumination to be realised. We must wait until we have at our disposal a sufficient luminous flux to give a mean of 8 or 10 lux before attempting it. In short, we may conclude that the holophane globe actually approaches very closely to the conditions laid down in my "Theory of Public Lighting," and undoubtedly gives a better result than opal or opaline globes where constant-current arcs are used.[53] Two practical objections may, however, be made: First, the price is necessarily higher than that of opaline globes, in the manufacture of which there is no need of moulding or complex handiwork; and secondly, the division of the globe into two parts is objected to. The first is only serious at first sight. For if we calculate the annual expenses we see that the saving of 1 or 2 amperes, which

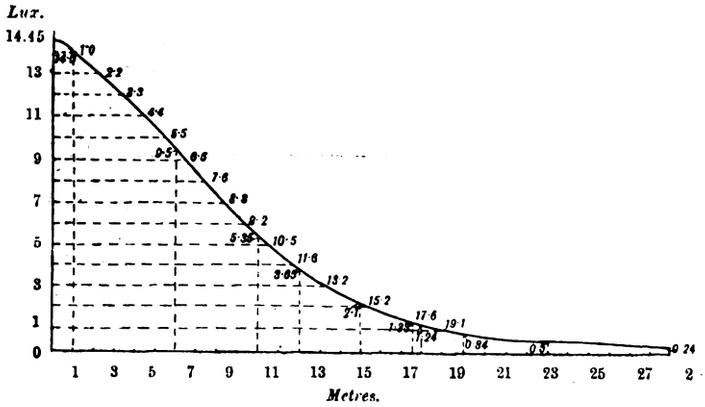


FIG. 57.—Curve of Illumination on a horizontal plane from a 10-Ampere Continuous-current Arc with Holophane Globe 34cm. diameter 6m. high.

we can straightway effect, results in an economy of more than 10 per cent. of the energy consumed, and the cost of the energy consumed constitutes the greatest item of the total cost. For instance, in Paris the cost being about 800f. per lamp per annum, the economy on this head alone would be 80f. in the first year; that is to say, more than would cover the cost and fixing of *many globes*. As to the division into two parts, experience on the Boulevards shows that there is no practical inconvenience with such a method of fixing as is in use in Paris (Fig. 25). It would nevertheless be

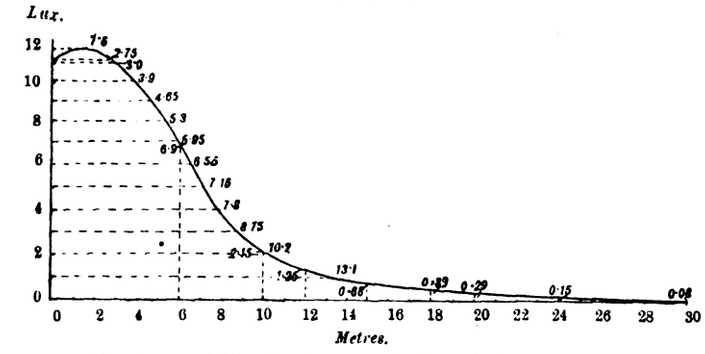


FIG. 58.—Curve of Illumination on a horizontal plane from a 10-Ampere Continuous-current Arc with Opaline Globe 34cm. diameter 6m. high.

preferable in many cases, in order to avoid the cost of cutting the globes, to use another type of support without hinges—allowing either the whole globe (as in Figs. 26 and 28)[54] or the lower half to slide up or down.[55]

*(To be continued).*

sufficient accuracy, and which may be placed on the roadway without interfering with traffic. Such an instrument has not yet been arrived at in France, and indeed those generally in use for measuring illumination more often indicate quite another thing. Mr. A. P. Trotter has invented a very ingenious photometer with which he has from actual observations made several complete plans of illumination, a result not previously attained by anyone. These plans have a very great value. I have, with the assistance of M. Broca, recently constructed a new universal photometer with the special object of enabling measurements of this nature to be made with accuracy.

[53] In this article I have only mentioned the holophane globe as applied to public lighting. These conclusions can also be applied to the other types of holophane covering.

[54] A similar arrangement has been adopted in the Grand Hall of the Cairo railway station, where the quays are illuminated in a very satisfactory manner by 18 Fabius-Henrion lamps, taking 24 amperes, and fitted with holophane globes.

[55] M. Oudry, Director of the Maison Durenne, appears to have satisfactorily carried out this arrangement.

## NOTES ON SOME AMERICAN ALTERNATING-CURRENT MACHINERY.*

### GENERATORS AND SYNCHRONOUS MOTORS.

Since all alternating-current generators can be used as synchronous motors, the two different classes of machines will be considered at the same time.

*General Electric Simple Alternators.*—These generators being designed for 125 cycles, are unsuitable for long-distance power distribution; since, however, transformers designed for higher frequencies are cheaper than those for lower frequencies, these generators have a wide field of utilisation for lighting and for limited power transmissions. Being simple alternators they are not self-starting when used as synchronous motors, but run very satisfactorily after being driven up to speed with external power.

The method of winding these generators is as shown in Fig. 1, each slot having two coils connected so as to give opposite polarity.

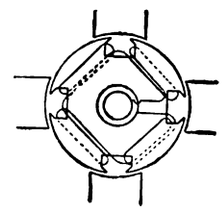

FIG. 1.

*Three-Phase Machines.*—Generators of this class are made in several types. That known as "A.T." comprises machines of uni-tooth construction, or having one slot per pole and phase, and having a moderately high armature reaction, and consequently great safety in case of short circuits. These machines are designed for any periodicity, but since the General Electric Company has adopted 60 cycles per second as its standard, by far the greater part of them are designed for this frequency. They are built in capacities from 50 kilowatts up to 1,200 kilowatts. This type, which is at present in considerable use throughout the country, is particularly applicable in places where power is distributed at moderately long distances, say 5 to 10 miles; owing, however, to the wave shape of these generators, which is of the saw-tooth type, they are not well suited for very long-distance transmissions. Up to 300 kilowatts they are usually built with a rectifying commutator for automatically compounding. The compounding is about 12 per cent. at full non-inductive load.

The accompanying diagram, Fig. 2, shows the method of connecting these machines. The armature has a Y-winding; that is, the three single-phase windings, which are displaced 120deg., or one

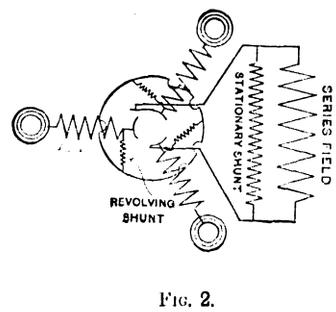


FIG. 2.

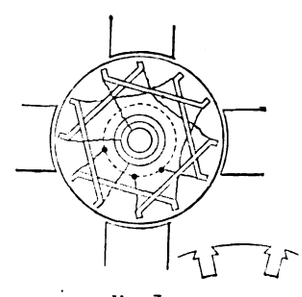

FIG. 3.

third of the distance between two poles, are connected to one common junction, which in this case is the commutator, and the other three sides are brought to the collector rings. The common connection is shunted by an external stationary and internal revolving shunt as indicated in the diagram. The object of these shunts is to give a means of regulating the amount of compounding necessary, part of the main current, 70 to 75 per cent., going through the series-coil and the remainder through the two shunts. The stationary shunt is made adjustable in order that the compounding may be varied with the different nature of the load. For instance, in the forenoon, when practically all the load consists of motors, a higher compounding is necessary than in the evening, when the lighting load is predominant. Another object which the shunts accomplish is to eliminate sparking at the commutator.

Fig. 3 shows the shape of the armature punchings and the method of winding. As will be seen, the winding is exceedingly simple, consisting of merely three single-phase windings displaced 120deg.

* Abstract from the *Electrical World* of New York. We are indebted to our New York contemporary for the blocks illustrating this article, which gives a useful insight into American methods.

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The coils are made in two different shapes, and are machine-wound, so as to make it easy to replace one coil in case it is damaged by any cause. The slots are open, which decreases the self-inductance and, consequently, the amount of compounding for the same armature reaction. To prevent eddy currents in the pole-pieces

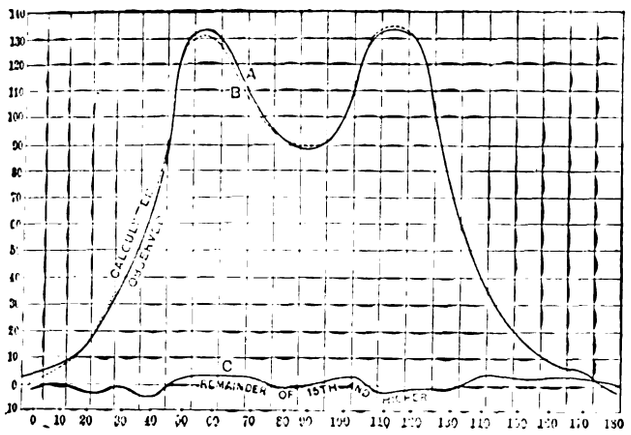



FIG. 4.

these are made of sheet iron. The yoke is made of cast iron to enable it to respond quickly to the magnetisation of the series-field.

Fig. 4 give the Y-E.M.F. of a standard "A. T." machine at no load, and Fig. 5 the Y-E.M.F. under load. In the no-load curve (Fig. 4) a distinct triple harmonic of 12 per cent. magnitude, and a very distinct fifth harmonic of 23 per cent. magnitude, are present. In

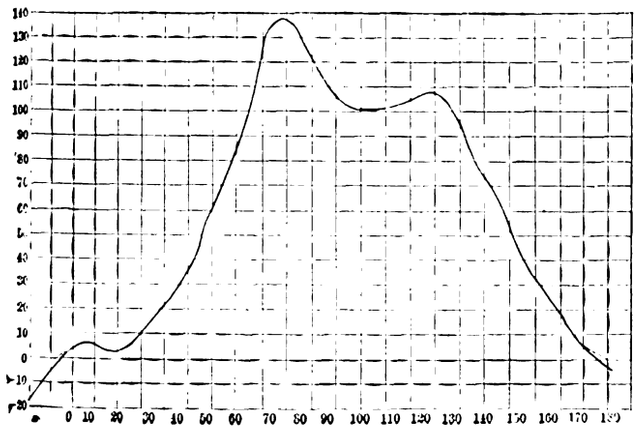


FIG. 5.

the load curve (Fig. 5) the triple harmonic is about the same as in the first case, it being 17 per cent., but the fifth harmonic is greatly decreased, being only of 8 per cent. magnitude.

The Δ-E.M.F.'s—that is, the E.M.F.'s between the main collector rings of the same machine—are shown in Figs. 6 and 7. Fig. 6 gives the shape of the no-load E.M.F., and Fig. 7 the shape of the E.M.F. under load. Both curves can easily be obtained from Figs. 3 and 4, as each is the sum of two of these waves displaced 60deg.

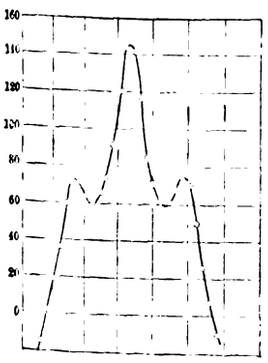


FIG. 6.

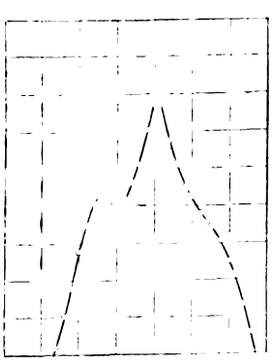
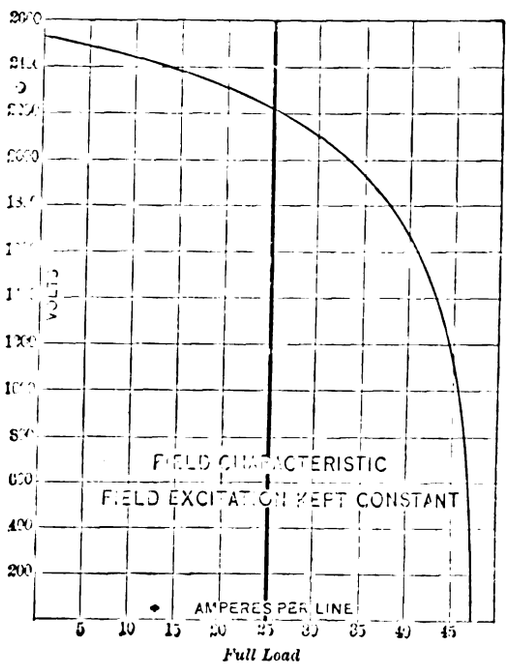


FIG. 7.

Fig. 8 gives the field characteristic of a standard "A.T." generator. As will be seen, at constant full-load excitation the drop in voltage at full load is about 12 per cent. The short-circuiting current is not quite twice the full-load current. The maximum momentary power at short circuit is only 18 per cent. more than full-load power.

A modification of these machines is the "A. F. T." type, having a non-overlapping fractional pitch winding. These machines have a very simple winding, with no crossings whatever, and consequently are of a very suitable construction for high-potential armatures.

For transmission of power to very long distances, the "A. T." machines are not so suitable, as the possibility of resonance is greater with the saw-tooth type of E.M.F. curve than with the sine type. The General Electric Company has, therefore, designed another line of machinery, known as the "A. P." which has a distributed winding, and is of the multi-tooth type of construction.




*Full Load*

FIG. 8.

These machines are mostly built for low potentials, say 500 volts, as there are a number of crossings in the winding, as may be seen from Fig. 9. They are usually built with two or three slots per pole and phase; that is, the number of slots is usually six to nine times the number of poles. The slots are open, and each has two rectangular conductors. They have a very low armature reaction so as to make it unnecessary to compound them, the total drop at full load being only a very few per cent. They are connected either Δ or Y, depending upon the voltage required, and are generally used in connection with step-up transformers.

As synchronous motors they are self-starting from rest; in starting they take a current two or three times that at full load, and start with moderate torque. Figs. 10 and 11 give the form of

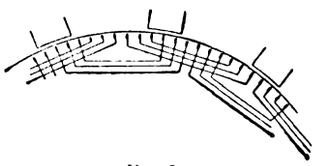


FIG. 9.

E.M.F. curves of one of these machines, which it will be seen, are practically sine waves—at least within error of observation, the greatest deviation amounting to only 2 per cent.

The field characteristic of an "A. P." machine of 75 kilowatt capacity is shown in Fig. 12. It will be observed that at full load the drop in potential at constant full-load field excitation is fully 4 per cent. The current at short circuit is about four times the full-load current. The maximum output is about twice the full-load power. This class of machines has the advantage of better regulation, and of giving the sine form of wave shape for long-distance transmissions.

*Monocyclic Machines.*—Three-phase generators are preferably used in places where the power is mostly utilised by motors. For cases where the current is mainly used for lighting, the General Electric Company has devised what it calls the monocyclic system. A greatly unbalanced load on the three branches of the three-phase or other multiphase system will cause the potentials between the different phases to vary. Monocyclic generators were brought out



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a year or two ago to solve the question of running motors from single-phase mains, thus enabling compounding to be effected for the total output of the machines. The monocyclic generator is simply a single-phase generator with a slightly different armature, the monocyclic armature having a small winding, called the "teazer" winding, connected midway between the main coils. The object of this teaser winding is to supply an out-of-phase E.M.F. for use in starting and running motors only. This auxiliary winding creates an E.M.F. displaced 90deg. from, and one fourth the magnitude of, the main E.M.F. as shown in the diagram. At no load on the generator the value of the voltages between the outside of the tesser winding and the terminals of the main winding is there-

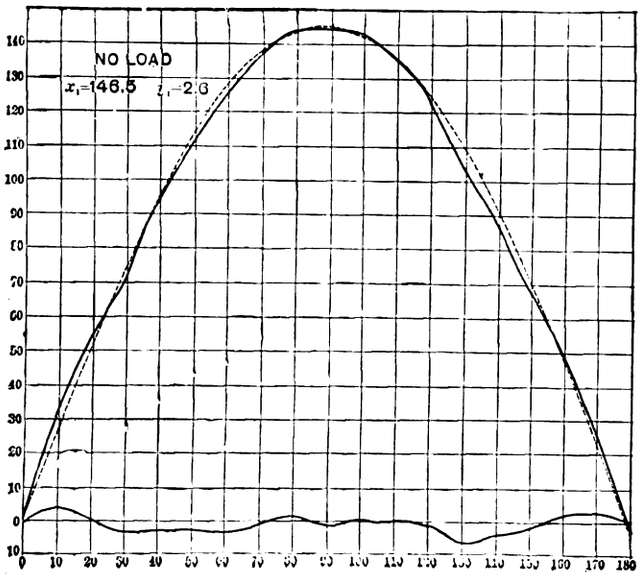


FIG. 10.

fore, say, 1,040 volts between the two main collector rings, and 580 volts between either of the two mains and the teaser (*see* Fig. 13). If the main line is loaded the induced E.M.F. is not in phase with the terminal E.M.F., but displaced a certain angle depending upon the self-inductance; consequently the triangle of E.M.F.'s, when the main line is loaded, is something like what is shown in Fig. 14, where, however, the magnitudes of the phase displacements are exaggerated. If the main voltage is, say, 1,040, the voltage between the teaser and one of the mains is 660, and of the other 480.

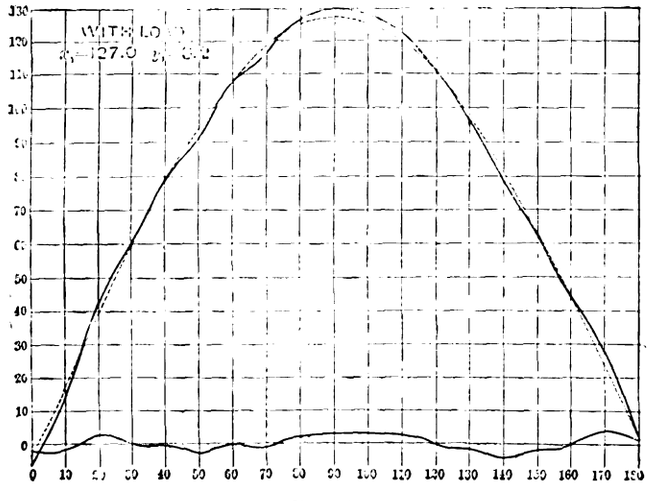

FIG. 11.

The effect of loading the teaser line, that is, of putting induction motors on the monocycle generator is to decrease the teaser potential and, on account of the self induction in the teaser circuit, to shift it; so that the triangle representing the E.M.F.'s at the terminals of the collector rings of the machines when the machine is supplying power as well as light, is something like that shown in Fig. 15. A discussion of the advantage of these changes of the phase relations will be given later when discussing induction motors operated on the monocyclic system. To run induction motors from a monocyclic generator, the E.M.F.'s generated by the machine are transformed to three other E.M.F.'s of approximately three-phase relation, it being, however, unessential to have the three-phase condition. Two-phase, or, in fact, any multiphase condition of E.M.F.'s can be got in a similar manner as the three-phase relation. To get three-phase E.M.F.'s two transformers are used. These have the primaries connected in series across the mains, and the secondaries reversed in their relation one to the other. The common terminal of the primaries is connected to the teaser line, and the three secondaries go to the motor terminals. Since the primaries of the two transformers are connected in series and the secondaries in multiple, the currents in two of the secondaries are smaller than in the third. The teaser wire of the primary practically carries only a magnetising current.

The proper sizes of the main and teaser wire may be approximately determined by the following method:—The main lines are calculated as for a regular, simple alternating-current system, taking, of course, not only the resistance but also the reactance of the line into account. Then the teaser-wire is made of such a cross-section that its ratio to the cross-section of the main wire is the same as the ratio of the total motor load to the total load of the machine.

The mains leading to each motor should be calculated as if the entire power of the motor were supplied through them only, and the teaser made of the same size. This method gives a cross-section somewhat too large, but one at least simple to calculate and safe. For the secondary wiring the total output of the induction motor should be figured as supplied by two single-phase mains with a common return; that is, one wire—that leading from the common connection of the transformers—should be made 50 per cent. larger than either of the other two, and the latter of such a cross-section as to carry jointly the total motor-power as a single-phase current.

All of the above machines—the simple alternators, the three-phase and the monocyclic machines—are usually built with revolving

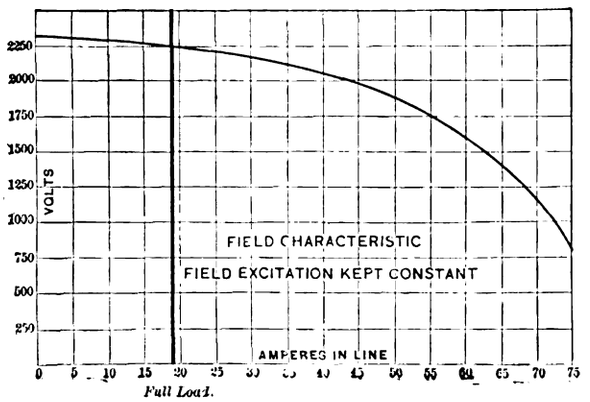


FIG. 12.

armature and stationary field. In special cases, as for very high voltages or very large currents, the machines are built with stationary armature and revolving field. In the latter case the field is inside, the armature outside.

*Calculation of Lines.*—In the continuous-current system the drop and the loss in the line may be readily obtained by simply multiplying the current and the square of the current, respectively, by the resistance. In the case of alternating-currents the matter is not so simple, since the drop is not only due to ohmic resistance, but also to the reactance. The resistance is practically the same whether the line be supplied with alternating or continuous current, but the reactance, which is zero when continuous currents are employed, has always a value in alternating-current systems. The reactance depends upon the frequency and the inductance, and is expressed by the following equation: $S = 2\pi N L$, where N is the frequency or the number of complete cycles per second, and L the coefficient of self-induction, or more properly, the inductance. This latter quantity depends upon the size of the wire and the distance between the conductors, and can be calculated for any given condition. The influence of reactance is very prominent when using heavy copper conductors in the lines. For instance, the reactance of No. 0000 B. and S. wire is 2·5 times its resistance, but with a No. 8 wire the reactance is but one-quarter of the resistance. This illustrates the advantage to be gained by the use in multiple of as many small conductors as possible instead of a single conductor. The reactance, as stated above, may be readily calculated for any given set of conditions, or may be obtained from several tables which have been published. Knowing the resistance and reactance, the drop due to each may be obtained, by simply multiplying each by the current. The impedance drop is the square root of the square of the ohmic drop plus the square of the reactive drop, or $E = \sqrt{c^2 r^2 + c^2 s^2}$, when $s$ is the reactance. The loss in the line depends

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upon the resistance, and is expressed by $C^2R$. The reactance, being in quadrature with the current, does not represent a loss in power.

To make a complete and exact calculation of the conditions of current and E.M.F.'s in a long line is a complicated problem, but in general, very good approximate results may be obtained by several methods. The following is an example of the application of one of these methods. We will calculate a line suitable for supplying a 1,000-kilowatt three-phase power transmission with a distance of 10 miles, and at a difference of potential of 10,000 volts, employing 60 cycles per second. We will assume that the power factor of the load, which may consist of induction or synchronous motors and lights, is 90 per cent., or, in other words, the energy consumed is 90 per cent. of the total watts transmitted.

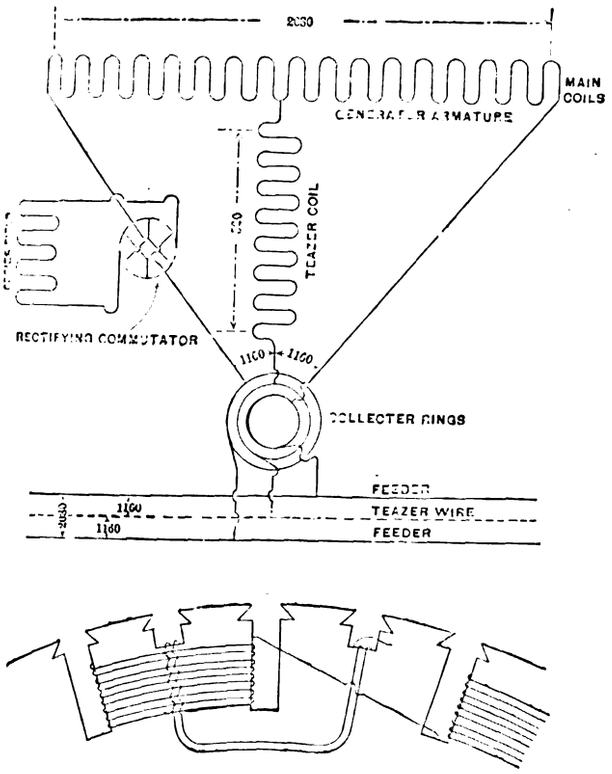


Fig. 13.

We will further assume that the step-up and step-down transformers each have a hysteresis loss of 1½ per cent., that the copper loss in each is ½ of 1 per cent., that the magnetising current is 4 per cent., and that the reactance drop is 4 per cent. Further, that the total loss in the power transmitted is to be 10 per cent. Since the total hysteresis and copper losses in the two transformers is 4 per cent., the loss in the line will be 6 per cent. The difference of potential at the generator between any two conductors will be $\frac{10,000}{\sqrt{3}} = 5,775$ volts. Consequently the energy current for each phase, that is, in each conductor, will be 58 amperes, since each phase is to supply 333 kilowatts. As 6 per cent. of the total volts is about

Fig. 14.

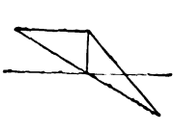

Fig. 15.

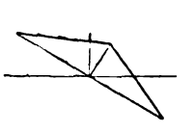

Fig. 16.

350 volts, the C R drop will be 350 volts. With a power factor of 90 per cent., the total current in each conductor will be $\frac{58}{0.9} = 64$ amperes. It follows that since C R = 350 volts, $R = \frac{350}{64} = 5.4$ ohms, or, since the line is to be 10 miles long, 0·54 ohms per mile. The resistance per mile of a No. 0 B. and S. wire is 0·518 ohms, and this, therefore, will be about the proper size to suit our conditions. The reactance of No. 0 wire, at 60 cycles per second, is seven-tenths of an ohm per mile, or seven ohms in this particular case. The C S drop, that is, the drop due to reactance, is $7 \times 64 = 448$ volts, or about 8 per cent. of the total voltage between two conductors. The energy voltage consumed in the two conductors is twice one-half of 1 per cent., or 1 per cent. As the energy volts consumed in the line is 6 per cent., the total drop in the energy voltage will be 7 per cent. The voltage consumed by the reactance in the step-up and step-down transformers will be twice four, or 8 per cent., and the reactive voltage consumed in the line, as calculated, is 8 per cent., and consequently the total reactance drop will be 16 per cent.

The energy current loss in each transformer, due to hysteresis, will be 1½ per cent., or for the two, 3 per cent. The wattless or magnetising current in the two transformers is 8 per cent. The percentage of the wattless current in the load, since the power factor is 90 per cent., will be $\sqrt{1-0.90^2} = 44$ per cent. Consequently at the generator the energy current is $90+3=93$ per cent., and the wattless current is $44+8=52$ per cent., and consequently the total current is $\sqrt{92^2+52^2} = 106.5$ per cent. of the current at the secondary terminals of the step-down transformer. Therefore the current at the generator is 6 per cent. larger than the current at the receiving end.

The energy voltage at the generator will be 90 per cent., which represents the power of the load, plus 1 per cent, which represents the ohmic drop in the two transformers, plus 6 per cent., which represents the ohmic drop in the line, giving a total of $90+6+1=97$ volts. The idle volts are 44 per cent., corresponding to the idle voltage of the load, 8 per cent. due to the reactive drop in the line, and 8 per cent. due to the reactive drop in the transformers, giving a total of 60 volts. Therefore the voltage at the generator is $\sqrt{97^2+60^2} = 114$ volts. The voltage at the generator has therefore to be 14 per cent. larger than the voltage at the receiving end. consequently the total volt amperes per phase at the generator will be 114 times 106·5, or 121 per cent., giving a power factor of only 82 per cent.

If the charging current of the line is to be taken into consideration, it being about 90deg. ahead of the impressed E.M.F., has to be subtracted from the wattless current due to reactance, which is about 90deg. behind the E.M.F. In this particular case the charging current is 0·17 amperes per mile, or 1·7 amperes in this line, which is 10 miles long, or, in other words, it is equal to 3 per cent. of the total current. The total actual idle current flowing in these lines is therefore not 52 per cent., but $52-3=49$ per cent. The total current will be $\sqrt{93^{-2}+42^{-2}} = 105$ per cent. instead of 106·5 per cent., as before found.

It is stated by the experts employed by the General Electric Company that transformers supplied with sine wave and non-sine wave E.M.F.'s give widely differing core losses. From actual tests it has been found that the difference in loss may amount to as much as 10 per cent. This depends upon the character of the flat topped wave. Since the maximum value of the flat wave is less than the maximum value of the sine wave of magnetisation corresponding to a sine wave-shaped E.M.F. and since the core loss depends upon the maximum magnetisation, the core loss is less with a flat wave than with a sine wave.

*Parallel Running of Alternators.*—The fact that it is the common practice both in this country and in Europe, to run alternators in parallel, leaves no doubt as to its feasibility, but naturally some types of machines are better adapted to this purpose than others. The smooth core machines are in some respects not as good as the iron clad, owing to the fact that a slight variation in the field excitation of one of the machines causes a very large cross current to flow between the two, thus loading them up with idle current. Further, if the machines are not completely in synchronism when thrown together, an exceedingly large cross current will flow when closing the switch. A machine having a very high self-induction is not suitable, as it will not allow a sychronising current to flow between the machines. Consequently the best sychronous motors or generators for parallel running, considered from a commercial standpoint, should have a moderate self-induction, that is, be of the ironclad type, and have a comparatively small armature reaction. The moment at which two single-phase alternators are in synchronism may be readily determined by connecting the secondaries of two transformers in series with one or more lamps, the primaries being each connected to one machine. Synchronism will occur when the lamps no longer glow.

In sychronizing three-phasers care must be taken to have all three phases in sychronism. The safest and simplest method of determining this is to place in series with each pair of legs a series lamp bank, and see when all three banks are dull. When this is the case the machines may be thrown in multiple.

When the potential employed is high it is better to use transformers. If the machines are self-compounding it is not sufficient to have only the mains of the machines connected in multiple, but also to have the series windings connected in multiple.

This can be done as shown in Fig. 17. If the commutator is put on to but one leg, great care must be taken in order to synchronise correctly, so that not only the three phases are synchronised, but also those two particular phases which have the commutators may be thrown together.

*Unbalancing of Alternators.*—A drawback in the polyphase distribution is the possibility of unbalancing the different circuits. Although this disadvantage is very much less marked than supposed

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it does occur, but with reasonable care in the installation it will be hardly noticeable if the machines regulate well. It is impracticable to give any definite figures about the magnitude of this unbalancing, as it depends upon the type of machines used, the condition of the line, &c. To feel sure that no unbalancing will occur, it may prove desirable to follow the rule of distributing the load with the same care as in the Edison three-wire system, and no noticeable unbalancing will take place. In the monocycle system no unbalancing is noticeable, since all the load is on the same circuit, and this circuit is the only circuit on the machine. Unbalancing, however, whatever be the system, does not have a very serious influence on the potentials.

*Measuring of Alternating-Current Power.*—In the single-phase system the power supplied by a generator can readily be measured by means of a wattmeter having the current coil in one line and the potential coil between the lines. The total watts supplied by the generator are then directly read. The apparent output is the product of the current and the potential; the power factor of a single phase system is then found by dividing the wattmeter readings by the product of volts and amperes.

The power may be determined about as readily in the three-phase system as in the single phase. The first method that suggests itself is to employ three wattmeters, each having the current coil in one

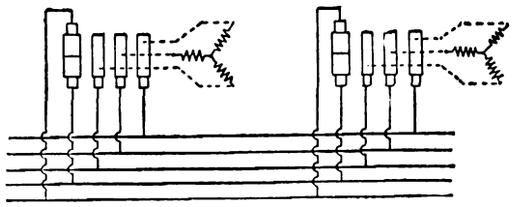

Fig. 17.

of the lines, and a potential coil connected between the three single phases. This method gives the full power, but since all alternators do not have the Y connection (which is necessary to give common connection) this method cannot always be used. Furthermore, it introduces the use of three wattmeters, which makes it rather complicated and expensive.

If the load is balanced in the three branches, the three wattmeters should read the same power, and consequently it would be necessary to use but one, and multiply the reading by 3. Another method of measuring the three-phase power is to use two wattmeters having their current coils connected in two of the lines, and the potential coils between these respective lines and the third line as shown in Fig. 18. If the power factor of the machine is more than 50 per cent., the wattmeters will read positive. If the power factor is less than 50 per cent., one of the meters will give negative readings. To get positive readings, one of the leads will have to be reversed. The total watts will, in the first case, be the sum of the two readings, and in the second case the difference. Instead of using two independent wattmeters, one wattmeter would suffice if this is provided with two armatures and two fields.

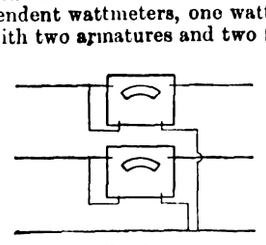

Fig. 18.

The third method of measuring the power is the use of an artificial neutral point. Three wattmeters have to be used if the load is unbalanced, and one wattmeter if the load is balanced. To get the artificial neutral points—that is, an artificial common connection—it is necessary to have three resistances connected together, each going from one of the lines, and of such magnitude that the total resistance of the three circuits (one including the resistance of the wattmeter) is equal. The total volt-amperes, that is the apparent power from the three-phaser is the product of the volts between the lines times the current in the lines times the $\sqrt{3}$—that is, $1{\cdot}73 \times$ volts $\times$ amperes. Consequently the power factor is $= \frac{\text{total watts}}{1{\cdot}73 \times \text{volts} \times \text{amp.}}$

In the quarter-phase system the power can be measured with a wattmeter in each of the individual circuits, as shown in the case of the single-phase system. If the circuits are equally loaded the total power will be twice the power in one phase; that is, twice the power that is read on one wattmeter, having a current coil in one of the lines, and a potential coil across the lines of the same phase. If the power is not equally distributed two wattmeters will have to be used. The total power is the sum of the two readings. The total volt-amperes, if the load is balanced, are twice the volts between the two mains of one phase times the current in that phase, or if the load is unbalanced the sum of the volts times amperes in each phase. The power factor is, as before, $\frac{\text{total volts}}{\text{total volt} \times \text{amp.}}$

*(To be continued.)*

## ELECTRIC TRAMWAYS AND TELEPHONIC DISTURBANCES.

With reference to Dr. C. S. Du Riche Preller's article on "Electric Tramways and Telephonic Disturbances," in *The Electrician* of January 10th, and Dr. V. Wietlisbach's article on the same subject in our issue of March 27th last, the *Elektrotechnische Zeitschrift* in its current issue makes some editorial remarks which may be of interest to our readers. The following is an abstract of our German contemporary's observations:—

"The opinion that tramways with slide contacts disturb telephone circuits less than those with trolley contacts was expressed some months ago by Dr. C. S. Du Riche Preller in an article published in *The Electrician*, in which he relates his observations made on the lines at Zurich, Geneva, Bale, Mulhouse, Havre and Marseilles. The contents of this article, however, shows clearly that there were no careful and thorough investigations, all the different tests being made in a very superficial way, which, in a case where important material interests are in question, must be strongly condemned. For this reason we abstained at the time from making any reference to the article, the author of which, however, received a sharp retort from Mr. E. Kolben in a letter to *The Electrician*. However, finding in Dr. V. Wietlisbach's article the same opinion expressed—namely, that trolley lines cause greater disturbances than tramways with slide contacts—we inquired, first of all, of the author of the article whether he based his opinions on Dr. Du Riche Preller's investigations, or whether he had arrived at the same results independently. To this Dr. Wietlisbach answered that the latter was the case, and that his investigations date further back than Dr. Du Riche Preller's. He further writes:—"It is now quite certain that all trolley lines do not produce the same amount of noise, as is shown, for instance, by the tramline at St. Moritz, which was constructed by Schuckert and Co., and which has given rise to very little telephonic disturbance. There is no doubt that a great difference exists in the telephonic disturbances caused by the different tramways, but the cause of it is not exactly known to me. The discovery of the real cause is rendered the more difficult since tramway companies will not permit conclusive experiments to be carried out on their lines." Undoubtedly the remarks of Dr. Wietlisbach in his article with regard to the elastic oscillations of the trolley wire are to the point, but in spite of this we cannot share his opinion that the principal source of disturbance lies in the contact of the collector and the trolley wire. If this view were a correct one, the tone of the noise in the telephone should change more markedly when the car passes curves than is the case, for the reason that the number of oscillations in the short sections of the trolley wire in the curve is different from those in the straight line. Instead of looking for the main cause of disturbance at the constant point of collector and trolley wire it appears to us obvious to ascribe it to the variations of the resistance between car wheels and rails. As is well known, the running of a car causes oscillations of high frequency in the rails and wheels, and the consequence is a corresponding variation of the resistance between wheel and rail. These variations of resistance will for obvious reasons, be far greater at curves than on the straight, without, however, acquiring a quicker succession. The increase of the noise in the telephone when a curve is passed is thus explained. In the same way the large difference in the disturbance caused by various systems, as mentioned by Dr. Wietlisbach, can be explained. The frequence and amplitude of the oscillations of the rails depend upon the size and the foundation of the rails. With regard to these factors, however, there exist among the various tramways large differences, which must have some influence on the disturbances in question. The increase in the disturbances during the first few weeks of the working of a tramway is, upon this supposition, easily explained. In the newly-laid rails the tightly-fitting foundation has a damping effect upon the oscillations. Gradually, however, the rails become loose, the damping is reduced, and the cause of disturbance increased. If this increase is less noticed on lines with slide contacts than on a few trolley lines, the cause of it should be put down to the accidental differences of the foundation, which, however, have nothing to do with the system of overhead construction. We made some experiments a few days ago on the Berlin-Charlottenburg line, and find the correctness of the above opinion confirmed. The details of these experiments will be published in our next issue."

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## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April 17, 1896.*

**The National Electric Light Association Electrical Exhibition**—The Exhibition which will be held in New York in connection with the annual meeting of the National Electric Light Association, promises to be one of the most successful exhibitions of this character that has ever been held, and second only to the great electrical display at the World's Fair at Chicago in 1893. Great interest is being taken in the matter, and the individual exhibits will be many and of an extremely interesting nature. Governor Morton, of New York State, will start the machinery in motion by closing a circuit with the same golden key that was used for the same purpose at the World's Fair by President Cleveland. It is proposed that when Governor Morton closes the circuit and starts the power machinery, he shall, by the same act, close a circuit from New York to San Francisco and back. Another interesting feature of the Exhibition will be the proposed transmission of electric current from the Niagara Falls power plant to New York, which current will operate Tesla two-phase apparatus in the Exhibition building. It is intended to further extend this idea by using long-distance telephones for the purpose of transmitting to New York the noise of Niagara Falls, thus heightening the realistic effect. Mr. Stillwell, of the Westinghouse Company, goes a step further, and proposes to deliver some of the Niagara Falls current to condensers for the purpose of transmitting signals through some of the Atlantic cables to England and Europe. If the latter idea is carried out, therefore, it is probable that our friends in London may receive telegrams transmitted across the ocean by some of the transformed power of Niagara Falls. At this Exhibition Mr. Edison will make a great display.

**The Application of Electric Power to Textile Industries.**—An interesting application of electricity has recently been made by the General Electric Company in the mills of W. J. Dickey and Son, Baltimore, Md. A horizontal water-wheel is belted to two 90 H.P. moderate-speed generators, and the current is transmitted about 200ft. to the third story of the woollen mill, where it is to be used to operate motors and furnish light. There are in this plant 36 60in. woollen cards and four mules are to be placed, the cards being arranged in three rows, 12 in each row, with a line of shafting for each row. Two of these line shafts will be operated by two 25 H.P. slow-speed motors, and for the operation of the mules a 20 H.P. moderate-speed motor will be connected to the shafting.

**Municipal Ownership of Electric Plants.**—It is proposed that the National Department of Labour and the Bureaus of Labour Statistics in the several states of the Union should take up as a subject for joint investigation municipal ownership of gas and electric light plants. Every electric and gas lighting plant in the United States which is owned by a municipality will be reported upon, and a sufficient number of private establishments will be included to afford a basis of comparison between the two classes of stations.

**An Electric Yacht.**—Mr. John Jacob Astor is having an electric auxiliary yacht built at Nyack-on-the Hudson. The boat will be 72ft. long, 12ft. wide, and with a draught of 4ft. She will be fitted with twin screws, which will be driven by electric motors. The two motors will aggregate 50 H P., and will derive their power from 480 cells of storage battery placed underneath the cabin floors. The motors will also be located under the floor, this arrangement giving the owner use of the entire space in the cabin. It is calculated that the yacht will be capable of developing a speed of 16 miles an hour. The craft will, it is needless to add, be handsomely fitted out.

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**The Cost of Building an Electric Locomotive.**—By a curious coincidence, says the *Electrical World* of New York, the new Westinghouse-Baldwin locomotive weighs 160,000lb. and cost $16,000, which is just 10 cents a pound.

## CORRESPONDENCE.

### THE MELBOURNE MUNICIPAL ELECTRIC LIGHT STATION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue dated January 31st you refer to the Melbourne City Electric Light Station in a manner which calls for a few remarks from me, which I trust you will be good enough to publish.

In Great Britain there is no station erected solely for street arc lighting of the capacity of the Melbourne plant, and, if there were one, I should like to know from you what design would have been adopted in the year 1891, when the Melbourne plant was designed. If you say that small unit engines coupled direct to dynamos of 50 arc light capacity each would have been economical, your opinion would be contrary to that of most of the engineers in America and on the Continent who have had experience in that class of station.

In Milan, which I visited in 1892, the engineer of the arc station of similar capacity to the Melbourne one, informed me that he was throwing out the high-speed engines then employed and installing instead four compound condensing engines of 300 I.H.P. to drive by countershaft the Thomson-Houston dynamos in use, and by that change he hoped to save 50 per cent. in the coal bill as well as a large saving in oil and other expenses. The first of these engines I saw in course of erection.

In America I can refer you to several arc plants which had in 1892 been quite recently erected and were identical in many ways with the one now in Melbourne. They were situated at Worcester, Mass.; Boston, Mass.; Chicago (three stations); Pawtucket, R.I.

From extended tests of the coal consumption at the Melbourne station I find that the coal per unit generated is 5·3lb., which compares very favourably with the Board of Trade returns from electric lighting stations in 1894, which, according to Prof. Unwin, taking only the largest and best stations, the consumption of coal varies in different cases from 7lb. to 12lb. per unit of electricity generated. The details of my tests above referred to I hope shortly to have the honour of forwarding to the Institution of Civil Engineers.

The cost of labour would be increased if the four large horse-power engines were replaced by ten high-speed of lower power. At present the engine, countershafting and separate condensing machinery attendants consist only of one engine driver and two greasers. If less attendance than this would be required with the other systems I would be very much surprised.

As to breakdowns, we have now been running for over two years, and have never had a cessation of the lights for one second. The Council ordered the gas lamp standards to be dismantled the week after the electric light was switched on. Repairs have been very slight, a fitter and a boy maintaining the whole plant in the station in thorough repair. As far as defects in the plant are concerned, including the 20 arc dynamos, only one hot bearing is the record for the two years.

If you, Mr. Editor, can mention a parallel case in which the Council of a city of 4,700 acres has entirely replaced the gas with arc and series incandescent lamps, where the whole cost of maintenance of the new light, including 4 per cent. interest on capital and 7½ per cent. depreciation, is below the previous cost of gas lighting, I shall be pleased to hear of it.

In a letter by Mr. Pardoe, published in a subsequent issue of your esteemed journal, a gentleman I do not remember meeting, but who kindly defends the system adopted, refers to the only plant in Australia he knows of in which the dynamos and engines are direct coupled, viz., the Hotel Metropole, Sydney. I may say I had the pleasure of installing that plant immediately after my arrival from the old country in 1889. I admit that the best system for incandescent lighting where the dynamo units can be obtained of larger capacity is that in which the engine and dynamo are direct coupled, especially when the load is a varying one, but where the load is constant and only small arc dynamo units are available, and

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when water is convenient for condensing purposes, then by all means erect slow-speed compound or triple-expansion condensing engines, even if one has to use your *bête noire* a countershaft.

In conclusion, I would point out that had I desired to erect high-speed engines there would have been serious opposition by the ratepayers to the importing of them from home, as I would not be able to recommend their construction in the colony; a payment of 35 per cent. duty would also be a serious consideration.

The steam plant, although practically all manufactured in the colony, excepting the tubes and staggered headers for the boilers, is a credit to colonial engineering, but I am certain I would not be able to say that of the engines I would require for direct driving, the engine makers out here having no experience with that class.

I can only add that if I were asked to design a station for the same purpose as the Melbourne plant, with the same systems only then available and circumstaaces the same, I could not improve on the Melbourne plant.—Yours, &c.,

A. J. ARNOT, A.M.Inst.C.E.,
Electrical Engineer's Office, City Electrical Engineer.
Town Hall, Melbourne, March 10, 1896.

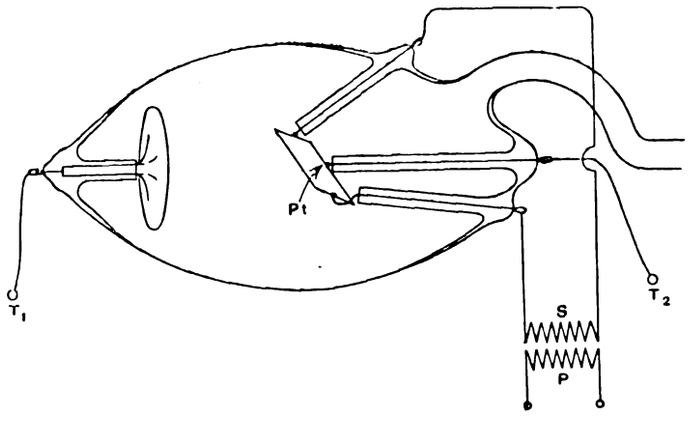
## RÖNTGEN RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It would be better, in these days, not to add too quickly to the sea of unclassified new results with the Röntgen radiation; but the following observation is communicated in the hope that it may prove of practical value in the use of Jackson tubes.

Convincing experiment has shown that *reversing the current in a focussing tube improves it for its normal working after "fatiguing" has set in.*

I am aware that this is in direct opposition to the instructions accompanying Newton's expensive little toy, and I hasten to add that the reverse current used should be comparatively weak.




Of late there has been some discussion as to the localisation of air layers, the "improvement" of the vacuum with use and the beneficial effect of heating the fatigued tube. It has therefore seemed that the revival due to reverse current is caused by the generation of heat in some particular part. If one could hold the fanciful idea that the air molecules were, by continued use, driven to a part of the tube where they remained sticking—then it would be a convenient hypothesis to assume that the reversal drove them back. But Tesla's statements regarding the unwelcome improvement of a long-used vacuum due to actual loss of air from the tube oppose the said fanciful idea.

It then occurs to one that a surface fatiguing of the platinum leaf may come in. The writer is, therefore, about to try the effect of leaving a current-flow in the platinum during the action of the tube.

The above figure explains itself. Uni-directional current rushes could be sent through S, and thus subject *Pt* to the conditions referred to.—Yours, &c., JAMES MARK BARR.

# LEGAL INTELLIGENCE.

## Electric Construction Corporation v. South Staffordshire Tramways Company.

This case came before Mr. Justice Romer in the Chancery Division on Saturday last, when

Mr. EVE, Q.C., in opening the case, said that the action was brought for the payment of sums of money due under an agreement entered into between the plaintiffs (the reconstructed Electric Construction Company) and the defendant Company in February, 1892. There had been a defence and several amended defences put in, but the last defence came to this, that the agreement was, under the circumstances, so tainted with fraud that the Court would not enforce specific performance. In their counter-claim the defendants set up that the agreement was not binding on them, and asked for rescission, other relief and damages. So far as the plaintiffs were concerned there was the admitted agreement and the execution, and one might rest there and leave the defendants to make out their counter-claim, but that would be obviously inconvenient, seeing that several persons who would be called as witnesses were accused of fraud, and, therefore, it was necessary to go into the matter and see what the agreement really was. The defendant Company was incorporated under a special Act passed in 1889, and were the successors of a limited company, which was incorporated in the eighties for the purpose of acquiring the benefit of certain Provisional Orders for the construction of tramways in Staffordshire and their maintenance. Under the Provisional Orders the tramways were made in 1883. The original idea was that some sections of the tramways should be worked by horse power and other sections by steam power. In 1888, after two years working by steam, the local authorities in the districts served by the tramways intimated they could no longer grant the licences for the working of the sections worked by steam unless the whole working plant and mode of working was altered. There was no doubt, therefore, that as early as 1888 the Company was told they must get some other system. Under these circumstances the limited company, which had raised all the money it possibly could, was at a loss to know what to do, and it was considered necessary or desirable that the limited company should be dissolved, and a statutory company should be formed for the purpose of acquiring the assets and liabilities of the limited company, and that, if possible, some other means of working should be devised. A Bill was accordingly formulated and passed in Parliament. The Company being face to face with the fact that the permanent way was out of order, their engines of antiquated construction, and there being difficulties in the way of the weight of the cars, had to set about seeing what form of motive power they should substitute for the steam power. At this time there had been introduced a system of working tramways by means of overhead electrical appliances, and on October 17, 1889, it was agreed to invite tenders for the supply of traction power and maintenance. In May, 1839, a company was registered for the purpose of introducing the system of electrical working into this country, and that was the plaintiff company in this action. This company was formed with a capital of half a million sterling in 50,000 shares of £10 each. Mr. Joseph Smith, who subsequently changed his name to Ebbsmith, was the Managing Director. Previous to 1883 Mr. Ebbsmith was a member of a firm of solicitors acting for the South Staffordshire Company, and he was the person who engineered the Bill through Parliament. The works director was Mr. Thomas Parker, and the engineering adviser of the Company was Mr. Carruthers Wain. By one of the amended defences it was supported that this Company was got up for the purpose of foisting the undertaking on the defendant Company or to bleed the defendant Company in the matter of the traction part of the undertaking. One of the equities relied upon against the plaintiff Company was that Mr. Spencer Balfour and Mr. Carruthers Wain were founders of the Company. The Company was floated, and ultimately the agreement of February, 1892, was made. In March, 1895, the plaintiffs, under a clause in the agreement, elected to determine, and if the notices given were valid then the plaintiffs were entitled to the sums they sued for and a declaration that they were entitled to determine the agreement.

His LORDSHIP asked if the defendant Company had been wound up.

Mr. EVE replied that it had not. When the petition came on the petitioners were paid off upon an understanding that the matter should be raised in an action.

His LORDSHIP said that in his opinion if the plaintiffs were so greatly interested it would have been to their advantage to carry on the business.

Sir F. LOCKWOOD, Q.C., for the defendants, said that he had already made an offer, and he thought there ought to be some *modus vivendi* that would put an end to the action.

At this juncture a consultation took place between the counsel engaged with a view to a settlement, but it was found impossible to come to an arrangement, and the hearing of the case was therefore continued.

Mr. EVE read the remainder of the correspondence which had passed between the parties, at the conclusion of which the learned counsel said that the plaintiff's case was this. Here was an agreement which was entered into from the beginning by two parties who were at arm's length. From the correspondence it looked as if both parties had been trying to make the best bargain they could for their respective Companies, and there was no suggestion of *mala fides* or over-reaching in respect of that. Under all the circumstances the plaintiffs claimed that they were entitled to recover the sums properly paid to them under the contract, having regard to the events that had happened. The difficulty that had weighed with him was that, suppose this contract was put an end to, the plaintiffs would still be entitled to be paid for the work done by them, which would amount to considerably more than the sum sued for.

His LORDSHIP here offered his assistance towards a settlement, but unavailingly. He asked Mr. Eve what relief he sought?

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Mr. EVE replied that he asked for an account of what was due in respect of the mileage during the working of the tramways; that they were entitled to determine the contract; that they were no longer bound by clause 8 of the contract, which provided that for a period of five years they should manage the work, and inasmuch as the mileage for five years on 250,000 was a portion of the price payable to the plaintiffs, and by reason of the determination of the contract they were not able to receive that price, they asked for the difference between the actual mileage run and the minimum mileage in five years, namely, £13,186, being 4½d. per mile. The defendant's answer to that was that the agreement was over-reaching and ought to be set aside, in respect to which they counter-claimed.

Evidence was then called in support of the plaintiffs' case.

Mr. JOHN I. COURTENAY, a Director of the plaintiff Company and formerly a Director of one of the companies which the plaintiff Company was formed to take over, said he was always opposed to the contract in question, as it was a lock-up of capital and the South Staffordshire Company had no money, though he was always desirous of making use of the patents they had in order to show what could be done for electric traction in this country. Jabez Spencer Balfour and Ebbsmith were promoters of the plaintiff Company, and Ebbsmith was a strong supporter of the contract. Mr. Parker, the engineer, was in favour of the contract, and witness was eventually won over because it was proposed to issue debentures. It was not true that the details of the contract were discussed and arranged between Mr. Ebbsmith as Managing Director of the plaintiff Company and Mr. Wain on behalf of the defendant Company. The preliminaries were so discussed and arranged, but the details were gone into by the Board. He regarded the contract as an advantageous one for the South Staffordshire Company, but he would not say they could not have survived without it. He had read a report of a trial in which it was said that Ebbsmith and Wain had fraudulently conspired against the South Staffordshire Company. After Ebbsmith ceased to be Managing Director of the Company, he had no more authority for a contract than an ordinary director had. With regard to the debentures, it was not anticipated from the first that they would find their way into Mr. Ebbsmith's possession, but ultimately they did do so. The reason he was apprehensive that the defendant Company could not carry out the contract was that they had no capital, and it meant the locking up of such capital as there was.

Mr. ALFRED DICKINSON said that in 1883 tramways then existing were worked by steam and horse-power. In 1889 complaints were made by the local authorities respecting the permanent way, and consequently in June, 1891, he went to America, at the instance of the defendant Company, to inquire into the electric traction systems of that country, and he reported in favour of its adoption by the defendant Company. He had left the defendant Company, and was now in the employ of the plaintiff Company at a salary of £300 a year. The Dickinson Appliance Company was formed for financing and working patents witness had invented. Mr. Ebbsmith was practically that Company. He knew nothing of the transactions between Ebbsmith and that Company at the time, but had since learned that Ebbsmith sold the patents to the Company for a greatly enhanced price. Witness knew of the result of the trial before the Lord Chief Justice.

Mr. JAMES GRAY, secretary to the plaintiff Company, produced the books of the Company, and gave evidence as to their contents, after which

Sir F. LOCKWOOD, for the defence, said that his contention would be that in the negotiations which led up to the contract of February 26, 1892, the interests of the South Staffordshire Company were betrayed and the interests of the plaintiff Company ignored. The view he presented to the Court was that so far as the plaintiff and the defendant companies were concerned the beneficial nature of this contract to either of them was absolutely ignored, and the only object was to capture the South Staffordshire Tramways Company and its advantageous concessions. In the negotiations for the contract between the parties the interests of the Tramways Company were not only betrayed by those who were representing it, but the interests of the plaintiff company were entrusted to one who knew perfectly well how the South Staffordshire Company was being treated. The position of the plaintiff Company, he took it, was this: so far as its directors were concerned they should have employed as their agent a person who was perfectly cognisant of the fraud which was being practised on the South Staffordshire Company, it might be they could not be held responsible in damages in respect of the fraud of their agent, but it was perfectly clear they could not avail themselves of any contract entered into under such circumstances. He admitted that he had to satisfy the Court that Mr. Ebbsmith in this matter was the accredited agent of the plaintiff Company. It had been clearly proved in another action that Ebbsmith had manœuvred the affair of the South Staffordshire Company for his own benefit, and this had gone on for some years, when Ebbsmith conceived the idea that it would be a good thing to obtain powers to use electricity as a motive power for the tramways. The necessary Parliamentary sanction was accordingly obtained. The assistance of Jabez Balfour was then sought by Ebbsmith, and they, between them, promoted the Electric Construction Company, and the first matter to come before the Board was the contract now in question. He therefore submitted that if he fixed Mr. Ebbsmith as the agent of the plaintiff Company he would be entitled to read the pleadings and the judgment in the action before the Lord Chief Justice referred to.

His LORDSHIP said he would admit that evidence *de bene esse*.

Sir F. LOCKWOOD submitted that if he established that the contract was oppressive, and that the Tramways Company could not survive under it, then the plaintiff Company must fail, and he was entitled to rescission of the contract.

The judgment and evidence in the former trial was then put in and read.

Evidence was then called for the defence.

Mr. THOS. PARKER said he was an unwilling witness. He was works director of the plaintiff corporation. His opinion was that the cost of the construction of the works would be £24,000. The tramway lines had been constructed by himself and his staff, and he had frequently inspected the lines. Before the execution of the contract he prepared and sent a specification to Mr. Ebbsmith. He was introduced to Mr. Jabez Balfour in London, but not by Mr. Ebbsmith. His opinion was that if the South Staffordshire Company had to pay 9d. per mile for the working of the Company it would not survive. He expressed that opinion to Mr. Ebbsmith and other Directors of the Company. After he left the plaintiff Company he started a company called Thomas Parker (Limited). The plaintiff Company offered to pay him £1,000 a year to remain with them, and also to allow him to carry on a private company. Considering he was a servant of the Board, he spoke as strongly as he could against the contract. At the time the contract was carried out he was works director. He did not consider the cost price as taken from the books was accurately given, his impression being that the cost was at least one-third more. In January, 1894, several of the directors desired him to continue as works manager, and when he refused he was requested to remain in the employ of the plaintiff Company as consulting engineer at a salary of £1,000 a year. He gave notice to the Company on February 17, 1894, that he should leave their employ at the termination of his agreement on May 30, 1894, and on April 9th he wrote asking that the employment might cease forthwith.

Mr. EVE said this evidence rendered it necessary that he should call the directors of the Company, as his information was that witness had never given any intimation to leave until he wrote the letter of February 14, 1894, and that, instead of requesting him to continue in the service of the Company, it was desired that his engagement should terminate before the end of the agreement.

Sir F. LOCKWOOD said he should oppose any application to call witnesses after the plaintiffs had closed their case, particularly as he put to Mr. Courtenay the question whether it was not the fact that Mr. Parker informed him of his belief that the contract was of such an onerous nature that it would be impossible for the defendant Company to survive it. The allegation against Mr. Parker was that he was a dismissed servant of the Company, and was consequently prejudiced against the Company. It was not until now that he learned of the letter giving notice of the termination of Parker's agreement which was sent to the plaintiff Company on February 14th.

Mr. Justice ROMER said that he would consider the application.

Further evidence was then given, and the hearing was adjourned till to-day (Friday).

## Central London Railway Company.

In the London Sheriff's Court on Saturday an action was heard in which the Kensington Woodhouse Park Syndicate endeavoured to obtain from the Central London Railway Company £28,000 as compensation for the compulsory acquisition of their estate at Shepherd's Bush. This is the action which has thrown such strange light upon the financial results of the exhibitions held of late years at Earl's Court, &c. The presentation of these statistics proved effective against the excessive claim put forward in this action, and after a lengthy hearing the jury awarded £4,950 as full compensation.

## Von Buch v. Grant.

In the London Sheriff's Court on Friday last Mr. Carl von Buch, described as "electrical engineer and company promoter," sued Mr. C. N. Grant for slander. Plaintiff's counsel stated that the defendant described his client to a Mr. J. C. Mackenzie as "a wrong 'un," in league with a gang of thieves, and one of the worst men in the City of London. Although the plaintiff bore a German name he was in reality an Englishman. He was a graduate of Oxford, and carried on business as an electrical engineer. Even if the jury awarded £10,000 damages the plaintiff would not be able to sell his verdict for 6d., as the defendant was an undischarged bankrupt, and quite recently he had taken his passage to Australia. After hearing the evidence of the plaintiff and Mr. Mackenzie the jury awarded £100 damages.

## London Electric Supply Corporation (Limited) v. Prentice.

On Wednesday, at the Westminster County Court, a claim was made by the plaintiff Corporation for £15 for breach of contract. A contract was signed by defendant for the plaintiffs to supply the electric light at 60, Park-street, W. After signing, defendant said he did so under a misapprehension, and the contract was not carried out. Plaintiffs now sued for £10 as loss of profit, £1 for three plans, and £4 for men's time.

Mr. PARKER, a clerk, said defendant, after signing the contract, said he did not want plaintiff Corporation but the Westminster Company to carry out the work. The plaintiff had to send plans to the County Council before they brought their mains into the street. They went on with the work after getting notice from defendant that he had signed the contract under a misapprehension. The Westminster Company were supplying the light to the former tenant of the house. Plaintiff Corporation had an agreement with the Westminster Company "not to try and steal each other's business."

The JUDGE: Why do you fight this? You all seem at cross purposes. You have an understanding with the Westminster Company not to take their streets, or whatever it is. If you recover anything it will not be more than £10. I should think you might settle it during lunch time.

The action was, however, not settled, and for the defence it was urged that plaintiffs' canvasser brought the contract and defendant signed it under the belief that he was signing a contract with the Westminster Company to re-connect, and that Company had now done the work.

The Judge was of opinion the Westminster Company had acted as fairly as any company could, judging from correspondence and the evidence. Judgment would be for the defendant with costs. Defendant signed a contract under a misapprehension for the plaintiffs to put on the light. They had not done so, but the Westminster Company had.

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### Clarke v. Julius Sax and Co. (Limited).

This case came before the Court of Appeal on Friday last, being the appeal of Messrs. Julius Sax and Co. (Limited) from a decision of Mr. Justice North in the Chancery Division, refusing to rectify the register of designs by striking off design No. 206,807, registered by John C. Clarke, on the ground that it was not novel, and that similar designs had been used before, the design consisting of a lamp used for an electric lamp to light shop windows. The case was reported in *The Electrician* of Feb. 14th last.

Mr. VERNON SMITH, Q.C., for the appellants, said an action was originally brought by Mr. Clarke against Julius Sax and Co. (Limited) to restrain them from infringing on his design, upon which Messrs. Julius Sax and Co. introduced their cross-notice of motion to rectify the register by striking it off. Mr. Justice North dismissed both motions, holding that the design was one which was entitled to be registered, and that Messrs. Julius Sax and Co. had not infringed it. Only one order was drawn up, and notice of appeal was served before that was done. The only matter to consider now was whether the design in question ought to remain on the register, the contention of the appellants being that the design was not within Section 47 of the Act of 1883.

At the conclusion of the arguments of counsel their Lordships reserved judgment.

### Chadwick v. British Insulated Wire Company (Limited).

At the St. Helens County Court, on Wednesday last, Samuel Tate Chadwick and his wife Barbara sued the British Insulated Wire Company for £50 compensation for injuries sustained by the female plaintiff through the alleged negligence of the defendants. For the plaintiffs it was stated that some time ago the defendants were laying electric light mains in St. Helens, and Mrs. Chadwick fell into an excavation and sustained injuries, both knees being hurt and bruised; in addition, she had suffered a severe shock to the system, and had incurred expenses for medical attendance, &c. On the case being called it was announced that the matter had been settled, the defendants paying £40 in settlement.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

TENDERS INVITED.—The vestry of Hammersmith require tenders for (*a*) supplying and laying high-pressure and low-pressure cables and pipes, (*b*) supplying and erecting arc lamps and lamp posts, (*c*) supplying and erecting transformers and sub-station equipment, (*d*) supplying and erecting a 5-ton overhead travelling crane. Specifications, &c., can be obtained of Mr. A. H. Preece, 39, Victoria-street, London, S.W., and tenders must be delivered at the vestry offices, 57, Fulham Palace-road, Hammersmith, by noon of Wednesday, May 27th. Mr. W. P. Cockburn is vestry clerk. Some further information is given in our advertisement columns.

——— The Bray Town Council invite tenders for the supply and delivery of a 75-kilowatt steam alternator, a 200 H.P. Lancashire boiler, a 100 H.P. vertical high-speed engine, a fuel economiser, feed pump, &c. Tenders must be sent in to the Town Clerk (Mr. P. MacDonnell, Town Hall, Bray, by the 18th inst. Some further information will be found in our advertisement columns.

——— The Electric Light Committee of the County Borough of Oldham invite tenders for the supply of one 360 H.P. steam engine and dynamo. Tenders by May 12th.

——— The Public Lighting Improvement Committee of St. Helier, Jersey, invite communications from persons wishing to establish a lighting station in that town for the supply of electric, gas, or other forms of light for both public and private purposes. Communications should be sent to Mr. P. Baudains, Ecr. Constable, Town Hall, St. Helier, Jersey.

——— Tenders are required for the provision and fixing of electric bells, telephones, fire alarms, &c., at the Brook Fever Hospital, Shooter's Hill, S.E., for the Metropolitan Asylums Board. Tenders by 2 p.m. on Wednesday, May 6th.

——— The Electric Lighting Committee of the Coventry Corporation invite tenders for the supply and erection of (*a*) boilers and fittings, mechanical stokers and economiser, feed pump, &c.; (*b*) steam engine, alternator, oil filter, fittings, &c., steam, exhaust, feed, blow-off, and sundry pipes, valves, &c. Tenders to the Town Clerk, St. Mary's Hall, Coventry, by May 12th.

——— The Council of the City of Wakefield invite tenders for the construction and erection of an electricity generating station. Tenders to the Town Clerk, Town Hall, Wakefield, by the 13th inst.

——— The General Direction of Roumanian Posts and Telegraphs require tenders for the supply of 40 tons of galvanised iron wire and 10 tons of galvanised steel wire. Tenders to the Direction at Bucharest, by the 12th inst.

——— The Sunderland Corporation require tenders for the extension of their electric supply station and also for an iron roof. Tenders by the 6th inst.

TENDERS INVITED.—The Telegraph Department of the South African Republic invite tenders for the supply of 10,000 insulators with supports. Specifications, &c., may be obtained from Messrs. Belinfante Bros., Paveljoensgracht, The Hague, Holland. Tenders to the Consul-General, 8, Doelenstraat, Amsterdam, by the 15th inst.

TENDERS ACCEPTED.—The Cardiff Town Council have received the following tenders for the supply of additional plant at their electricity generating station :—

*Engines and Alternators.*

| | Type of engine. | Type of alternator. | K.W. | Speed. | Price. |
|---|---|---|---|---|---|
| S. Z. de Ferranti (Ltd.) (*Accepted*) | Ferranti's | Flywheel | 300 | 200 | £3,250 |
| Ditto | Belliss | Do. | 350 | 350 | 3,500 |
| Electric Construction Co. | Peache | E.C.C. | 250 | 350 | 2,493 |
| Ditto | Pollitt and Wigzell | Do. | 300 | 127 | 2,970 |
| Ditto | Belliss | Do. | 300 | 300 | 3,407 |
| Brush Company | Raworth | Mordey | 300 | 266 | 2,668 |
| Crompton and Co. | Peache | Crompton Brunton | 300 | ... | 2,770 |
| Ditto | Willans | Crompton Brunton | 300 | ... | 3,015 |
| Ditto | Belliss | Do. | 300 | ... | 3,051 |
| Johnson and Phillips | Do. | J. and P. | 300 | 300 | 3,350 |
| Siemens Bros. and Co. | Do. | Siemens | 300 | 300 | 3,560 |
| Ditto | Wil'ans | Do. | 300 | 267 | 3,740 |
| Easton, Anderson and Goolden | Corliss | Patent | 300 | 120 | 4,100 |

*Boilers.*

| | | | | |
|---|---|---|---|---|
| E. Danks (*accepted*) | Dry back marine | £767 | 10 | 0 |
| J. Thompson | Economic | 890 | 0 | 0 |
| Fraser and Sons | Dry back marine | 974 | 0 | 0 |
| G. Sinclair | Do. | 990 | 0 | 0 |
| Davey, Paxman and Co. | Economic | 998 | 0 | 0 |
| Crompton and Co. | Do. | 1,023 | 0 | 0 |
| Tinkers (Limited) | Dry back marine | 1,060 | 0 | 0 |
| Fleming and Ferguson | Clyde water tube patent | 1,079 | 0 | 0 |
| Ditto | Do. | 1,095 | 0 | 0 |
| Lindsay, Burnett and Co. | Dry back marine | 1,100 | 0 | 0 |
| Hawksley, Wild and Co. | Do. | 1,110 | 0 | 0 |
| Babcock and Wilcox (Ltd.) | Water tube | 1,100 | 0 | 0 |
| Abbott and Co. | Dry back marine | 1,150 | 0 | 0 |
| Electric Construction Co. | Do. | 1,155 | 0 | 0 |
| R. Hornsby and Co. | Do. | 1,400 | 0 | 0 |
| John Brown and Co. | Scotch marine with patent draught, &c. | 3,700 | 0 | 0 |

——— For the wiring of the Northern Polytechnic Institute seven tenders were received, and the lowest, that of Messrs. Russell and Lennard (£219) has been accepted. The other tenders ranged from £245 to £1,027.

WESTINGHOUSE ENGINES FOR SALE.—An important list of engines for sale by the Metropolitan Electric Supply Company will be found in our advertisement columns, including engines of 320 I.H.P., 250 I.H.P., and 85 I.H.P., all fitted with variable expansion gear controlled by flywheel governors.

APPOINTMENTS VACANT.—The Shoreditch Vestry invite applications for the post of resident electrical engineer to take charge (under the superintendence of the Vestry's consulting electrical engineers) of the laying of mains, the erection of plant at the electricity station, &c., for a minimum period of four months at a salary of £4 per week. Applications must be sent in to Dr. H. Manstield Robinson, The Town Hall, Old-street, London, E.C., before 4 p.m of the 11th inst. Some further particulars are given in our advertisement columns.

APPOINTMENT.—The Hampstead Vestry have appointed Mr. Harold Morton to the post of assistant electrical engineer at the Vestry's electricity works, in place of Mr. C. O. Bastian resigned.

——— Mr. J. Davies Williams, Town Clerk of Southport, informs us that Mr. Charles Davis Taite, who has been engaged as an assistant at the Southport Electricity Station, has been appointed borough electrical engineer, in place of Mr. Arthur Ellis, who has been selected to fill the Bolton vacancy.

DISSOLUTION OF PARTNERSHIP.—Messrs. Alfred, Stephen Francis and Francis Pegler, india-rubber manufacturers, hitherto trading under the style of the Northern Rubber Company, at East Retford, Nottingham, have dissolved partnership. Mr. A. Pegler retires.

BUSINESS CHANGES.—Messrs. Charles Jennings and Co. have become successors to the firm of George Schultz and Co., engineers, steel and iron merchants, of 90, Cannon-street, London, E.C.

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BANKRUPTCIES.—Claims against the estate of Philip C. Pope, electrical engineer, Hapton, near Burnley, must be sent in to the Official Receiver (Mr. T. Edelston), County Court, Preston, by May 6th.

——— A first and final dividend of 7s. 6d. is payable in the estate of George I. Reakes, electrical engineer, lately trading as G. Reakes and Co., Cherry Orchard, Shrewsbury, at the Official Receiver's, Shrewsbury.

——— The liabilities in the recent failure of W. Northcote and Co., electricians, of New Cross-road, London, are returned at £379. 10s. 10d., assets at £25. 5s.

——— At the London Bankruptcy Court on Tuesday an application was made by G. F. Rogers, electrical engineer, for his discharge. The receiving order was made in March, 1895, and from the Official Receiver's report it appeared that the bankrupt was a director of various companies, and had signed a number of bills. The debtor attributed his failure to liability on accommodation bills, loss on trading and investments, law costs, bad debts and depreciation of securities. Liabilities were returned at £19,800. 14s. 3d., and the assets have realised £496. 13s. 3d. Among other offences it was alleged against the applicant that the assets were not equal to 10s. in the £, and that he had been guilty of rash and hazardous speculation and extravagance in living. In the end his Honour suspended the discharge for three years.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from April 22nd to 28th, with the ports of destination :—

*Australasia*—Adelaide, £3,220; Melbourne, £22; Sydney, £421; Wellington, £52. *Belgium*—Antwerp, £75. *Hong Kong*, £10; *China*—Shanghai, £110. *France*—Brest, £1,200. *Germany*—Cologne, £75. *Gibraltar*, £36. *Holland*—Amsterdam, £110. *India*—Bombay, £101; Calcutta, £380. *Japan*—Yokohama, £715. *Malta*, £692. *Panama*—Santos, £89. *Russia*—Revel, £31; St. Petersburg, £563. *South Africa*—Cape Town, £123; Durban, £36; East London, £50; Port Elizabeth, £15. *Spain*—Barcelona, £7. *Straits Settlements*—Singapore, £28. *Sweden*—Stockholm, £120. *United States*—Baltimore, £13 (carbon diaphragms).

I. E. S. ACCUMULATORS.—We have received a new catalogue, issued by the I. E. S. Accumulator Company, of Palace Chambers, Bridge street, London, S.W., which gives useful details of the manufacture of these cells. Tabulated statements show the working rates, approximate capacity, dimensions, &c., of the various types of I. E. S. cells, which include batteries for traction and lighting purposes, and one cell called the "Central 'D' Type Station" (a description which is not particularly clear). One of the illustrations shows the I. E. S. battery for omnibus and tramcar lighting, reading lamps, &c. Some particulars are also given of the formation of I. E. S. accumulators.

ART FITTINGS.—A handsome catalogue of electric light fittings, illustrated by Mr. Holland Tringham, is issued by Messrs. F. and C. Osler, of Oxford-street, London, W. A large variety of pendants (fixed and sliding), ceiling lights, brackets, standard and table lamps, figure lamps, French bronzes, and an excellent assortment of shades for electric lamps and ornamental sundries are included in the catalogue. As might be expected, many of the designs possess high merit, and architects and contractors engaged in artistic electric light work can be safely recommended to consult the catalogue of this firm, which stands in the first rank in this particular department of the industry.

ELECTRICAL ADVERTISEMENTS.—On the opening of the exhibition at Earl's Court a novel form of advertisement is likely to be conspicuous. This is a series of luminous words formed of incandescent electric lamps, the letters of the words being 300ft. from the ground, and each 40ft. in height, and covering in all an area of about 10,000 sq. ft. From tests which have been made, on a clear night the illuminated letters would, it is stated, be visible for from six to eight miles, but whether legible at anything like so great a distance remains to be seen.

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BATTERSEA (LONDON).—The result of the competition for the best method of dealing with a public supply of electricity in Battersea is announced. In September last the Vestry invited competitive schemes for the lighting of the parish by electricity and for the utilization of the dust destructor in connection therewith. Instructions were prepared and premiums of £50, £30, and £15 respectively were offered for the best three schemes submitted, it being stipulated that the schemes finally selected should become the absolute property of the Vestry, and the premium of the successful competitor in the event of his scheme being carried out, to merge into and form part of the commission or remuneration for the supply of the necessary detailed plans, specifications, &c., and for the general superintendence of the execution of the works. The schemes were, as usual in such cases, sent in anonymously, accompanied only by a sealed envelope containing the name and address of the competitor. The instructions were issued to 28 applicants, and 21 sets of schemes were submitted by December 12th. The Electric Lighting Committee then appointed Mr. Robert Hammond to advise them and to report on the schemes submitted. His report was considered by the Committee, and in accordance with his recommendations the premium of £50 has been allotted to the scheme prepared by Mr. R. A. Dawbarn on behalf of the Brush Electrical Engineering Company (Limited); the £30 premium to Mr. W. Best; and the £15 premium to Mr. J. Hardie McLean, of Oxford. The Committee have now given instructions for a scheme to be prepared for dealing with the electric lighting of the parish, which the Vestry will discuss at an early date. The electric lighting of the Town Hall is to be at once proceeded with, and Mr. Hammond has been appointed as the consulting engineer to carry out the work. It is estimated that the work will cost about £3,000. The generating plant for the Town Hall lighting will be erected on the vacant land at the rear of the present building. Application is to be made to the London County Council for a loan of £3,000.

BELFAST.—The petition presented by the Corporation against the Belfast Street Tramways Company's Bill has been withdrawn. The Company seek powers to construct new tramways and to introduce electric traction throughout the entire system. There is now no opposition to the Bill.

BLACKPOOL.—A Local Government Board inquiry was held on Tuesday last at Blackpool into the application of the Town Council for permission to borrow £30,000 for making extensions to their electric lighting system. Particulars of the application were given by the Town Clerk (Mr. T. Loftos). The electrical engineer (Mr. J. Hesketh) stated that further extensions of the works were urgently needed; at the present time the demand for current was so great that they could not supply all those who were willing to take it, and unless new plant were put down for the summer season the Electricity Committee would not be able to fulfil its obligations. A Mr. Sansome put various questions to the engineer with a view to show that orders for the new plant had already been given out, and that the work was well in hand, though without the Local Government Board's consent. Mr. Sansome made various other statements of a more or less irrelevant character, but finished up by supporting the extension of the works. There was no other opposition, and the inquiry terminated.

BOLTON.—This week a deputation from the Streets and Electricity Committees paid visits to Bristol and Walsall for the purpose of inspecting the electric tramways in these towns. It is anticipated that the deputation will recommend the adoption of the overhead side trolley system. It is proposed to start with the Daubhill route (about 2½ miles in length) which will afford a good test of the system as there is a steep gradient. The estimated cost of this section is £10,000. The total length of tramway rails owned by the Corporation is over 17½ miles.

BRAY.—The Town Commissioners held a special meeting on Monday for the purpose of considering the proposals of the British Electric Traction (Pioneer) Company to construct electric tramways in the town. After considerable discussion it was decided to adjourn the further consideration of the matter for six months.

COMMISSION OF SEWERS (LONDON).—At the last meeting of the Commissioners the Streets Committee presented their report on the recent application of the National Telephone Company for permission to lay their telephone wires underground. The report concluded as follows :—"That as the Company was not prepared to make any concession for the public benefit for the easements in question, they were unable to recommend compliance with the application." The Committee's recommendation was unanimously agreed to.

DONGOLA CAMPAIGN.—Lieut. Manifold, R.E., has succeeded in laying the telegraph to Akasheh by the river route. The greatest distance accomplished in one day was 15 miles. No. 8 wire was employed. Telephonic connection has also been established. There is said to be some difficulty in finding skilled telegraph operators.

ELECTRIC LIGHT AND NIGHT TARGET PRACTICE.—It is stated that an electrical plant has been laid down at Lydd, near the Camp, for the purpose of working the search light to be used during heavy-gun firing practice at various objects during the night.

GARSTON (LANCS.).—Major Philip Cardew, R.E., held a Board of Trade inquiry on Tuesday last into the application of the Liverpool District Lighting Company for a Provisional Order for the districts of Garston and Much Woolton. Opposition was offered to the scheme by the Garston District Council.

GLASGOW.—This week a deputation from the Town Council are paying a visit to Hamburg for the purpose of making a detailed examination of the system of electric traction employed on the tramways of that city. The deputation are also to visit Bristol and Coventry. Until a report is presented the consideration of Messrs. Crawford and Young's report, a short abstract of which was given in our last issue, is postponed.

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GRIMSBY.—The Grimsby Council Provisional Order expires in July next, and at a meeting held on Friday last, Mr. Alward made some practical suggestions as to the measures which ought to be taken for the immediate establishment of electricity supply works if the Order is to be retained. A motion was, however, made to apply for an extension of time, and the Town Clerk pointed out that if the Council waited until the close of the present Session of Parliament, and applied in November for an extension, there was no doubt this would circumvent any private company stepping in before them. In the meantime particulars are to be obtained of electric lighting matters from other towns.

HAMPSTEAD (LONDON).—The Vestry have approved the plans of the proposed additional buildings at the electricity supply station, and tenders are to be invited. Various small extensions of the electric light mains are also authorised at an estimated cost of £570, and testing instruments, stores, &c., at a cost of £122. 16s. The total number of applications to March 31st was 324, and 305 customers, representing 22,945 8 c.p. lamps, have been connected, an increase of over 3,500 8 c.p. lamps for the quarter. The works cost of the station for this period was £1,231. 9s., or 2·29d. per unit.

HOTEL LIGHTING.—The Great North of Scotland Railway Company have decided to introduce the electric light into the Palace Hotel at Aberdeen, and are negotiating with the Electric Lighting Committee for the supply of current from the Corporation mains.

HULL.—The Town Council are much exercised over the question of the system of traction to be adopted on the local tramways, and have now instructed the borough engineer to prepare a report on the various systems in use.

KINGSTON-ON-THAMES.—On the recommendation of the Electric Lighting Committee the Town Council have decided to lay a cable to the waterside for the purpose of charging electric launches.

KINGSTOWN (DUBLIN).—The Board of Trade have approved the application of the Town Commissioners for an Electric Lighting Provisional Order. The Lighting Committee's recommendation that Mr. Manville be authorised to prepare a report on the electric lighting of the town at a fee of 50 guineas was approved —— During the past week a number of cars have been running on the Dublin Southern Tramways Company's line between Kingstown and Dalkey for testing purposes. The line is to be shortly opened for traffic.

LAMBETH.—There was another full-dress debate on the electric lighting question at the last meeting of the Vestry. Various amendments were considered and numerous eloquent and persuasive speeches were delivered in support thereof, one member objecting to the Vestry undertaking a lighting scheme on "moral, social, financial and philosophical grounds." We were always under the impression that light was one of the most potent factors in the moral and social well-being of a district.

LEEDS.—*Daily Tenders and Contracts* states that notice has been given on behalf of the Leeds City Council of the intention to bring forward a motion to suspend the standing order which prohibits a Parliamentary Committee from giving power to the Corporation to work the local tramways. This course has been rendered necessary in consequence of the Government having adopted the principle in their Light Railways Bill of Local Authorities working tramways.

LIMERICK.—It having been suggested that the Corporation might be able to obtain sufficient water power from the river Shannon for lighting the town electrically, the consulting electrical engineer (Prof. A. B. W. Kennedy) has the matter under consideration.

MUSIC HALL LIGHTING.—The new Empire Music Hall, Cardiff, is to be lighted electrically.

KIDDERMINSTER.—Owing to the serious opposition with which the Bill for the construction of an electrical tramway from Kidderminster to Stourport was threatened, it was thought that the promoters would be compelled to abandon their scheme. It is now stated that the opposition has been withdrawn, except to minor features of the Bill. There is therefore every prospect that the Bill will be reported to the House at an early date, and that the work of construction will be started without delay.

MAIDSTONE.—At the last meeting of the District Council a long discussion arose on the proposal to transfer the Maidstone Provisional Order to Mr. Thomas King. Several members objected to the transfer, and ultimately it was agreed to let the matter stand over for twelve months.

MIDDLESBOROUGH.—Some time ago Mr. R. Hammond presented a report on the electric lighting question in which the Electric Lighting Committee were recommended to establish an electricity station at a cost of £10,000. After consideration of the report the Committee have decided not to proceed with the matter.

MILL LIGHTING.—The Moss Field Mills, Bolton, are being fitted throughout for the electric light by Messrs. W. Banks and Co. (Limited), Bolton.

PETERBOROUGH.—Some time ago the Town Council decided to borrow £20,000 for the purpose of establishing electricity supply works, but at the last meeting of the Council an attempt was made to rescind this resolution. Mr. Batten moved "that in view of the information acquired by the Council since January last it is undesirable to proceed with the application for the loan." In support of his motion Mr. Batten said that up to the present only 51 municipal bodies had established electricity works, while there were 50 private companies, and he contended this proved that it was not advisable for the Council to proceed with their scheme. Brighton, singular to say, was cited in support of the motion as a Town Council which had bought out the rights of a private company with a capital of £35,000 for £5,000. After a long and heated discussion the motion was rejected by 12 votes to 11.

PORTSMOUTH.—At the last meeting of the Electric Lighting Committee it was decided to increase the salary of the electrical engineer and superintendent of the Corporation electricity supply works to £275 per annum. Mr Price's initial salary was £200, but some time ago this was raised to £240 per annum. Other advances to the engineering staff were approved.

SHANGHAI.—The Municipality have had before them a proposal to grant to a syndicate represented by Messrs. L. S. J. Hunt and J. R. Morse, the right to construct a system of electric tramways. The scheme provided for the payment to the Municipality of 1 per cent. of the gross receipts from the tramways for the first five years, 1½ per cent. for the second five years, and an additional ½ per cent. for every succeeding five years until the maximum of 4 per cent. was reached. It was proposed that a local directorate should be formed and the public be invited to subscribe the necessary capital. After 25 years the Council were to have the option of purchasing the entire system on a valuation based upon its earning capacity. Serious opposition was offered to the scheme by the Council, and representations were made on behalf of the Imperial Chinese Telegraph Administration, the Eastern Extension and Great Northern Telegraph Companies, and the China and Japan Telephone Company, pointing out the serious effect of the heavy currents used in electric traction work upon the weaker currents employed for working the telegraphs and telephones, and suggesting that if the concession were granted it would be necessary to frame a set of rules safeguarding the interests of the telegraphs and telephones. The discussion upon the scheme at the ratepayers' meeting was worthy of the occasion, several speakers showing themselves fully acquainted with the views of leading experts on electric traction matters. In support of the introduction of electric tramways one speaker expressed his intention of approving the suggestion, even though the interests of Shanghai were temporarily affected. They were constantly asking the Chinaman to adopt western notions—to introduce railways, waterworks, and modern systems of lighting—and now that the opportunity was before them for introducing up-to-date electric traction in the city he, for one, welcomed the proposal. Most of the speakers agreed that it would be necessary, before introducing so great a novelty into the narrow streets of Shanghai, that the greatest care should be taken to safeguard the interests of the telegraphs and telephones, although one or two supporters of the traction scheme displayed a disposition to ignore these rights. After a discussion lasting some hours, the proposal to grant the concession was lost, the Council's opposition proving its death knell.

SOUTHAMPTON.—Mr. J. G. W. Aldridge, the electrical engineer to the Harbour Board, has suggested certain alterations to the new electric cranes on the town quay by which their lifting weight will be increased to three tons in place of 30cwt. at an additional cost of £100. The proposal has been adopted.——The Electric Lighting Committee of the Town Council have appointed Mr. E. Manville their consulting electrical engineer. The members of the Committee this week paid a visit to Portsmouth for the purpose of inspecting the electricity works of that town.

SOUTHPORT.—A Local Government Board inquiry was held on Friday into the application of the Town Council to borrow £4,000 for additions to the electric light mains, &c. The Town Clerk (Mr. J. Davies) gave particulars of the expenditure the Council had already incurred in connection with the electricity supply scheme, and stated there was a steady increase in the demand for current. The electrical engineer (Mr. A. Ellis) supplied technical details. There was no opposition.

STORES LIGHTING.—The Haslingden Industrial Co-operative Society have decided to introduce the electric light into four of their shops at a cost of £470.

WESTMINSTER (LONDON).—The Vestry have decided to make some alterations to their electric light installation at the Public Baths at a cost of between £250 and £300. Tenders for the work have been invited from Messrs. Crompton and Co., Drake and Gorham, Nalder and Harrison Syndicate, the Electrical Installation Company and Mr. T. J. Rorke.

WORCESTER.—The action brought by Messrs. Quarrell and White against the City Council for damage alleged to have been caused by the Electricity Committee in the erection of the Powick electricity works has been settled, a compromise having been effected by payment of £50 as compensation in addition to costs.

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# COMPANIES' MEETINGS AND REPORTS.

## Eastern Extension, Australasia and China Telegraph Company (Limited).

The forty-fifth ordinary general meeting of this Company was held at Winchester House, London, E.C., on Wednesday, under the presidency of the Marquis of Tweeddale.

The SECRETARY (Mr. F. E. Hesse) read the notice calling the meeting and the minutes of the last meeting, which were signed as correct. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, before referring to the proceedings of the past half-year, I desire to express the deep regret of myself and my colleagues, as well as, I believe, of every shareholder, present and absent, at our being deprived of the presence of our able and esteemed chairman, Sir John Pender, through severe indisposition. Sir John Pender has been chairman of this Company ever since it was founded in 1873. I believe that he has presided at every half-yearly meeting since that date. He gave the Company his unremitting attention, and it is only fair to say that it is due in great measure, if not entirely, to his foresight, energy, and administrative ability that we owe the success which this Company has achieved. No more conspicuous evidence of this could be found than is contained in the report which I am going to ask you to adopt to-day. The gross revenue for the half-year under review has amounted to £311,582, against £261,322 for the corresponding period of 1894, or an increase of £50,260. As mentioned in the printed report, this increase is mainly due to the exceptionally heavy traffic exchanged with Western Australia in connection with the gold mining industry that has so largely developed in that colony. This industry may prove lasting, or it may only be a temporary industry. All gold mining, however, being more or less speculative, we must not reckon upon a continuance of these abnormal conditions. The working expenses for the half-year have amounted to £84,044, against £89,740 for the corresponding period of 1894, or a decrease of £5,696, due to the cost of cable repairs having been much lighter during the past half-year than during the same period of 1894. As this is the close of the financial year, it will interest you if I compare the receipts and expenses of the whole year with those of 1894. The gross receipts for 1895 amounted to £575,722—the largest revenue the Company has ever earned—against £509,003 for 1894, or an increase for the year of £66,719. The working expenses for the same period show an increase of £9,263, but this is accounted for by the cable repairs being unusually heavy during the first half of 1895, whilst several exceptional items, such as repairs and additions to station buildings and furniture, also came into last year's accounts. It will be seen from the printed report and accounts that the Fire Insurance Fund has been credited with £20,000 from the revenue account. This fund was started some two years ago owing to the premiums charged on the Company's property abroad being considered excessive for the risks involved. The Company thereupon decided to underwrite three-fourths of the risk, and as the property insured is valued at about £125,000, the fund was obviously inadequate without a considerable addition being made to it. It now stands with this addition at £26,159. It will be necessary to make further additions before this fund can be considered in a thoroughly sound condition. The usual interim dividends have been distributed during the past year, making, with the dividend proposed to be paid to-morrow, a total payment of 5 per cent. for the year 1895. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the past year. The balance of £129,329 has been carried to the general reserve fund, which, after debiting the fund with the balance of cost of the alternative Singapore-Hongkong cable, and the cable renewals effected during the half-year, now amounts to £561,546. This is a substantial figure, no doubt, but having regard to the great length of our cables over 18,000 nautical miles—we can hardly regard this sum as sufficiently large. It will be necessary therefore still to add to the reserve fund. The renewals I have referred to consisted of the insertion of 340 knots of cable in the New Zealand original section, which had given from time to time considerable trouble, and 109 knots in the Tasmanian original section. Further extensive renewals have still to be carried out at various parts of the system in order to effectually maintain its efficiency, and these will be done as opportunities occur. I am happy to say that at this moment all our cables are in good order. I believe this is almost the first time that such a statement has been possible at a half-yearly meeting. With so many cables, so many different seas, and exposed to so many different risks, it rarely happens that some one cable or other is not interrupted, but at this particular moment I am happy to say that in no instance is there any interruption to the transmission of messages by our cables. The report informs you that a further drawing of the Company's Five per Cent. Australian Subsidy Debentures (409 in number) took place on the 1st inst. for payment at par on July 1st next, when the debenture debt, which originally amounted to £640,000, will have been reduced to £168,600, and will shortly, of course, be extinguished. Whilst paying a handsome dividend, strengthening the Company's position by making judicious renewals, additions to reserve funds, and reductions of capital, your Directors have not been unmindful of the interests of the telegraphing public, and have accordingly decided to revise the local tariffs by placing them on a more uniform and satisfactory footing. Most of these tariffs were originally fixed without regard to any definite or uniform basis, and some of them have proved to be anomalous and even excessive. The change will come into operation on July 1st. The reductions are expected to result in a considerable loss of revenue at first, possibly not less than £40,000 per annum. This is a statement which in many companies would be received with alarm, but I think you may receive it with equanimity. It is quite true that it is a very large figure, but at the same time we look forward to recouping gradually the loss by the increase which is almost certain to take place in our traffic. I have also to tell you that an international telegraph conference, to which the Company is invited to send delegates, will be held in June next, when it is quite possible that further sacrifices to meet public requirements may be pressed on the Company. If this proves to be the case the demand which may be made will receive the fullest consideration from us, and it will be our desire to meet it as far as possible, as far as it is reasonable, and as far as it is compatible with the interests of the Company. You have no doubt heard from time to time of proposals to connect Canada with Australia by means of a cable across the Pacific Ocean touching British possessions only. As many of the statements put forward in support of these schemes appear to be wanting somewhat in precision, and even in accuracy, I am glad to be able to say that an Imperial Commission will be held very shortly when this important matter will be fully considered. I rejoice at this, because I think it will be the first occasion on which the subject will be discussed in a thoroughly practical and businesslike manner by people who are thoroughly acquainted with the whole subject. My own impression is that the difficulties, both physical and financial, of giving effect to the desire for what is called an "all-British cable" (that is, a cable from Canada to Australia touching on no other than British possessions), will be found far greater than is generally believed; but whether this is the case or not our duty is clear—that is, to do all in our power to protect the interests of the shareholders of this Company. Without going into any detail as to how we consider that may be best done, I hope you will accept my assurance that it will be done, and done in a manner best suited to attain that end. I think I have now touched on all important matters connected with the operations of the last half-year. Again, I must express my deep regret that we have not with us to-day our able Chairman. I cannot, I am afraid, hold out the hope of seeing him here again, but I do indulge the hope that he may be restored shortly to, at any rate, a better condition of health than he at present enjoys. The motion I have now to make is

*"That the report and accounts of the Directors now submitted be received and adopted, and that a dividend be now declared of 2s. 6d. per share, together with a bonus of 4s. per share, both free of income tax, payable on the 30th inst., making, with previous distributions, a total payment of 7 per cent. for the year 1895."*

Mr. F. A. BEVAN: I have great pleasure in seconding that.

The CHAIRMAN: Before I put the Resolution I will invite any remarks which may have to be made. No shareholder, however, rising to address the meeting he put the motion in the usual way, and it was carried unanimously. Continuing, he said: I have next to propose

*"That Mr. John Denison Pender, who now retires by rotation, be and is hereby re-elected a Director of this Company."*

Mr. C. W. EARLE: I second the motion with much pleasure.

The resolution was carried unanimously.

Mr. BEVAN: I now beg to propose a resolution which the Chairman cannot move, as it affects him. It is as follows:—

*"That the Most Hon. the Marquis of Tweeddale, who now retires by rotation, be and is hereby re-elected a Director of this Company."*

Sir. A. J. LEPPOC CAPPEL, K.C.I.E.: I have the pleasure of seconding that resolution.

The resolution was carried unanimously.

The CHAIRMAN: I beg to thank you for the honour you have done me.

Mr. JOHN NEWTON: I beg to propose "That Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. Welton, Jones and Co., be and are hereby elected auditors for the ensuing year at a remuneration of £100 each." May I take the opportunity, in moving this resolution, to express to the Directors, I am sure on behalf of all the shareholders—our great regret at the absence of our respected chairman, and to assure Sir John Pender and his family of our sorrow in their great calamity. I think you held out some little hope that Sir John may live to take an interest in what is going on respecting our affairs, and I do trust that he may live to see the great prosperity which the Company has been brought to. We are told that this is the most successful and prosperous year the Company has ever passed through, and it is a source of great regret that Sir John Pender is not in a condition to be with us on such an occasion. We may hope with you that he may recover to take an interest in the progress of our Company and that he may live long in restored health with his family.

Mr. ANSELL seconded the motion, which was carried unanimously.

The CHAIRMAN: That constitutes the business of the meeting.

Mr. W. GRIFFITH: I think we ought to propose a vote of thanks to our able Directors for the way in which they have managed our business in the past half-year. While proposing this I may take the opportunity of expressing my acquiescence in the sympathetic remarks which have been made respecting Sir John Pender. I hope that the Marquis of Tweeddale will transmit this expression of feeling from the meeting, and that it may be some comfort to him and his family in their affliction. We all trust that he will soon be restored to health and to us again. I now beg to propose a vote of thanks to the Directors for their able and successful conduct of our business in the past six months.

Mr. ANSELL, I beg to second that

The resolution was carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I beg to express my thanks for the kind manner in which you have received this vote. I hope the next time we meet I may be able to give you a better account of our chairman, although I am afraid it will not be a very good one even then.

The proceedings then terminated.

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## Indo-European Telegraph Company (Limited).

The twenty-ninth ordinary general meeting of the members of this Company was held at Winchester House, London, E.C., on Wednesday, Mr. J. Herbert Tritton presiding.

The MANAGING DIRECTOR (Mr. W. Andrews) read the notice convening the meeting.

The CHAIRMAN said: Gentlemen, I beg to propose—

*"That the report and accounts now submitted be received and adopted, and that a dividend be and is hereby declared for the half-year ended December 31, 1895, of 17s. 6d. per share, making, with the interim already paid, 6 per cent., and a bonus of 20s. per share, both free of income tax, making in all 10 per cent. for the year."*

In submitting that motion to you there is very little to be said in reference to the transactions of the past year. The year has been a blank as far as unusual or exciting variations of occurrences are concerned. Perhaps you will agree with me in preferring the unexciting and quiet march of assured prosperity to the stirring but unproductive episodes that occasionally attend upon companies in exciting but altogether undesirable forms. We have, fortunately, to deal with a satisfactory revenue. Our receipts for 1895, as the report shows you, amounted to £123,734. 11s. 7d., and compare in a favourable manner with the revenue of the preceding year, which only reached £119,117. 18s. 3d., the increase on the year being £4,616. 13s. 4d. We owe this increase to the trans-Indian business, and we owe that again to the discoveries of gold in Australia and the consequent development of new forms of telegraphic communication, which, it must be remembered, is bound to increase and to grow with the prosperity and enlargement of trade consequent upon the gold discoveries and their influence upon the Australias. With respect to India, our trade is pretty much where it was; there is a slight increase, but the income derived from the traffic has not made up the lee-way that set in with the reduction of rates made in the year 1885. I am afraid we must face the fact that in an old-established trade improvements and additions made year by year in merchants' codes, by which an enormous number of words in plain language can already be sent for one code word, absorb, so to say, any growth in the number of words there might otherwise be. In fact, the code tariff per plain word over the wires with India takes rank amongst the lowest tariffs in the world, and for each 100 miles of line, is so very much below the charge made, for instance, by the Post Office for telegrams in this country, as to be beyond all reasonable comparison. This may seem a startling announcement, but it can be proved by figures in the knowledge and in the possession of this Company. Turning to the other side of the account our expenses in the year 1895, under all heads, were £67,820. 10s. 4d., exceeding by £2,981. 17s. 3d. those of 1894. They include, however, certain items written down in pursuance of the policy which you have already several times approved. After deducting these expenses, the interim dividend already paid, and the amount placed to reserve, the Directors are enabled to recommend the dividend and bonus announced in the report. There will be next June at Buda Pesth a conference of delegates from the states parties to the Telegraph Convention. At this conference, to which the companies are invited to send representatives, the rules and regulations and tariffs affecting national and international telegraphs will be discussed and settled.

Major-General G. B. TREMENHEERE, R.E., seconded the resolution, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. C. HOLLAND, the retiring Directors, Messrs. L. Delbrück and C. W. Earle were re-elected unanimously.

The auditors (Messrs. C. F. Kemp, Ford and Co.) having been also reappointed, a vote of thanks to the Chairman and the other Directors brought the proceedings to a close.

## Great Northern Telegraph Company.

The following abridged report of the general meeting, held at Copenhagen on April 25th, is issued:—

Mr. F. Zahle presided, and the Managing Director (Commodore E. Suenson, D.R.N.) gave an account of the working of the Company during the past year. He said that, with regard to the state of the cables, the year 1895 had been less favourable than the preceding one. In Europe nine cables had been interrupted 16 times, and in the Far East there had been 14 interruptions of six of the cables, without reckoning renewals and strengthenings of weak places. The cable steamer "H. C. Orsted" had been employed on active service for 157 days and the "Store Nordiske" for 229 days, 113 of which, however, were for the account of other administrations, including the Japanese Government. Amongst the work executed for the latter was a second connection between the Japanese Islands of Tsushima and Iki, the cable having been taken from their stock in China, and the value credited to the reserve fund. In Siberia the Wladiwostock line had not given all the satisfaction that could be desired, neither with regard to the condition of the line itself nor to the transmission of the traffic. The Russian Government has, however, sanctioned the outlay of considerable amounts for improvements, and the Imperial Telegraph Administration is actively engaged in the restoration of the line and the reorganisation of the service. The military and political events in the Far East, which during the latter half of 1894 created an extraordinary traffic on our eastern cables, might be said to have lasted during nearly the whole of 1895, although the war between China and Japan was practically ended in March, and peace finally concluded on April 17th last year. Japan had, however, to continue military operations on the Island of Formosa, the pacification and annexation of which was accomplished towards the end of the year. The missionary troubles and the insurrectionary movements in China, as well as the numerous political and financial negotiations between Europe and the far East were also responsible for the large traffic during the past year. Nearly the whole of this traffic had passed over their cables, as the competing Chinese lines had practically been closed owing to the war and to the refusal of the Chinese Administration to transmit code telegrams over their lines, and it was only in December last that the competition of the Chinese line (the Helampo route) with the cables was resumed, and it was taken up with the same animosity as in 1893-94, forcing them to reduce their rates in China to the same level as those of the Chinese. This resumption of the competition came on them as a surprise, as in order to avoid it they opened friendly negotiations with the Chinese Administration in March last. In these negotiations they went to the utmost possible limit of concessions, but the competition was resumed without any definite answer having been given to their proposals. In spite of this, and thanks to the extraordinary events already mentioned, and to the satisfactory traffic on the European system, the year 1895 had, nevertheless, been an exceptional one from a financial point of view. The net traffic receipts amounted to £370,700, or £55,935 more than in 1894, although the value of the dollar had not sensibly increased during the year. "Sundries" also came to an unusual figure, due to the extensive employment of the cable steamer "Store Nordiske" by other administrations, as already referred to. The Board of Directors have, therefore, decided to propose to make the final dividend 2s. 10d. per £10 share more than the preceding years, which would make a total dividend of £1, or 10 per cent. This proposal has been made by the Directors after considerable hesitation. It might have been more prudent to keep the whole of the exceptional surplus receipts in reserve, in order to place the Company in a better position to face the demands and claims which are sure to be made in the near future, although provisionally put off by extraordinary and unforeseen events. Their differences with China were sure to entail great sacrifices on their part, and in addition they must be prepared to meet demands for great reductions in their tariffs at the forthcoming International Telegraph Conference. Lastly, the efforts for completing the submarine telegraph system of the globe by the laying of cables in the Pacific had lately developed to such an extent that they might be called upon at any moment to take an active and costly part therein. With the view of strengthening their resources and their resisting power, the Amortisation Fund has been increased by adding an extraordinary amount to the same. Finally, in referring to the death of Col. V. Hoskier Commodore Suenson said the Company had suffered a great loss through his death. Col. Hoskier took a very active part in the organisation of their technical service in the early days of the Company, and supervised the manufacture and laying of several of their cables.

The report and balance sheet were then unanimously agreed to. The retiring Director (Mr. C. F. Tietgen) was re-elected, and Lieut.-Col. V. E. Tychsen was elected a Director in the place of the late Col. Hoskier.

## London Platino-Brazilian Telegraph Company (Limited).

The report of the Directors to be presented at the meeting to be held at the offices, Blomfield House, London Wall, E.C., to-day (Friday) states that to December 31st last the total earnings amounted to £21,564. 17s. 8d., against £20,674. 6s. 8d. in the previous year, and the working expenses to £8,051. 5s. 11d., against £7,895. 11s. 10d. Including the amount brought forward (£332. 19s. 2d.) the balance to credit of revenue was £13,846. 10s. 11d., from which has been deducted £6,000 for debenture interest and £411. 11s. 4d. for income tax. After placing £1,500 to reserve, £5,934. 19s. 7d. remains for distribution. The Directors recommend that a dividend at the rate of £1. 5s. per cent. per annum (2s. 6d. per share) be paid for the year, carrying forward £1,241. 9s. 7d., payable to-day.

The lines of the Company are in good working order.

Mr. W. S. Andrews and Mr. D. H. Goodsall offer themselves for re-election as Directors, as do the auditors, Messrs. Deloitte, Dever Griffiths and Co.

## Submarine Cables Trust.

The following report of the trustees will be presented to the annual meeting of certificate holders, to be held at the offices, 50, Old Broad-street, London, this day (Friday), at 2:45 p.m.:—

The accounts for the financial year to April 15th show that the revenue, including the balance of £224. 11s. 5d. brought forward, amounted to £22,538. 6s. 6d. During the past year the usual coupon payments have been met. The expenses of the Trust amounted to £1,099. 14s. 4d., and payments on account of the coupons to £21,131. 5s. (together £22,230. 19s. 4d.), leaving £307. 7s. 2d. to be carried forward. The investments of the Trust remain unchanged since last year.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**BROTHERTON'S TUBE COMPANY (LIMITED).**—This Company has been registered, with a capital of £20,000 in £1 shares, to acquire the undertaking of the Excelsior Tube Works, Wolverhampton, and to carry on the same.

**LIVERPOOL METER COMPANY (LIMITED).**—This Company was registered on April 25th with a capital of £30,000, in £1 shares, to carry on the business of mechanical engineers, electricians, iron and brass founders, metal workers, metallurgists, and of manufacturers and dealers in all apparatus required for or capable of being used in connection with the production, generation, distribution, measurement and employment of electricity and gas.

**RANSOMES AND RAPIER (LIMITED).**—This Company has been registered with a capital of £100,000, in 1,500 Preferred shares and 8,500 Ordinary shares of £10 each, to acquire the business carried on at the Waterside Ironworks, Ipswich, under the style of Ransomes and Rapier.

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and to carry on the business of mechanical and electrical engineers, and manufacturers of engines, cranes and other machinery, tool and boiler makers, machinists, &c.

**TELESCRIPTOR SYNDICATE (LIMITED).**—This Company was registered on April 22nd with a nominal capital of £40,000 in £1 shares, to acquire certain patents and inventions of Bernhard Hoffmann relating to telegraphic apparatus and to typewriting machines, and also to establish, work, control and regulate electric recording systems, and to carry on the business of a telescriptor, veloscriptor, telephone and telegraph company. The first subscribers, with one share each, are:—L. Epstein, electrical engineer, P. Hoffman, C. M. Owen, B. Hoffman, inventor, P. Holyoake, C. F. Jones and C. Scott.

**LIVERPOOL ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return to March 13th has been filed. 50,000 shares have been subscribed for out of a capital of £300,000, in £5 shares, and the full amount has been called and paid.

**NATIONAL TELEPHONE COMPANY (LIMITED).**—The annual return to March 5th has been filed. The nominal capital is £4.000.000, divided into 15,000 First Preference shares of £10 each, 15,000 Second Preference shares of £10 each, 250,000 Third Preference of £5 and 490,000 Ordinary shares of £5 each. All the First and Second Preference, 19,234 Third Preference and 484,597 Ordinary have been taken up; 28,284 Third Preference and 44,413 Ordinary have been issued as fully paid. The full amount has been called and paid on the remainder.

**SCARBOROUGH ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return to April 2nd has been filed. The nominal capital is £50,000, in £10 shares: 3,434 shares have been subscribed for, and a call of £9 per share has been made.

**SHEFFIELD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).**—The annual return to April 6th has been filed. 8,625 shares have been taken up out of a capital of £98,000, in £7 shares, and 4,000 have been issued with £5 per share considered as paid. A call of £4 per share has been made on 4,625, and £2 per share on 4,000 shares.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31⅛d. per oz. (April 30th). Consols (2¾ per cent.) 111⅛–111⅛ for money, 111⅛–111⅛ for account; 2½ per cent. 105—105½ (April 30th). Stock Exchange Settling Days: Consols, May 4th to May 6th; Stocks and Shares Continuation Day, May 12th; Ticket Day, May 13th; Pay Day, May 14th; Mining Share Carry-over Day, May 11th.

**AKTIENGESELLSCHAFT FUR FABRIKATION VON KOHLENSTIFTEN VORM F. HARDTMUTH AND CO.**—This is the title of a Company which has been formed at Vienna with a capital of 1,260,000 marks (about £63,000) to acquire the business of manufacturers of electric light carbons, hitherto carried on by Messrs. F. Hardtmuth and Co., at Plania, near Ratisbor Silesia), and at Vienna, and generally to carry on business as carbon manufacturers and dealers.

**AKTIENGESELLSCHAFT MIX AND GENEST (BERLIN).**—The annual meeting of the shareholders of this Company was held on the 22nd ult., when a dividend at the rate of 8 per cent. was declared. The Directors report a promising outlook for the current year.

**ALLGEMEINE ELEKTRICITATS GESELLSCHAFT (BERLIN).**—It is stated that the Directors intend to increase the capital of this Company by M.3,000,000, in order to provide means for the further expansion of the business, and to erect cable works, a scheme for the establishment of which is at present being elaborated.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended April 26th were £889, against £900 in the corresponding week of 1895, a decrease of £11. The total receipts for the half-year amount to £16,149, against £16,119 for the corresponding period of 1895, an increase of £30.

**CONTINENTAL METROPOLITAN TRAMWAYS COMPANY (LIMITED).**—At the meeting of this Company last week the Chairman (Mr. B. H. Van Tromp), referring to the question of traction, said the Paris municipal authorities were becoming alive to the advantages of mechanical traction, and were pressing the various companies under their jurisdiction to submit their conditions for its general introduction. The Directors of the Continental Metropolitan Company had signified their willingness to adopt mechanical traction provided their concession was prolonged for another thirty years, but the Paris Council would not entertain this proposal. They had to submit other conditions which were at present being considered by the Council. The cost of working the tramways mechanically would be considerably less than at present, but they would have to allow for the amortisation of the capital in 14 years. They had, therefore, decided to ask the town for a subsidy of £16,000 a year to get over that difficulty.

**ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY (LIMITED).**—The annual meeting of the shareholders of this concern was held on Monday last, Mr. John MacFarlan presiding. The chairman referred to the financial transactions mentioned in the abstract of the report given in our last issue, and contended that as a result of these operations the position of the Company had greatly improved. The depreciation shown in the accounts had been in 1893, £3,300. 0s. 10d.; 1894, £3,198. 4s. 7d.; and 1895, £2,554. 8s.—in all £9,052. 13s. 5d. The Directors had spent £2,511. 16s. 3d. during the year in putting down additional plant and in alterations to the old plant. The sales were more than double, while the amount spent on manufacturing, purchases, and wages, after deducting copper, was not much larger than in 1894, and the stock in trade in hand on December 31st was £2,194. 3s. 6d. more than on December 31st in the previous year. One of the difficulties connected with the business was that a large working capital was required. In other industries, as a rule, the raw material was cheap, but in their business the raw material was very expensive, and while they had to purchase for cash, they were compelled to sell at three months credit, according to the conditions of the trade. At present a sum of £11,478. 9s. 5d. was locked up in copper stores and sundry debts. The value of the work done in 1893 was £3,194. 3s. 4d.; in 1894, £8,130. 10s. 10d.; and in 1895, £17,052. 12s. 3d., which went to show that some progress had been made. They had received as many as 110 repeat orders from one firm, and had again secured the Imperial Railway's contract for the present year, and also contracts with other important manufacturing firms in Germany. They had, in addition, supplied the Government with a certain quantity of goods during the past year, concerning which they had not received a single complaint. Many improvements had been made during the past year, the small tube trade having been developed to a considerable extent, and they could now produce tubes from one-eighth of an inch up to 7ft. in diameter. The number of orders that they had in hand precluded them from fixing an early date for delivery, and in some cases they were compelled to refuse good paying work. The sales for the current year, up to the 19th inst., amounted to 59¼ tons (of the value of £5,648), compared with 40¾ tons (of the value of £3,706) last year. A further sum of £25,000 was required in order to carry out certain necessary extensions of the plant which the Directors considered urgent, and also to pay £4,200, being balance of the final instalment on the property of the Austrian Company. In conclusion the Chairman stated that negotiations had been begun for the working of their Austro-Hungarian patents.

**GREAT NORTHERN TELEGRAPH COMPANY.**—Notice is given that the coupons for the year 1895 (No. 36) on this Company's shares should be presented for payment at the offices of Messrs. C. J. Hambro and Son, 70, Old Broad-street, E.C.

**HASTINGS AND ST. LEONARD'S-ON-SEA ELECTRIC LIGHT COMPANY (LIMITED).**—The annual meeting of this Company was held at Hastings on Friday last, the Chairman (Mr. F. A. Langham) presiding. In moving the adoption of the report and accounts, the Chairman expressed regret at the character of the report, but said the prospects of the Company were good. During the year current was supplied to 8,199 lamps, an increase over the previous year of 988. The law expenses were £137 more than last year, £840 had been lost on the sale of installation fittings, and the bad debts came to £355 more than last year. Taking all these items into account, the net increase of income amounted to £537. Inclusive of these extraordinary items, the income had increased by £1,302, and the expenditure by £600, and the shareholders could thus see that they were not in a position to pay a respectable dividend. He was not sure that the new system of charging for current benefited either the Company or the consumers. Large consumers might derive benefit; but in order to obtain the full advantage electricity should be as liberally used as gas. The more current they used, the cheaper it would be. He regretted that the public lighting had been a great burden to the Company, as it entailed an absolute loss. They had carried out their contract to light the Front at a very low sum, and the loss on this account alone meant quite sufficient to pay a dividend, and until they could get rid of the contract, or obtain better terms, the Company could not be in a flourishing condition. The Directors had also under consideration the question of the price they should charge the Corporation for current. If they did not wish to continue the supply, the Corporation was bound to buy the fittings at a valuation, so that the shareholders would get some of their money back. Their private incandescent lighting business was sufficient to keep them busy. After the motion had been seconded, Dr. B. H. Allen expressed disappointment at the report, and attributed their position to want of economy. The motion was eventually agreed to.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 26th inst. amounted to £1,168. The amount for the corresponding week last year was £1,121. Increase £47.

**OXFORD ELECTRIC COMPANY (LIMITED).**—We are informed by the secretary that the recent issue of £5 Ordinary shares was over applied for.

**QUEEN ANNE'S MANSIONS LIGHTING AND HEATING COMPANY (LIMITED).**—A meeting of the debenture holders will be held on Monday at 251, Winchester House, E.C., at three o'clock, for the purpose of approving an agreement dated April 22nd, modifying a document dated May 16, 1895.

**STOCK EXCHANGE NOTICES.**—Applications have been made to the Stock Exchange Committee to allow the undermentioned stock to be quoted in the official list:—Crompton and Company (Limited), £82,850 Five per Cent. First Mortgage Registered Debentures; National Telephone Company (Limited), further issue of £229 471 Three and a-Half per Cent. Debenture stock; Sir W. G. Armstrong, Mitchell and Co. (Limited), 77,555 Four per Cent. Cumulative Preference shares.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company have decided, subject to final audit, after placing £3,000 to the reserve fund and £7,952 to the debenture redemption fund to recommend, at the forthcoming meeting of shareholders, the payment of 5s. 3d. per share, free of income tax, making, with the interim dividend paid in November, a total distribution of 3 per cent. for the twelve months to December last, the same as paid for 1894. This will give 5s. 3d. to the Ordinary, 3s. 9d. to the Preferred Ordinary, and 1s. 6d. to the Deferred Ordinary shares. This Company's traffic receipts for the week ended April 24th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,648.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company have decided to recommend the payment of a dividend of 6s. per share on the First and Second Preference shares, and 1d. per share on the Ordinary shares for the six months ended December 31st last

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name | Previous Week's Price, Apr. 22. | Price Wednesday, Apr. 29. | Rate per Cent. Yielded. | Dividend Due | Business Done During Week Ending Apr. 25. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 49 51 | 49 51 | 4 18 0 | Jan., Apr., July, Oct. | 51 | 49½ |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 92 93 | 92 93 | 5 7 6 | " " | 93½ | 91½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9½ 10 | 10 10½ | .. | .. .. | 10¼ | 9⅝ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 10 | January and July .. | 102¼ | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10½ 11 | 10½ 11 | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 14¼ 14⅝ | 14¼ 14⅝ | 4 14 11 | Mar., June, Oct., Dec. | 14⅝ | 14½ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 117 | 113 117 | 4 6 7 | June and December | .. | .. |
| 10,000,000 | $100 | $1½ | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 2 7 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ 13½ | 12 13 | 6 3 1 | February and August | 13 | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20½ 21½ | 20½ 21½ | 4 13 0 | " " | 20¾ | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 4 5 | 4 5 | 4 0 0 | April and October .. | 4 | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 15 3 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 106⅞ 109⅞ | 108⅞ 109⅞ | 4 3 9 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10 | 9½ 10 | 4 0 0 | Jan., Apr., July, Oct. | 9¾ | 9⅝ |
| 400,000 | 10 | 2/6 | Eastern | 17 17½ | 17 17½ | 3 14 4 | " " | 17⅝ | 17½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18 18½ | 18 18½ | 3 4 10 | " " | 18½ | 18 |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock ..xd | 130 133 | 129 132 | 3 0 7 | May and November | 132⅜ | 131½ |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 109 | 104 107 | 4 14 7 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 17⅞ 18¼ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅛ | 18 |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 129 132 | 130 133 | 3 0 7 | February & August | 132 | 130½ |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 101 105 | 101 105 | 4 16 7 | January and July .. | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 16 7 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 108 | 105 108 | 3 14 9 | February & August | 105½ | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 112⅞ 115⅞ | 112⅞ 115⅞ | 3 10 10 | May and November | .. | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust | 10½ 11 | 10⅝ 11 | 4 1 10 | Jan., Apr., July, Oct. | 10¾ | 10½ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 16¾ 17½ | 16¾ 17½ | 3 9 7 | " " | 17⅛ | 16¾ |
| 150,000 | 10 | 5/0 | Great Northern | 23 23½ | 23 23½ | 3 8 2 | Jan., April, and July | .. | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 14 1 | March & September | .. | .. |
| 17,000 | 25 | 12/6 | Indo-European | 53 56 | 53 53 | 4 9 3 | May and November | 54½ | 52½ |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 108 111 | 109 112 | 5 8 1 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 11 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 5 6 | 5 6 | .. | April and October .. | .. | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 133 138 | 133 138 | 4 6 11 | " " | 136 | .. |
| 15,609 | 10 | 2/0 | West African Telegraph | 5⅛ 6⅛ | 5⅛ 6⅛ | .. | January and July .. | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 105 | 102 105 | 4 15 11 | March & September | 104½ | 103 |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. | January and July . | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 97 102 | 97 102 | 8 0 0 | June and December | .. | .. |
| 88,321 | 10 | 1/3 | West India and Panama | 1 1¼ | 1⅛ 1⅜ | .. | .. | 1 1/16 | 1 1/16 |
| 34,568 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 11⅝ | 11½ 11⅝ | 5 2 2 | May and November | 11⅝ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 11 1 | June and December | 109½ | .. |
| 64,248 | 15 | 3/9 | Western and Brazilian | 8½ 9 | 9 9½ | 5 2 9 | May and November | 9½ | 8 13/16 |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6½ 6¾ | 6½ 7 | .. | — | 6 11/16 | 6 5/16 |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 2⅝ | 2⅝ 3 | .. | — | 2 11/16 | 2⅝ |
| £165,200 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 104 108 | 104 108 | 5 12 8 | February & August | .. | .. |
| £206,400 | 100 | 6% | Do. 6% Mort. Debs., Series "B" 1910 | 104 108 | 104 108 | 5 12 8 | " " | — | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 113 118 | 113 118 | 6 2 2 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 105 | 102 105 | 5 15 5 | March & September | .. | — |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3 3½ | 3 3½ | .. | — | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Maintenance | 1/16 1/8 | 1/16 1/8 | .. | May and November | .. | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) ..xd | 1/16 1/8 | 1/16 1/8 | .. | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7 7½ | 7⅛ 8⅛ | 3 7 8 | June and December | 7⅛ | 7 |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 18 | 16 18 | 3 6 8 | " " | 17½ | 17 |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16½ 17½ | 16½ 17½ | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅝ 6¾ | 6⅝ 7 | 3 11 5 | — | 6¾ | 6⅝ |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 4½% (red.) | 106 109 | 108 111 | 3 3 6 | January and July .. | 108¼ | 107½ |
| 58,000 | 5 | 3/0 | United River Plate | 3½ 4 | 3½ 4 | .. | " " | .. | — |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 96 101 | 97 102 | 4 19 6 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14 15 | 14½ 15½ | 3 4 6 | — | 15 | 14⅛ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ 17 | 16½ 17 | 3 10 7 | — | 17 | 16 1/16 |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 138 | 134 138 | 3 13 3 | June and December | 135½ | — |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | — | 7 1/16 | 7½ |
| £80,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 7½ 7⅞ | 7½ 8 | .. | — | .. | .. |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — — | — — | .. | — | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. | — | 8⅜ | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ 13½ | 12½ 13½ | .. | — | 12⅝ | 1 1/16 |
| 8,322 | £5 | .. | House-to-House Electric | .. .. | — — | .. | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. | January and July .. | — | — |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 7⅞ 7⅞ | 7⅞ 7⅞ | 3 16 2 | — | — | — |
| 111,000 | 5 | .. | London Electric Supply | .. .. | .. .. | .. | — | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13 14 | 13 14 | 2 17 2 | — | 13⅜ | 13½ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 118 120 | 119 122 | 3 14 10 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9 9½ | 9 9½ | .. | — | .. | .. |
| .. | .. | .. | Rand Electric | ⅜ ½ prem. | ⅜ ½ prem | .. | — | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 10¼ 10¾ | 10¼ 10¾ | .. | — | 10¾ | 10¼ |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 3 6 | — | 10¾ | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9¼ 10¼ | 9¼ 10¼ | 3 8 4 | — | 10 | 9¼ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1⅝ 1⅞ | 1⅝ 1⅞ | 5 8 8 | — | .. | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅝ 1⅞ | 1⅝ 1⅞ | 3 4 0 | — | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 114 | 111 114 | 3 19 6 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2¼ 2⅜ | 2¼ 2¼ | .. | January and July .. | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United | 1¼ 1⅜ | 1¼ 1¼ | .. | .. | .. | .. |
| £100,000 | Stock | 4½% | Do. 4% Mortgage Debenture Stock | 104 107 | 104 107 | 4 5 4 | .. | .. | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | — — | — — | .. | .. | — | — |
| 110,000 | 2 | .. | Electric Construction | 1⅜ 1⅝ | 1⅜ 1⅝ | .. | .. | 1 1/16 | .. |
| 12,845 | 2 | 2/9 | Do. 7 per Cent. Cumulative Pref. | 2¼ 2⅜ | 2¼ 2⅜ | 5 1 10 | .. | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅜ ⅝ | ⅜ ⅝ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | ¼ ½ | ¼ ½ | .. | .. | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 22 23 | 2 ⅛ 23½ | 4 5 1 | February & August | 23½ | 22½ |
| £200,000 | 100 | 4½% | * Do. 4½ per Cent. Debentures, 1896 | .. .. | .. .. | .. | March & September | .. | — |
| 15,995 | £10 | .. | International Okonite Ordinary | .. .. | .. .. | .. | — | — | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | — — | .. .. | .. | December and June | — | .. |
| 20,000 | 9 | .. | Manchester Edison-Swan "A" (£1 5s. paid) | ⅛ ¼ | ⅛ ¼ | .. | .. | .. | — |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 41 | 38 41 | 4 7 10 | March and July | 40 | 38½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 105 | 102 105 | 4 16 7 | January and July . | .. | — |
| 37,514 | £5 | — | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. .. | .. .. | .. | — | — | — |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. .. | .. .. | .. | — | — | — |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16½ 17½ | 16½ 17½ | 3 8 7 | — | — | — |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 16½ 17½ | 16½ 17½ | 4 0 0 | — | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 107 112 | 107 112 | 4 0 11 | — | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 40 42 | 40 42 | 2 19 6 | May and November | 41½ | .. |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15 | 14½ 15 | 3 6 8 | .. | 15 | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture ..xd | 135 137 | 133 135 | 2 19 3 | May and November | 137 | 136 |
| 87,500 | £10 | 3½% | Liverpool Overhead Railway | 14 14½ | 14 14½ | 2 2 6 | — | — | — |
| 10,000 | 10 | 5% | Do. 5% Preference | 16⅜ 16¾ | 16⅜ 16¾ | 2 19 3 | — | — | — |
| 145,000 | Stock | 4% | Do. 4% Debenture | 114½ 116½ | 114½ 116½ | 3 10 2 | January and July .. | — | — |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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The said Debentures will be PAID OFF at par on the 1st JULY next, at PARR'S BANKING COMPANY AND THE ALLIANCE BANK, Limited, Bartholomew-lane, London, E.C., after which date the interest thereon will cease.

120 DEBENTURES of £100 each, numbered

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 209 | 430 | 555 | 663 | 938 | 1081 | 1337 | 1515 | 1673 | 1997 | 2214 |
| 14 | 218 | 437 | 561 | 672 | 942 | 1082 | 1368 | 1549 | 1719 | 2026 | 2285 |
| 23 | 223 | 438 | 562 | 699 | 984 | 1120 | 1377 | 1589 | 1798 | 2069 | 2294 |
| 51 | 240 | 446 | 563 | 781 | 997 | 1163 | 1395 | 1593 | 1855 | 2096 | 2318 |
| 61 | 281 | 453 | 578 | 794 | 1011 | 1182 | 1405 | 1605 | 1886 | 2123 | 2319 |
| 70 | 287 | 459 | 580 | 818 | 1034 | 1204 | 1414 | 1610 | 1920 | 2125 | 2361 |
| 87 | 306 | 488 | 590 | 854 | 1037 | 1228 | 1427 | 1625 | 1945 | 2136 | 2372 |
| 92 | 334 | 506 | 596 | 884 | 1050 | 1281 | 1430 | 1650 | 1947 | 2177 | 2425 |
| 121 | 346 | 514 | 614 | 897 | 1060 | 1316 | 1448 | 1656 | 1952 | 2193 | 2427 |
| 191 | 429 | 547 | 657 | 923 | 1061 | 1323 | 1491 | 1657 | 1995 | 2203 | 2496 |

For £100 Sterling each ..... £12,000.

Countersigned, By order
W. E. VENN, H. E. PLANK, Secretary.
2, Pope's Head-alley, Cornhill, E.C.
Notary Public.
London, 1st May, 1896.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY
(Limited).

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By order,
RICHARD COLLETT, Secretary.

Winchester House, Old Broad-street,
London, E.C., May 5th, 1896.

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Aberdeen, 20th April, 1896.

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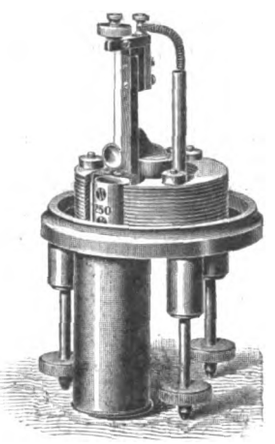

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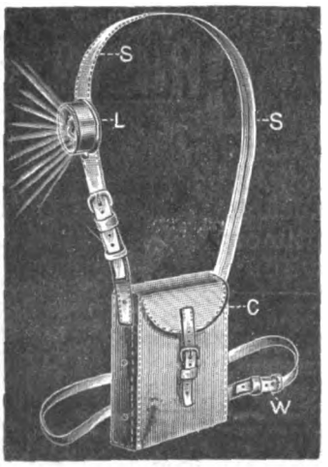


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Electro-Magnetic Theory—Electric Displacement—Maxwell's Theory—Displacement Currents and Displacement Waves—Mechanical Illustrations—Theory of Molecular Vortices—Comparison of Theory and Experiment—Velocity of Propagation of Electro-Magnetic Disturbances—Values of "$p$"—Vector Potential—Electrical Oscillation—Discharge of Leyden Jar—The Function of Condenser in the Induction Coil—The Alternative Path Experiments—Impulsive Impedance—Hertz's Researches—Resonance of Circuits—Interference Phenomena—Identity of Light and Electro-Magnetic Waves—Confirmatory Experiments—Experimental Determination of the Velocity of Propagation of Electro-Magnetic Waves—Recent Views.

**CHAPTER VI.—The Induction Coil and Transformer.**

General Description of the Action of the Transformer or Induction Coil—Experimental Determination of the Form of Current and Electromotive Force Curves—Curve Tracers—Discussion of Transformer Diagrams—Current and Electromotive Force Curves in Various Cases—Harmonic Analysis of Transformer Curves—Curves of Magnetic Induction—Power and Hysteresis Curves—Experimental Determination of Iron Arc Losses in Transformers—Practical Use of the Wattmeter—Efficiency Curves of Transformers—Secular Change in Hysteresis Loss in Transformers—Current Rushes into Transformers at Moment of Making Connection with the Circuit—General Theory of Transformer Action—The Power Factor—Importance of Large Power Factor—Open and Closed Circuit Transformers—Regulation and Secondary drop in Transformers—Magnetic Leakage—Control of Copper and Iron Losses in Transformers—Heat Radiation from Transformers—Transformer Specifications.

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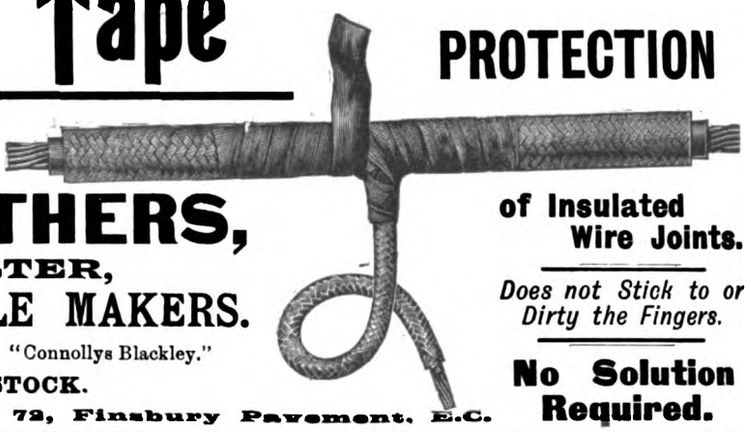

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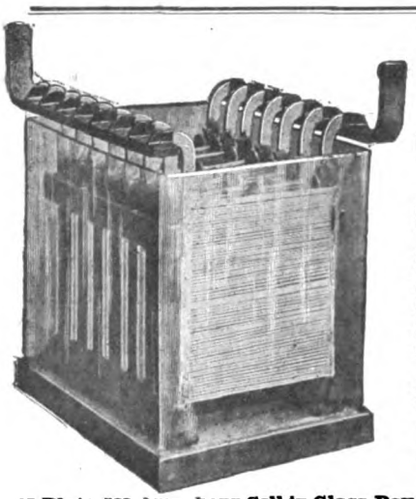

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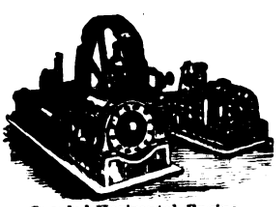

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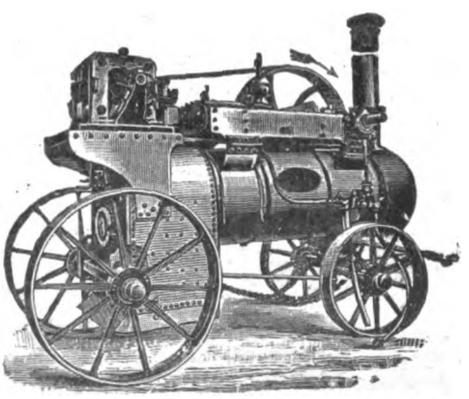

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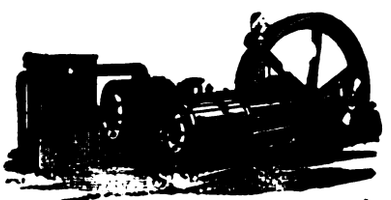

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

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## NOTES.

THE two most interesting electrical exhibits shown at the Royal Society *soirée* on Wednesday evening were Prof. EWING'S beautiful apparatus for rapidly making permeability measurements, a description of which will be found in another column, and the novel resistance boxes shown by Mr. E. H. GRIFFITHS and Mr. F. W. BURSTALL, which we hope to fully describe in a later issue. Mr. CAMPBELL SWINTON was allotted an entire room for the purpose of giving demonstrations of the Röntgen radiography, and Mr. HERBERT JACKSON, of King's College, was also in evidence with his focus tube.

A PRETTY little exhibit, due to the Rev. F. J. SMITH and Mr. VERNON BOYS, consisted in geometric wall brackets and geometric steady blocks. The object of these brackets is to provide wall supports with definite position for physical apparatus. Three small projections are fixed to the wall. Of the two upper ones, one is furnished with a triangular indentation, the other with a V-groove, the third having a vertical flat surface. The brackets are furnished at the top with hemispherically-ended screws, which drop into the recesses in the upper blocks, and at the bottom with a third screw, which rests against the flat projection. Three points of contact are determined by the sphere-and-triangle support, and these rigidly determine two in the sphere-and-cup support and one on the wall plate. Thus the system is completely and rigidly determined. The same idea is carried out in regard to the geometric steady blocks.

ALUMINIUM is probably the last metal to be recommended for fusible cut-outs. It will fuse readily enough, but it will not cut-out, at least not with any degree of promptness; it prefers to remain as a conducting filament of red-hot molten metal bridging across the terminals. At the Royal Institution last Tuesday Mr. VERNON BOYS showed a very effective experiment to illustrate the reluctance of a melted aluminium wire to break up into detached drops, as any self-respecting cylinder of liquid ought to do. Some eight or ten inches of fine aluminium wire were secured between two binding pillars, and a current sufficient to raise the wire to bright red heat was gradually switched on. While the wire was in this perfectly molten condition, the temperature being well above the melting point, a magnet pole was moved about in its neighbourhood. The liquid filament was attracted or repelled at will, and when sufficiently powerfully repelled it looped itself with the evident intention of getting into such a position that it would be attracted. The intention was fatal, for the moment the loop was completed the points of contact coalesced and the liquid system instantly collapsed.

As another instance of the highly-developed capillary properties of liquid aluminium, Mr. BOYS showed how enormously large are drops of molten aluminium in comparison with water or mercury drops of the same shape. In liquid aluminium the surface tension is very high, while the density, as compared with other metals, is very low. Consequently drops of aluminium approximate to a sphere in much larger sizes than in any other known metal, except perhaps magnesium. It is to this that the apparent pastiness of molten aluminium is due. That there is no real pastiness is quite evident from the fine lines which it will take in making a casting.

A DISCUSSION extending over three evenings is apt to become distinctly wearisome and sadly irrelevant, as those who were present on the occasion of the recent house-wiring debate at the Institution of Electrical Engineers know to their cost. It is doubtful, moreover, whether any scientific or engineering subject under the sun is worth so prolonged a tossing "upon the arguments of counsel." The Institution of Mechanical Engineers, however, did well not to keep the debate on steam-superheating within too narrow time limits. Regarded as a matter affecting modern steam practice, the subject is one of prime importance, and quite as worthy of the large amount of time devoted to it as anything we know of. But it certainly was regrettable that so long an interval as three months should have elapsed between the reading of Mr. PATCHELL'S Paper and the resumption of the discussion. Some of the later speakers had obviously forgotten the contents of the Paper, while others missed the chief point which its author had in view.

AT Maiden-lane station Mr. PATCHELL has found that the use of superheaters on a portion of the boiler plant results in both a higher economy and a greatly improved duty. More power can be got out of a given weight of fuel, and more steam out of a given space in the boiler room. It is true that the steam does not reach the engines in a superheated state, owing partly to the admixture of steam from the other

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boilers and partly to radiation. But it is quite beside the mark to say that the apparatus is not a superheater. It is also beside the mark to say that Mr. PATCHELL has devoted too much attention to the boiler gain and too little to the engine gain. For the laudable purpose of clarifying matters in text-books and in class-rooms there may be some advantage in saying that, theoretically, superheating gives only an engine gain. What the practical man wants to know is what it will do practically and on an £. s. d. basis; and as in practice we have not succeeded in getting superheated steam in the engine on the working stroke, and but rarely get it at the stop-valve, it is more to the point to pay attention to the improvements which a superheater brings about in the boiler plant, in the better utilisation of the heat from the furnace, and in the extra duty in evaporation.

WHATEVER may be the measure of success attending gas-engine electric supply stations on the Continent, those at home are not, it would seem, unqualified successes. At Coatbridge the gas plant has been replaced by steam, at Morecambe the station was declared a public nuisance and was for some time shut down, while at Belfast it has practically been decided to erect a steam-driven station capable of filling the future requirements of that city. The Belfast gas-engine station was originally the initial stage in a scheme of gas-power sub-stations, a system of which the late Mr. DENNY LANE was the first and most powerful advocate. It would be rash to infer from these three deviations from success that gas-power electric supply stations must of necessity fail; but it is highly probable that for some time to come both capitalists and engineers will draw the practical conclusion that this class of installation should be left severely alone. Pending further particulars as to why the Belfast municipal authorities do not propose to proceed with their original scheme, we cannot but regret that the matter has taken so unfortunate a turn. Coatbridge had elements of failure not essentially gaseous; Morecambe was too rough-and-ready a pioneer job to ensure permanent success; but of Belfast we had hoped that its sound modern design and solid construction would place the gas-engine station system on a secure and lasting footing. Unfortunately, the outcome of the Belfast venture seems to point to the temporary failure of this type of electric supply station, at any rate under conditions met with in this country.

THE exhibition now being held at the Crystal Palace, to which further reference is made in another column, is accurately described as horseless, for the greater number of exhibits are merely ordinary carriages with the horses taken out of the shafts. These are supposed to be of historic interest, to mark the era of quasi-civilisation which has led up to the glorious age of motor cars. As to the motor cars themselves, we saw a considerable variety within the building, and a couple running in the grounds. One of these latter was propelled by steam and the other by petroleum spirit. Both the one and the other was preceded by a great wave of noise, rendering the oft-repeated injunction to "Beware of the Horseless Carriages" quite superfluous, while the spirit-propelled vehicle had an equally pronounced wave of odour behind it. That is how we first learned it was driven by spirit. When it stopped to take up a fresh cargo of adventurous passengers its spirit was even more in evidence. Never did a restive steed prance with more vigour than did that petroleum-driven carriage; it was as if the spirit of ST. VITUS himself had got into the works. Something ought to be done to subdue the impatience of this benzolene steed when it is required to stand still a little while, for the vigorous jiggle which it maintains all the time is by no means inviting to a ride. Electric cars in active operation were conspicuous—by their absence.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique ..... ..... | Dec. 19, 1895. |
| Ceara—Maranham ..... | April 28, 1896. |
| San Thomé—Loanda ..... | May 2, 1896. |
| Monte Alegre—Santarem ..... | May 5, 1896. |

**Royal Society.**—Among the Papers down for reading on Thursday was one by Prof. Gotch, F.R.S., and G. J. Burch on "The Electromotive Properties of *Malapterurus Electricus*."

**The Evaluation of a Unit.**—It seems that in Vermont, U.S.A., there exists an unrepealed law to the effect that "one bushel and three-quarters of a peck shall be deemed a bushel."

**Appointment.**—Mr. E. W. Dickinson, late of the Bolton Corporation Electricity Works, has been appointed engineer to the Trinidad Electric Light and Power Company (Limited), Port of Spain, Trinidad.

**The "Sir John Pender" Gold Medal.**—The "Sir John Pender" gold medal, which is awarded annually to the best student of the electrical engineering department of the Glasgow and West of Scotland Technical College, has been won by Mr. Alex. H. Weddell.

**Compagnie Française des Cables Télégraphiques.**—We learn that the French cable steamer "François Arago" is at Havre refitting, and that she will be chartered by the Compagnie Française des Cables Télégraphiques to repair their West Indian system of cables.

**Terrestrial Magnetism.**—According to "Terrestrial Magnetism," M. Moureaux has been requested by the Imperial Russian Geographical Society to investigate the cause of an anomaly in the distribution of terrestrial magnetism, which certain observations have revealed in Southern Russia.

**Electric Railways for Brussels.**—According to a Brussels newspaper, the Belgian Government has determined to unite the two great terminal stations in that city by six underground tracks, and to construct a central station and a girdle line around the city. Two of the underground lines are to be worked by electricity.

**South-West London Polytechnic Institute.**—The governing body of this Institute have decided to hold the first annual conversazione on Saturday next, May 9th. Among other special items of interest may be mentioned the demonstrations and experiments of Messrs. Edser and Clark on "New Photography," including some negatives of fractures and necrosis.

**A Pacific Cable.**—A Reuter's telegram states that a Bill for the construction of a United States-Hawaii-Japan cable has been approved by the Senate Committee, and authorises the U.S. Postmaster-General to contract with any company to lay the cable with an annual subsidy not to exceed $160,000. The report estimates the cost of the cable at $3,400,000, and the annual maintenance at $586,000 for the first five years.

**Bacteria and Electric Currents.**—On page 71 of our issue of November 15th last, we alluded to some interesting and some what amusing experiments by a Dr. Waller on the behaviour of tadpoles when exposed to the influence of the electric current. In the *Comptes Rendus* for April 20th, M. L. Lortet, in a communication on "The Influence of Induced Currents on the Orientation of Living Bacteria," describes how he placed some bacteria in a drop of liquid, through which he passed in various

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directions the current from an induction coil; they invariably arranged themselves so as to become parallel to the direction of the current.

**Polyphase Motors in a Shoe Factory.**—The operation of shoe factories by electricity seems to be making steady headway in America. The General Electric Company of America is about to undertake the electrical equipment of a large shoe factory in Norway, Me. Seven non-synchronous multiphase motors, aggregating 100 H.P., will be put in. The current will be taken from the 250-kilowatt three-phase generator recently set up in its station by the Norway Electric Light Company.

**Three-Phase Patent Litigation in Germany.**—The three-phase patent of the Helios Company of Cologne, against which an action was brought a little time ago by Messrs. Schuckert and Co., the Allgemeine Elektricitäts Gesellschaft, Siemens and Halske, and Lahmeyer and Co. has been upheld by the Imperial Patent Office and the application dismissed with costs. Some three months ago the "Reichsgericht," the highest Court in Germany, dismissed a similar action against the same patent. The patent in question is a Zipernowsky-Déri patent. The firms mentioned have lodged an appeal against the decision of the Patent Office.

**The London Electric Supply Business.**—A well-written and accurate *critique* of the London electric supply business, from the point of view of the investor, is to be found in the current number of the *Investors' Review*. Tables are given showing the Board of Trade units sold during 1895, the dividends paid since 1891, the sums set aside for depreciation out of revenue, and the present prices charged for the Board of Trade unit and the maximum charges permitted. Much space is devoted to the finances of the City of London Electric Lighting Company. At the conclusion of the review the writer expresses his belief that "the companies appear to have a good future before them, and probably the present range of dividends will be improved upon," an opinion in which we entirely concur.

**International Congress of Electrical Engineers at Geneva.**—On the occasion of the Swiss National Exhibition at Geneva, the Society of Swiss Electrical Engineers has resolved to hold, during the month of August, an International Congress of Electrical Engineers, and has now sent invitations to different foreign societies. The Congress will last four days and the following subjects have been included in the programme:—(1) Magnetic units and their nomenclature; (2) Photometric units and their nomenclature; (3) Long-distance transmission of energy and its distribution by continuous and alternating currents; (4) Protection of high-pressure circuits from atmospheric discharges; (5) Disturbances caused by electric tramways. In connection with the Congress there will be excursions into the Jura and central districts of Switzerland for the purpose of inspecting various important electrical plants.

**Motor Car Club.**—A club has been founded to promote the manufacture and use of motor-carriages and other road vehicles, and an inaugural dinner was held at the Imperial Institute on Friday. Members of the House of Lords (who are discussing Lord Harris's Bill and the proposed amendments thereto) were invited to judge of the merits and capabilities of various types of motor carriages and cycles, which will be on view at the Institute during the exhibition which opened on Saturday. Several electrical exhibits are to be included shortly, amongst which will be an electric carriage, constructed by Messrs. Thrupp and Maberley, with a motor designed by M. Julien, of storage battery fame. At the dinner, in response to the toast of the "British Motor Car Industry and Club," Mr. H. J. Lawson, whose name is so well known in connection with the introduction of the bicycle into this country, responded, and referred to the remarkable exhibits which they had inspected, and claimed for them that they were the most wonderful inventions of this century. Arguing from the immense success of the cycle industry, which he had founded 20 years ago, the speaker stated that the horseless carriage industry, which had met with the same ridicule and opposition as its precursor had done, was now gradually assuming its place in the list of British industries.

**Royal Institution.**—The annual meeting of the members of the Royal Institution was held last week, Sir James Crichton-Browne presiding. The annual report of the Committee of Visitors for the year 1895 was read and adopted. The real and funded property now amounts to above £100,000, entirely derived from the contributions and donations of the members and of others appreciating the value of the work of the Institution. During 1895, 72 new members were elected, and 63 lectures and 19 evening discourses were delivered. The books and pamphlets presented amounted to about 260 volumes, making, with 594 volumes purchased by the managers, a total of 854 volumes added to the library in the year. The following gentlemen were unanimously elected as officers for the ensuing year:—President: the Duke of Northumberland; Treasurer: Sir James Crichton-Browne, F.R.S.; Secretary: Sir Frederick Bramwell, F.R.S.; Managers: Sir Frederick Abel, Sir Benjamin Baker, Mr. John Wolfe Barry, Lord Halsbury, Mr. Charles Hawksley, Dr. John Hopkinson, F.R.S., Mr. Victor Horsley, F.R.S., Mr. Willam Huggins, F.R.S., Lord Kelvin, F.R.S., Mr. Alfred B. Kempe, F.R.S., Mr. George Matthey, F.R.S., Mr. Ludwig Mond, F.R.S, Sir Andrew Noble, F.R.S., Earl Percy, and Mr. Basil Woo ld Smith; Visitors: Mr. Gerrard Ansdell, Sir James Blyth, Mr. Arthur Carpmael, Sir William James Farrer, Mr. Carl Hagg, Sir Francis Laking, Mr. Hugh Leonard, Mr. James Mansergh, Mr. Lachlan Mackintosh Rate, Mr. Felix Semon, M.D., Mr. Henry Virtue Tebbs, Mr. John Isaac Thornycroft, F.R.S., Mr. Thomas Tyrer, Mr. John Westlake, Q.C., and Mr. James Wimshurst.

**Applied Electro-Chemistry.**—In his second Cantor lecture on this subject at the Society of Arts, Mr. Swinburne, after showing some pretty experiments illustrating the dissociation hypothesis and the phenomenon of electric osmosis, proceeded to describe in some detail various electrolytic processes of copper refining, the Ashcroft process for winning zinc from the Broken Hill ores, and the best-known electrolytic methods for making caustic soda and bleach, referring incidentally to the deposition of lead, sewage purification, and to an ingenious but impracticable electrolytic meter, based on the principle of electric osmosis. In connection with the electrolytic refining of copper, the lecturer pointed out that in this country we preferred using $\frac{1}{2}$-volt cells having a number of anodes and cathodes in parallel, a system involving multitudinous connections; whilst in the United States, at the Anaconda Works, for instance, they used 100-volt vats, with a succession of crude copper plates intervening between the anode and cathode proper. The plates, of course, acted on one side as cathodes, and received pure copper, and on the other as anodes, and dissolved away. To prevent the process from going too far, and the *pure* deposited copper from being eaten away, a very ingenious device was adopted at the Anaconda Works. Sheets of paper were rivetted on to the cathode faces by means of copper rivets; these rivets afford sufficient conductivity to enable the job to be started, and the copper deposit soon spread from the rivets all over the surface of the paper. When the anode face of the bar was completely eaten away further action on the pure deposited copper was stopped by the intervention of the paper wall.

**Electrical Separation of Tellurium from Copper Residues.**—A method for the separation of tellurium from copper residues is described by Mr. Cabell Whitehead in the *Journal* of the American Chemical Society. In the electrical refining of copper the washings from the gold residues contain the tellurium as tellurous oxide or sulphate. The tellurium may be obtained from these either by precipitation with copper or by passing sulphurous anhydride through the solution. It may be finally purified by distillation in hydrogen. When a solution of sodium tellurite is added to a solution of an ammonium salt, a white precipitate of tellurous anhydride is thrown down, which becomes granular on boiling. A small amount of tellurium or of some metal which can be precipitated by sulphurous anhydride remains in solution; this soluble portion is still under investigation. Potassium ferrocyanide does not react with tellurium chloride at once, but after a few hours prussian blue is formed. When tellurium is heated with aluminum the two combine with explosive violence, forming a chocolate-coloured compound difficultly fusible, which has the

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composition of $Al_2Te_3$. It is hard and brittle, and can readily be ground to powder; when exposed to moist air it is decomposed, and hydrogen telluride is slowly evolved; when thrown into water it is rapidly decomposed. Tellurium is readily deposited by an electric current either from an acid or alkaline solution. It has been found possible to separate tellurium from copper by adding an excess of sodium hydroxide and about 3 grammes of potassium cyanide for each gramme of copper present, and passing an electric current through the solution, when the tellurium is thrown down as a black, non-adherent precipitate, which can readily be filtered off; the solution can then be slightly acidified with sulphuric acid, and the copper estimated in the usual way by electrolysis.

**The "Okinawa Maru."**—The Japanese Government cable steamer "Okinawa Maru" left the Telegraph Construction and Maintenance Company's works at East Greenwich on Monday evening, the 4th inst., for Japan, after loading some 236 knots of cable. This length completes the order for 800 knots secured by that Company last autumn. The first portion was shipped and despatched to Nagasaki in December last in the chartered steamship "Ayr." We understand that this cable is intended to be laid between Japan and Formosa *viâ* the Lu Chu group of islands, two of which will be connected up. Great reticence on the subject is, however, maintained by the Japanese Government. The "Okinawa Maru" proceeds to Nagasaki under the command, in the illness of her captain, of Capt. Lacy, who is the solitary Englishman on board, the technical staff and ship's officers and crew being all Japanese. The cable and electrical stores are in charge on the outward passage of Mr. S. Nishikata. During her stay off the Telegraph Construction works at Greenwich the "Okinawa Maru" has been visited and critically examined by a large number of cable men. The general verdict would seem to be that she is somewhat too much hampered about the decks for cable work, and that more space should have been provided below abaft the gear for stowing buoys, coiling ropes, &c. A flush deck, such as that of the "Britannia," for example, would have been preferable. The testing room is exceedingly spacious and well ordered, and is placed where every ship's testing room should be—namely, on the upper deck amidships. The chief electrician's cabin is most conveniently situated just outside the testing room. The saloon and cabin accommodation of the vessel leave nothing to be desired. It must be remembered that some 600 knots of cable manufactured for the Japanese Government by the Silvertown Company were shipped to Nagasaki some weeks back in a cargo steamer, the "Sarpedon." So far the destination of that cable has been kept secret.

**Röntgeniana.**—A steady stream of Röntgeniana continues to flow throw the Académie des Sciences. In the last number of the *Comptes Rendus*, M. R. Colson describes some experiments devised by him with a view of determining whether X-rays impress photographic plates directly or by means of a transformation due to the support or to the sensitive layer itself. He concludes that the rays act directly.——M. F. P. le Roux, in a memoir "On the Heterogeneity of the Rays emitted by Crookes' Tubes and the Transformation of the Rays by Screens," relates some curious results obtained by him in his first attempts at radiography. Pieces of metal were apparently more easily traversed the thicker they were; cardboard was relatively opaque, though when placed on a piece of metal the two were transparent; the gelatine was tinted red. The majority of M. Roux's conundrums were solved for him by M. H. Becquerel's discovery that the so-called X-rays, due to phosphorescence, traverse metals more easily than those derived from ordinary Crookes' tubes, and are reflected. The colouration of the gelatine is, M. Roux argues, due to a sifting effect of the cardboard screen. He suggests the term *hyperdiabatic rays* in lieu of the more common one.——MM. L. Benoist and D. Hurmuzescu find that:—All things being equal, the rate of discharge of a charged body varies as the square root of the density of the gas in which it is immersed. These experimenters put forward the hypothesis that the behaviour of electrified bodies under the influence of Röntgen rays is due to the expulsion by the body under their influence of the molecules of gas condensed on the surface or occluded at a certain depth.——M. A. Lafay, in a further communication "On Electrified Röntgen Rays," describes how he placed an insulated metal screen, connected to an electrometer or to an electroscope, inside a Faraday box of thick lead, and directed on to the screen a cone of X-rays, the rays entering the box through an aperture covered by some electrified conducting membrane. A charge of the same sign as that on the membrane was developed on the screen, the action resembling that which would occur if the electrified membrane and the screen had been connected by a badly-insulated highly-resisting wire. M. Lafay finds that the transference of the charge is the more rapid the more transparent the membrane. In the course of these investigations M. Lafay found that on suppressing the electrified membrane the electrometer, as a rule, showed the existence of a slight + charge on the screen; but the charge was from 20 to 30 times less than that obtained with "electrified rays," which gave an appreciable magnetic deflection.

**Recent Chemical Progress.**—In his last lecture on this subject at the Royal Institution last week, Prof. Dewar pointed out that a true solvent for aluminium having been found in cryolite which melts at a moderate temperature, we are enabled by electrolysis to break up the oxide, and deposit pure aluminium on the cathode, and this metal, owing to its great reducing properties, can be used to effect the separation of other metals, such as chromium and tungsten from their oxides. From the time of Davy it has been known that the alkaline metals could be obtained by electrolysis, but perhaps the greatest advance which has been made in the process from the chemical point of view is the use of a moving electrode which removes the alkali from the solution as fast as it is separated. It is well known that in all cases of electrolysis there is a powerful back electromotive force due to the tendency of the separated ions to recombine. This tendency was overcome by Daniell in his well-known cell by causing the substitution of copper for the separated hydrogen, which copper was deposited on a copper plate. In Groves's battery, nitric acid is used as a depolariser, and in all the modifications of these two batteries which have been introduced depolarisation has been effected by the introduction of some substance to combine chemically with one of the separated ions. But in the Castner process for the production of caustic soda and chlorine by electrolysis, travelling cathodes of mercury are employed, which combine with the sodium, and remove it from the electrolytic tank as soon as it is separated, and pass it into another vessel in which the sodium amalgam is decomposed with the formation of caustic soda, while the mercury passes on and is ready to be used again. By suitable connections the energy due to the formation of caustic soda is made to yield a current which supplements the electrolytic current. Thus not only is polarisation prevented, but the tendency of the ions to recombine, which would have caused it, is made to assist the electrolytic process. In electrolysis it is not only the back action of hydrogen and the metals which are liberated at the cathode which has to be overcome, but the effects of the anions must be guarded against. In copper we have a metal which is valuable in many instances, for it is not only readily oxidised by electrolytic oxygen, but its oxide is reduced with equal facility by the hydrogen evolved, and in many processes this fact has been taken advantage of. Groves in his gas battery attempted to utilise the combination of oxygen and hydrogen for the production of an electric current, and Ludwig Mond has recently tried to improve this battery which, for many reasons, was not commercially useful. Many attempts have been made to obtain electricity direct from the combination of carbon and oxygen. Coal is not a good conductor, and some fused oxidising agent is necessary as an electrolyte, so that there are difficulties in the way of using carbon as the positive electrode. Carbon monoxide, however, can be readily produced, and perhaps the solution of the problem will be found in some modification of Grove's battery in which carbon monoxide will replace the hydrogen. Passing on to the metals of the rare earths, the lecturer stated that the oxides of lanthanum, zirconium and thorium converted more heat into light than any other known substances, and illustrated the process of the manufacture of an incandescent gas mantle. Chlorate of potash, which was so much used by chemists as a source of oxygen, is now produced electrolytically.

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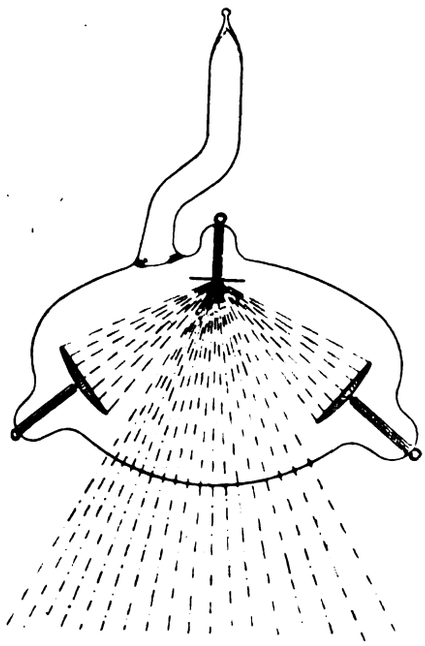
## FOCUSSING TUBE FOR USE WITH ALTERNATE CURRENTS.

BY A. A. CAMPBELL SWINTON.

In Prof. Röntgen's second communication to the Würzburg Physico-Medical Society, published in your issue for April 24th, he states that he is constructing a special form of vacuum tube for use with alternate currents from a Tesla transformer. For those whose laboratories are supplied with alternating current, but who cannot readily obtain continuous current, a tube suitable for use with Tesla current is an advantage. The annexed illustration shows such a tube which I had made nearly two months ago. The two curved aluminium discs serve alternately as cathode and anode according to the



direction of the current, each focussing its cathode rays upon an identical portion of the flat platinum reflector. If carefully made, so that the foci of the two discs are exactly in the same point, the tube will be found to work well.

By connecting both discs together and using them as cathode, and employing the platinum as anode, the same tube will answer for Rhumkorff currents.

## THE COMBINED ALTERNATE-CURRENT AND CONTINUOUS-CURRENT SYSTEM OF SUPPLY AT BRIGHTON.

Probably the most interesting of the many features of interest connected with the electric lighting of Brighton is the system of supplying the outlying districts during the greater portion of the 24 hours with continuous currents, and during the few hours of heavy load with alternate currents. The idea is in itself refreshingly original, but an engineer cannot afford to be original unless he can be assured of a substantial gain and of practical success. The figures relating to the coal consumption at Brighton for the past year will, we think, convince him that a substantial gain is achieved, and a few particulars about various subsidiary devices will be equally convincing as to practical success.

From the sketch-map of the town it will be seen that by far the greater portion of Brighton is supplied on the ordinary continuous-current (three-wire, 115 volt) system. In Fig. 1 the network served on the dual plan is given in greater detail. What is done is briefly as follows:—In the outlying quarters, known as the Preston and Lewes-road districts, a high-pressure alternate-current ring main is laid. The ring main is tapped at intervals by transformers, the secondaries of which are connected to the 3-wire distributing network. The high-pressure ring main and the distributors are, we may here remark, both of the paper-insulated concentric type. Into each of the two transformer sub-stations nearest to the town network, a low-pressure distributor is run. Means are thus available for connecting the districts at will with the ordinary town continuous-current network, or with the high-pressure alternate-current feeders coming direct from the alternators at the central station.

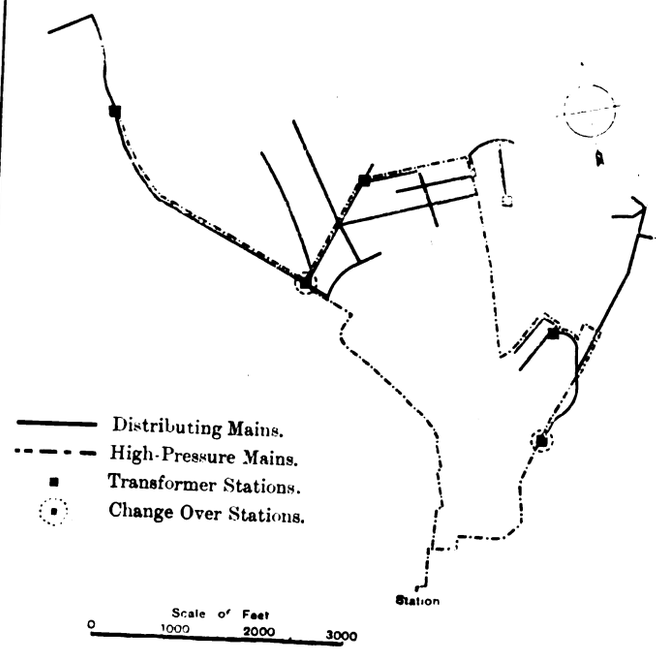



FIG. 1.—Map showing Network worked on the Combined System.

The whole system has worked perfectly satisfactorily since it was started in 1894, and with marked economy in coal. Although there are a few business streets in the area supplied on the combined plan, the main demand will, in all probability, always come from private houses and street lamps.

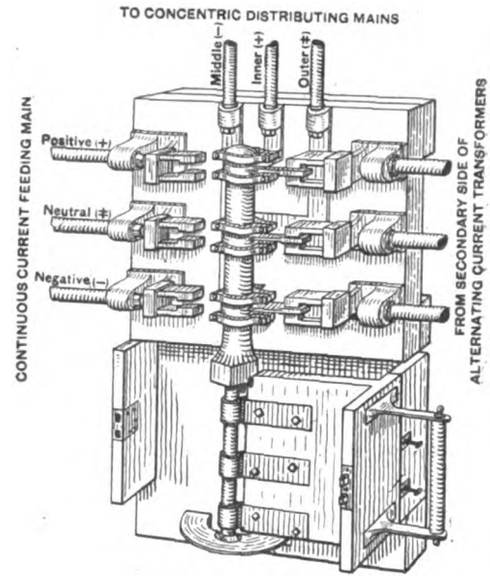



FIG. 2.—Interlocking "Change-Over" Switch.

The continuous-current is only supplied between the hours of 11 p.m. and sunset the next day, and it will thus be obvious to any central station engineer that owing to the extremely small load the whole supply can be carried out through the distributors without the aid of special continuous-current feeders. When, however, the load begins to increase the scattered network requires more regular feeding arrangements.

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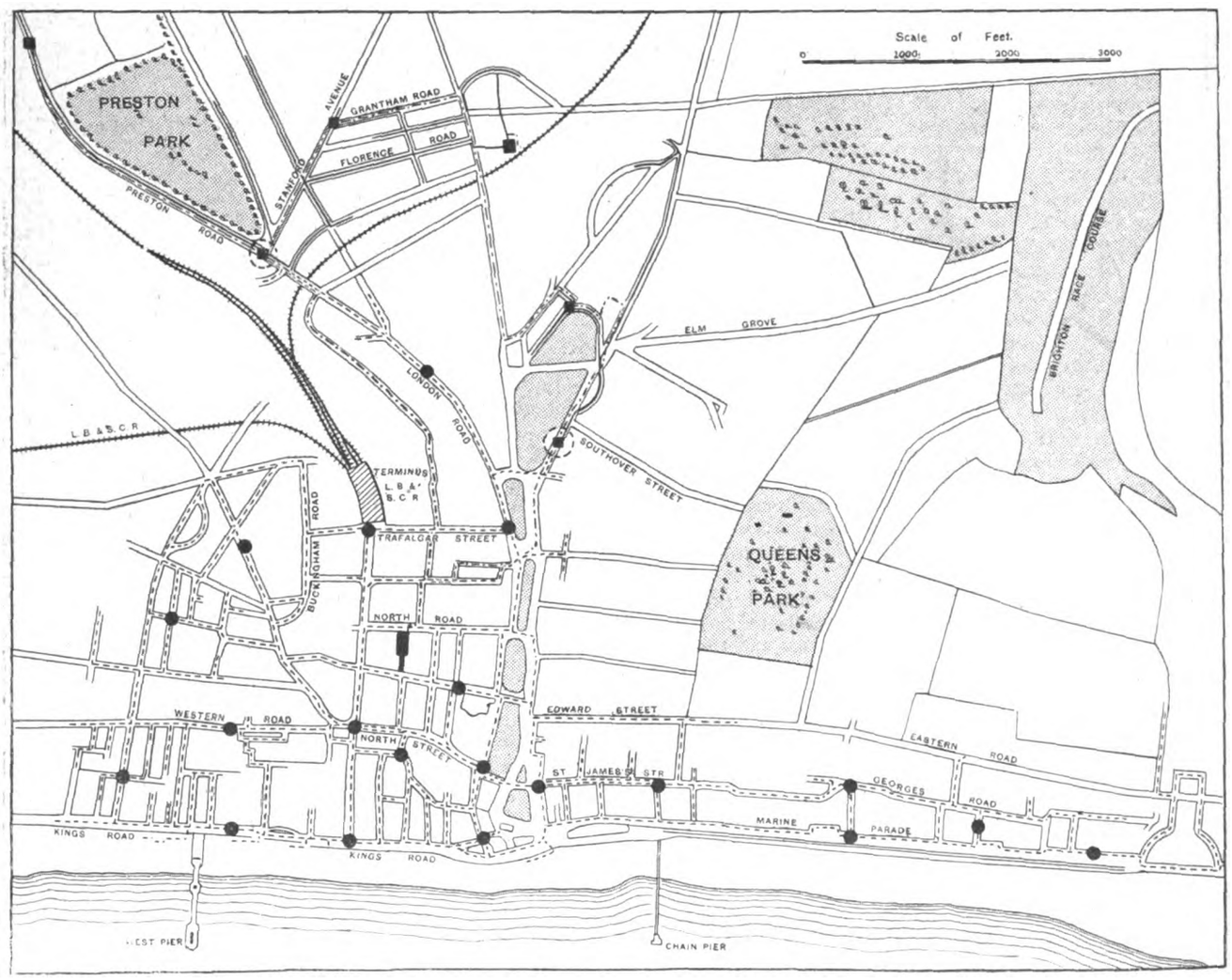
Of course the difficulty could be met by employing one or other of two expensive luxuries, to wit, a new station built specially to supply the outskirts of the town, or very heavy feeders. "Boosters" also might be used, but whether they would give a greater measure of practical success than the system actually in use is problematical.

It will be evident, from what we have described, that some very certain system of interlocking had to be devised before a public supply could be commenced on this plan. In this matter Mr. Arthur Wright has had the advantage of the very valuable assistance of his distribution superintendent, Mr. R. C. Quin, who has worked out a very complete system of keys and locks, which prevents any distributor being connected to the secondary of a transformer, while the distributor is connected to the continuous-current network, and which locks and prevents the changing-over switches being turned from the alternating source of supply to the continuous as long as there is a single transformer in the district connected to its network. A view of a change-over station switch is given in Fig. 2. On coming to the station in the evening the bicycle switchman finds the switch connected to the three-wire town main on the left. He pulls the lever over to the right, connecting the distributors of the section governed by the change-over station to the secondary of the live transformer and disconnecting the entire section from the continuous-current supply. He locks the switch, and in doing so releases the keys. With these keys he is able to release the switches of the transformers in the other stations belonging to the section, and to thus connect fresh alternate-current feeding points to the distributors. In the evening he commences at the feeding-stations, switching them off in succession and gradually throwing the entire load on to the change-over station. As he switches over at the sub-stations he locks the switch in position out of harm's way, and in so doing releases a key. He finally arrives at the change-over station with his due quantum of "open, sesame," by means of which he is able to release the switch and pull it over to the left, once more connecting the district to the town mains, shown in Fig. 3.

At the moment of changing over from one system to another, there is, of course, a momentary blink in the lights; but as this usually occurs before dusk, and about 11 p.m., it is hardly noticed. There are nearly 100 consumers supplied on this dual system, with some 4,000 lamps connected. The accompanying curve (Fig. 4), giving the number of pounds of Welsh coal used at Brighton per unit sold, shows how economical at all times of the year a station worked on this system can be. Had it been necessary to feed six transformers day after day during the whole of the 24 hours with magnetising current, the coal consumption during the dog-days would have exhibited a very pointed difference.

From the above description it will be easily seen how it was possible for the load factor of the alternating plant during the past year to have reached the high figure of 60 per cent.

There is one other feature that has yet to be explained, viz., the meter. It is obviously necessary for the consumers' meters to be of such a type as to register equally accurately with continuous as with alternate currents. This requirement,




Feeding Points.
Distributing Mains (Low-pressure).
Distributing Mains (Alternate).
High-pressure Mains.

Transformer Stations.
Change-over Stations.

FIG. 3.—Map of Brighton showing Streets in which Electric Light Mains are laid.

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it is found, is satisfied by the modern Thomson-Houston meter. The accompanying curves (Fig. 5) demonstrate this characteristic in a striking manner.

The success of the dual system of supply to the residential outlying districts of Brighton has been such, and its working has been found so simple, that Mr. Wright (at all events, at present) is very much inclined to advise the Corporation to continue to supply Brighton at 115 volts as heretofore, rather than worry consumers with a change to the double

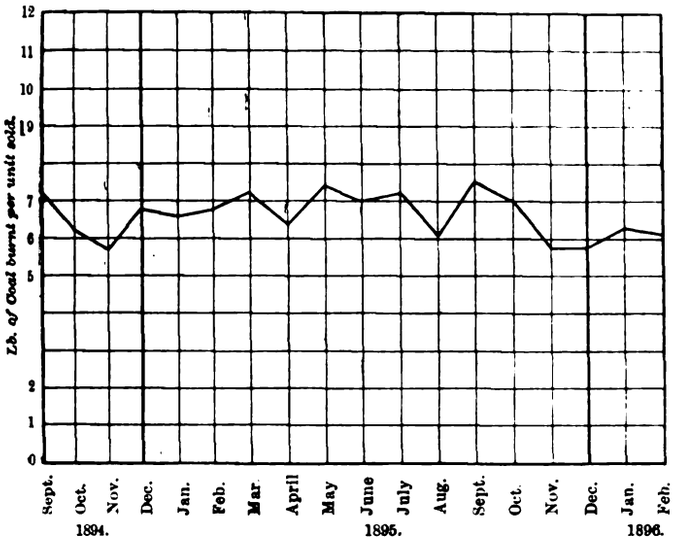


FIG. 4.—Coal Consumption Curve.

pressure, particularly as the inhabitants of Brighton have been treated to no less than four distinct systems of supply at his hands.

At present the alternating plant supplying this district consists of two E.C.C. motor alternators, having a periodicity of 70 ∿. Next year steam alternators will probably be added.

## THE THREE-PHASE SYSTEM IN SALT LAKE CITY.

In August, 1895, it became necessary to make immediate provision to increase the dynamo capacity in Salt Lake City, in order to meet the demand for lighting. A contract had been made with the Big Cottonwood Power Company for the supply of power; but there was no prospect of immediately getting this power. By this contract the Big Cottonwood Power Company have undertaken to develop a water-power in the Cottonwood Canyon, and transmit electricity over a distance of 14 miles into Salt Lake City, and there to sell the power to the Salt Lake and Ogden Gas and Electric Light Company. The Big Cottonwood Power Company will lay down a three-phase system, with a 10,000-volt transmission, stepping down at the distributing station in Salt Lake City to 2,000 volts. With these plans in view it was deemed advisable to put in three-phase dynamos at Salt Lake electric light plant, of sufficient capacity to supply the commercial centre with incandescent lights, and machinery for this purpose was purchased from the General Electric Company and erected in November last. The generating machinery consists of two 150-kilowatt and one 50-kilowatt three-phase alternators. One of the large dynamos is belted to a counter-shaft with other dynamos, and driven by a 600 H.P. Corliss engine, which runs at 100 revolutions per minute. The second is driven off the flywheel of a 250 H.P. cross-compound Armington and Sims engine, running at 230 revolutions. The third dynamo is used for the day load, and is driven off a 150 H.P. cross-compound Armington and Sims engine, together with two Edison dynamos used to supply power. All the dynamos are designed for 60 cycles. They are compound wound and have iron-clad armatures of the latest type manufactured by the General Electric Company. The 150-kilowatt dynamos are wound for an output of 2,300 volts and 37 amperes at a speed of 600 revolutions. The 50-kilowatt dynamo is wound for an output of 2,300 volts and 13 amperes at a speed of 900 revolutions. The manufacturers guarantee a commercial efficiency of 94 per cent. at full load on the large dynamos, a temperature not to exceed 70°F. above the temperature of the surrounding atmosphere after a continuous run at full load for 10 hours.

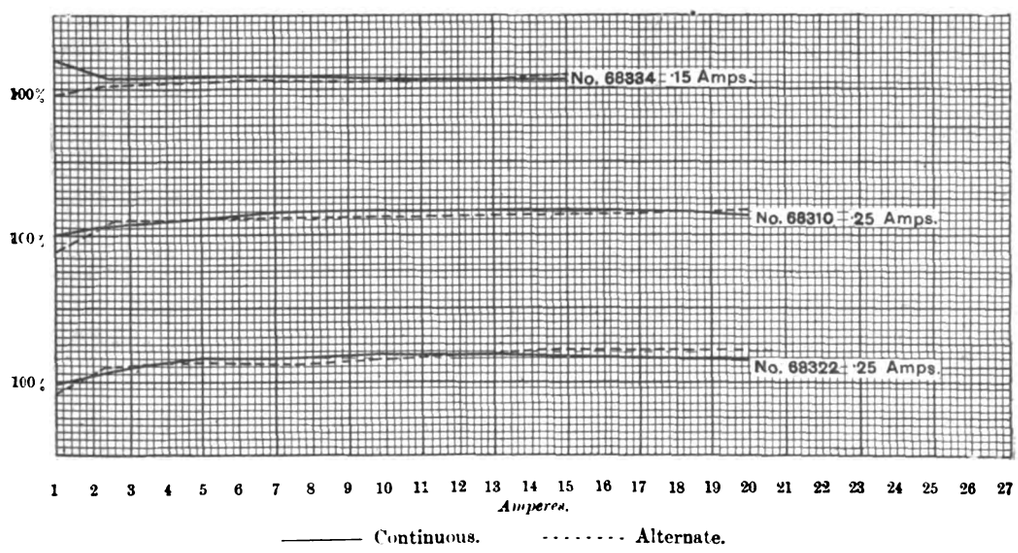


FIG. 5.—Comparative Test of Thomson-Houston Meters with Continuous and Alternate Currents. Ordinates, each division equals 1 per cent.

The length of the circuits and area of the districts can be seen from the maps. It is, of course, quite possible to work this combined system by means of pilot wires run from the central station, but as the street incandescent lamps require turning on and off, it is thought better to use that very reliable automaton the switchman. Should it ever be decided to light the streets in these residential districts by arcs, these will have to be of the alternating type, as the current is of that character during the period they are required.

There has been no opportunity of testing the dynamos for efficiency at present, but they come well within the temperature guaranteed and run absolutely sparkless at all loads.

The switchboard consists of five slabs of pink Tennessee marble, 90in. high by 30in. wide. Three of the panels contain switches for each of the three dynamos. One panel is for the measuring instruments, and the fifth panel for the circuit switches and voltmeter. At the back of the board are the 'bus-bars of the three high-tension mains, the equaliser

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'bus-bars for connecting all the compound windings together, and three lightning arresters of the well-known Thomson-Houston magnetic blow-out type, with an additional protection of a flat coil of a few turns of large wire between the arrester and dynamo. Each dynamo has one transformer, which is so connected to a 'bus-bar that by throwing a small switch it can be used for lighting a pilot lamp or put in series with the other transformers for synchronising.

The effective current, as measured at full load on one wire of the dynamo, is 37 amperes upon the larger and 13 amperes upon the small dynamo. The total effective current on the three wires is about 1·73 times that on one wire, this being the ratio between the ordinates of one sine curve and the added ordinates of three sine curves at phase angles of 120deg.

On the instrument panel are three main ampere meters for registering the whole current sent out on each leg of the system, and also a Thomson three-phase wattmeter. This wattmeter is simply a modification of the ordinary Thomson meter, and consists of three separate meters, the armatures

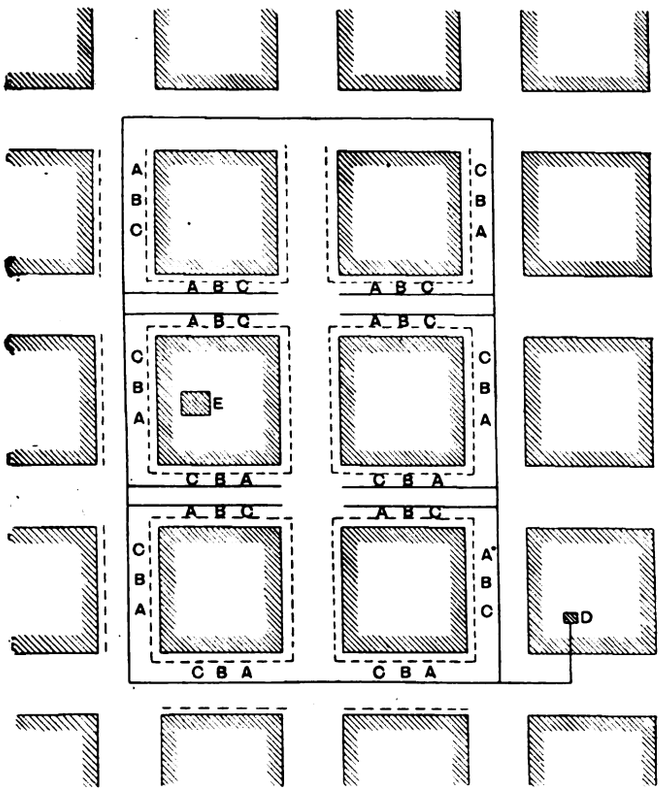


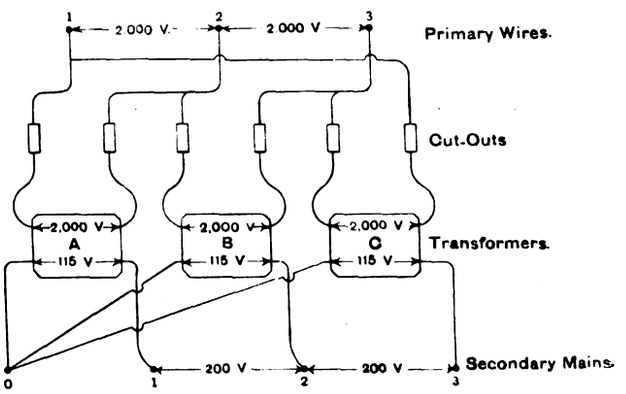

Fig. 1.—Plan of Primary and Secondary Mains in the Business District of Salt Lake City.

A B C, Transformers. D, New Sub-station. E, Old Electric Light Works. Full lines, 2,000 volt Three-phase Mains. Dotted lines, 115 volt Three-phase Secondaries.

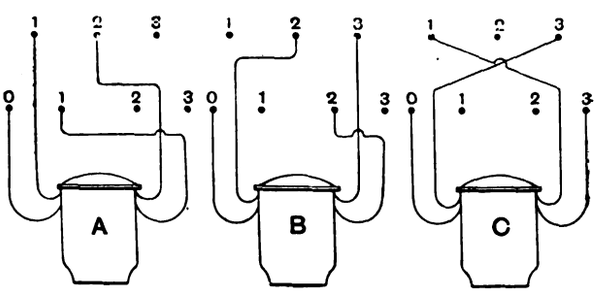
of which are all on the same spindle. In addition to these instruments a Bristol recording voltmeter is fixed in the station.

The compound commutators of the dynamos run absolutely sparklessly, and there is no trouble at all in synchronising. It may here be mentioned that the self-induction in the armatures of these dynamos is such that it is impossible to do any damage by a short circuit. Shortly after starting, a short-circuit occurred on the main lines while the small dynamo was running; the result was that the volts of the dynamo dropped off just as if the exciter switch had been suddenly opened, and, furthermore, the dynamo would not give any volts at all when running upon the short circuit. These dynamos, however, will carry 25 per cent. above their rated capacity without any loss of volts.

The distributing system consists of a three-wire high-tension network and a four-wire network of secondary mains. The accompanying plan (Fig. 1) shows how these mains are distributed over the business district. The transformers are placed upon the poles which carry the wires; the connections are made as shown in the diagram (Fig. 2). In carrying out a system like this it is, of course, important that the transformers should be fixed quickly, without any fear of getting the connections wrong. In order that the linemen may be able to make no mistake in this the wires on the poles are numbered as shown in the sketch, and the transformers are also lettered. The sketch also shows the position in which the transformers are placed in the streets, and the arrangement is such that in case of fire it would be very easy to cut off one portion of the district without interfering with the rest of the lighting. In order to save the loss in transformers during the hours of light load, arrangements are being made for cutting out a certain number of the transformers during the daytime, leaving the rest to supply the secondary mains. The transformers are wound for a ratio of 18 to 1, and it will be noticed that the secondary mains consist of a neutral wire and three others. By this means it is possible to get 115 volts between the neutral and any of the three other wires for incandescent lighting, and 200 between any two of the other wires for motor service. There is no difficulty in balancing up the three legs of the system, and, in fact, once the transformers and the secondary mains are fixed, it is easier to manipulate than an Edison three-wire system.




Transformer Connections as arranged in Banks.




Transformer Connections as arranged on Street Poles.

Fig 2

As soon as the Cottonwood power station is ready for work the preparation will be commenced for connecting the residence district on the three-phase system. At present these districts are supplied on the ordinary 1,000-volt single-phase system. A diagram (Fig. 3) is attached, which shows how the connections will be made for the three-phase. The arrangement of the streets in Salt Lake City is convenient for carrying out the necessary changes. The streets run north and south and east and west. The existing 1,000-volt mains run east and west. The three-phase feeder, as shown, will be brought up one of the streets running north and south in the centre of the residence district, and each of the cross streets will be attached to this feeder, as shown in the diagram; thus, where there are three streets, each one of the streets will form one leg of the three-phase system, and the three legs will be balanced up by throwing the side streets on to whichever leg is advisable. All the transformers at present laid down are wound for 1,000-volt primaries and 52-volt secondaries. Some

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of the step-down transformers supplied by the big Cottonwood Power Company can be connected for 1,000 volts, and it is proposed to connect up the three-phase feeder to the distributing station, as shown in the diagram, at a pressure of 1,000 volts. The existing transformers would not be very efficient at 60 cycles per second, but as quickly as possible the old type transformers will be transferred to Ogden, while the new type transformers will be fixed in the residence circuits, and then, as soon as sufficient new type transformers are fixed, the voltage will be raised to 2,000, and the house lamps changed from 52 to 104.

This is an outline of the system proposed to be pursued in changing over the residence district from the existing system to the new three-phase system. It will necessarily take some time to carry out this work, but there are portions which can very easily be connected up, while it will take several months to prepare other portions of the town. In a great many parts of the residence district the houses are so close together that

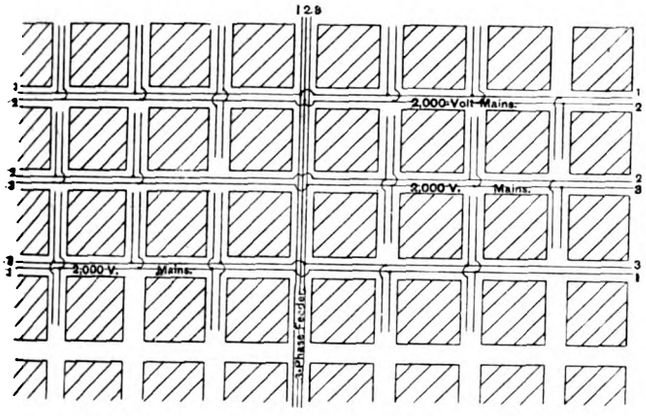


FIG. 3.—Three-Phase System of Mains in the Residential Districts of Salt Lake City.

it is very easy to fix one or two transformers to supply 10 houses. These transformers will be fixed on the street poles, and a short length of secondary main will be run, from which the houses will be supplied. At these places it is proposed to place two transformers, one, say, for 100 lights, and another for about 20, with an automatic switch to cut out the larger transformer when the number of lights does not exceed the load of the smaller, and so save the loss of power at light load.

## PROF. EWING'S PERMEABILITY BRIDGE.

Prof. Ewing's latest magnetic invention, which was exhibited for the first time at the Royal Society *soirée* on Wednesday, is appropriately described in the official catalogue as a companion instrument to the hysteresis tester which he produced a year ago (see *The Electrician*, April 25, 1895, Vol. XXXIV., p. 786). It measures magnetic permeability by a process nearly as simple as that by which the earlier instrument measures hysteresis. From the workshop point of view there is an obvious advantage in determining the **B-H** curve for a sample of iron or steel with only a fraction of the labour requisite for ballistic tests, and, it would seem, without sacrifice of exactness.

The principle of action of the new instrument is to compare the sample to be tested, step by step with a standard bar, the **B-H** curve of which has been previously determined once for all. The comparison is made by a process resembling the comparison of resistances in a Wheatstone bridge. The idea of a magnetic comparison between the piece to be tested and a standard metal is not new, having been employed in the differential magnetometer of Eickemeyer, but in Prof. Ewing's permeability bridge the idea is carried out in a very different way.

The two bars, namely, the standard whose **B-H** curve is known and the bar to be tested, are slipped into two parallel magnetising coils, and their ends are joined by two short yokes of soft iron. In Fig. 1 the bars are shown in place between the yokes, but with the coils removed. In Fig. 2 these yokes appear at the ends of the brass cover, which contains the two coils. From the yokes two long iron horns project upwards, which nearly meet above, and in the gap between these a box containing a compass needle is placed. This corresponds to the galvanometer of a Wheatstone Bridge; it serves as a detector to show when the two yokes are at the same magnetic potential, or, in other words, to show when there is no magnetic induction across from yoke to yoke through the two iron horns. Such a condition will be produced only when the magnetic induction on the two bars is the same. In that case the magnetic circuit consisting of the two bars and the yokes will be complete in itself. The lines that go from right to left along one bar will all return from left to right along the other. The yokes will be at the same magnetic potential; the horns will remain unmagnetised and the detector will not deflect. If both bars have the same perme-

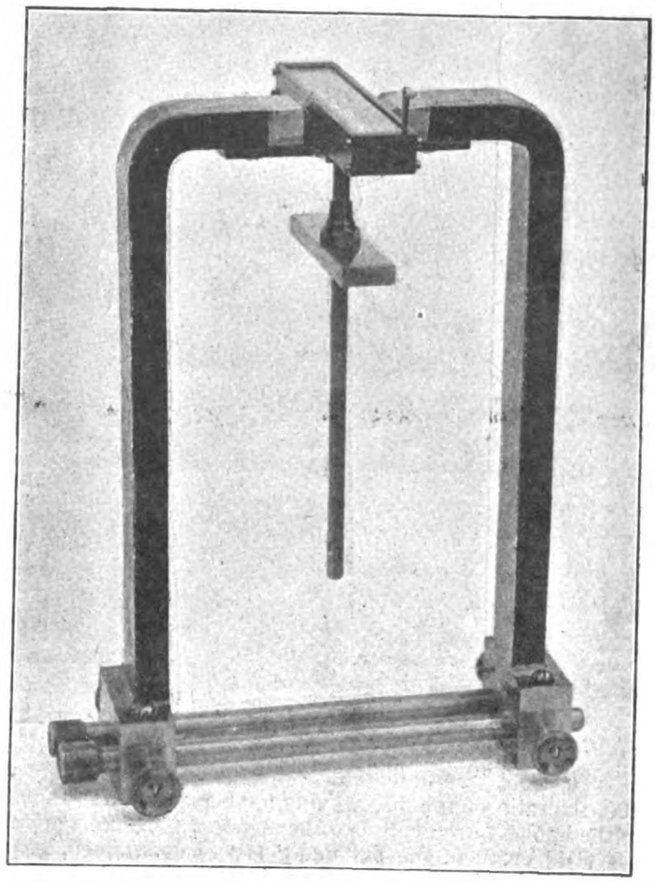

FIG. 1.—Bars, Yokes and Horns: cover removed.

ability this state of balance will be produced by having the same number of ampere-turns act on each; but if they differ in quality the condition of balance can still be produced by altering the relative number of ampere-turns. To do this the number of effective turns in the magnetising coil of the sample bar is altered by means of the dial switches, while the same current passes through both coils.

To get rid of all effects of hysteresis in the bars, and in the yokes and horns, a reversing key (shown on the right) is worked while the adjustment proceeds, and the balance is perfect when each reversal produces no permanent displacement of the compass needle between the horns. A transient kick will even then in general be observed, owing to a difference in the time-rate with which the two bars take up their magnetism. In practice the adjustment by means of the dial switches is very readily made, and takes no longer than the corresponding process in measuring resistances. To prevent the current from altering while it is going on, the switches are furnished with a second set of contacts which throw in

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compensating resistances as the number of turns in the magnetising coil is reduced, with the effect that the total resistance of the circuit remains unchanged. The clear length of each bar is 12·56cm. ($4\pi$), and the number of turns in the magnetising coil of the standard bar is 100. Hence, the magnetising force due to its coil is 10 C.G.S. units for each ampere of current. This allows any required magnetising force to be easily applied, with the aid of an ampere meter and an adjustable resistance outside the instrument. Further, since the relation of **B** to **H** is known for the standard bar, a knowledge of the current is enough to show at what value of the induction **B** the comparison is being made, and **B** is, of course, the same for both bars when the condition of balance is produced. The number of turns on the other bar then gives, by its ratio to 100, the ratio of the magnetising force required for that bar to the known force applied to the standard. Hence a point in the **B**-**H** curve of the bar under test is determined, and by changing the current as many points as are wished may be found. In practice it appears to be most convenient to bring the current to a value such as 1 ampere, and then increase it by similar steps, thus making **H** take values of 10, 20, &c., successively.

The detector is more than sensitive enough to show the effect of one turn more or fewer in the magnetising coil when the state of balance is approached, and might even be used, by interpolation between the deflections to right and left, to estimate the fraction of a turn necessary for exact balance, although in practically carrying out magnetic tests this would be superfluous.

We are informed by Prof. Ewing that he has for some months used the new bridge in his own tests, and that, apart from its great convenience over the ballistic method, he finds it actually a more delicate means of detecting difference between one sample and another. The absolute values are, of course, dependent on the primary measurement of the standard bar, which is made ballistically.

The dial switches in the instrument exhibited give the means of increasing the number of turns on the test-piece up to 210. In cases where the test-piece is magnetically much worse than the standard, a ratio of rather more than 2 to 1 may be insufficient; and to provide for that there is a two-way arrangement, by which the number of turns on the standard bar is readily reduced to 50, when **H**, of course, becomes 5 instead of 10 per ampere, and the sample under examination can then have more than four times as much magnetising force as the standard bar.

When it is desired to test the permeability of sheet metal the samples are formed by piling up a number of straight strips, giving a total cross-section equal to that of the standard, and a different form of yokes is employed. In the arrangement used with bars, which is shown in the above figures, the attachment of the bars to the yokes is of the simplest possible kind; the bars slip through holes in which they are a loose fit, and they are pressed against the middle portion of the yokes by a pair of set screws outside. The effective contact between bar and yoke, therefore, is made in the place best adapted for shortening the magnetic circuit through the yokes.

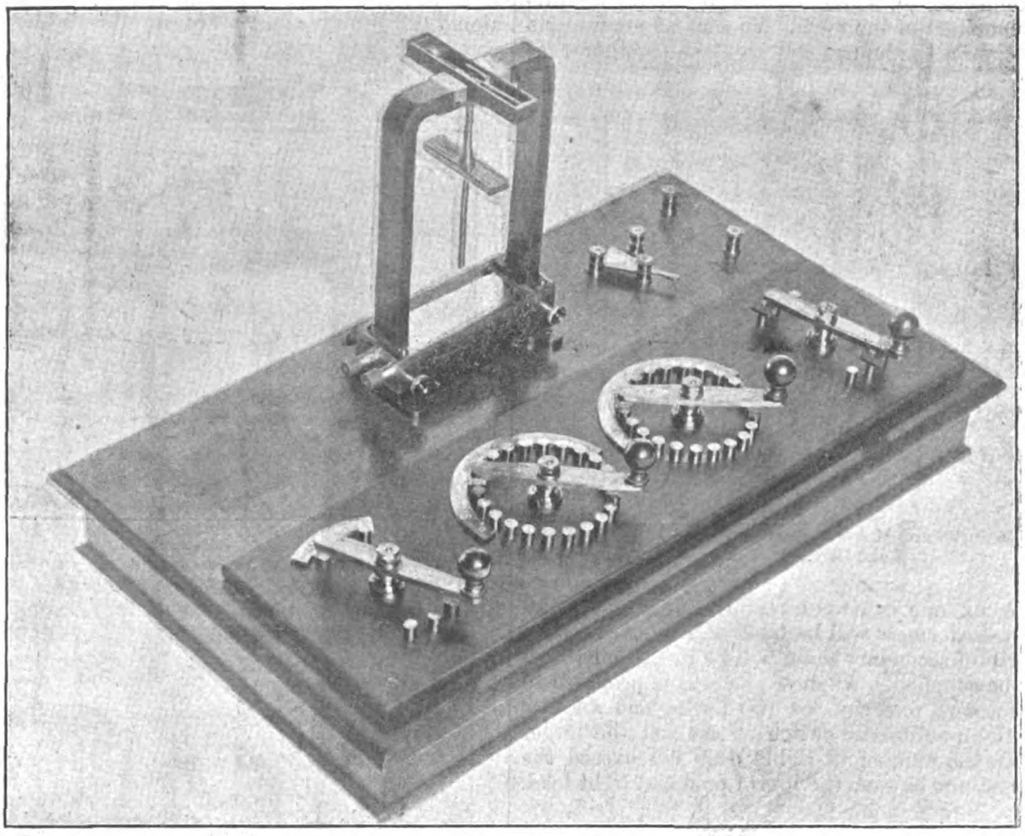

Fig. 2.—General View of Apparatus.

## PUBLIC LIGHTING BY ARC LAMPS.*

BY ANDRÉ BLONDEL.

*(Concluded from page 18.)*

### III.—USE OF ALTERNATING-CURRENT ARCS.

So far there have been very few towns lighted by alternating-current arcs, for the reason that the most important localities have generally been so long furnished with continuous-current supply stations or with special methods for series arc lighting; but as alternating-current supply stations have multiplied rapidly of late the question of the use of the alternating-current arc for public lighting comes up for solution. I shall, therefore, investigate the most suitable means of utilising this source of light, and then compare it with the continuous-current arc. The results of my preceding investigations will enable us to complete this comparison very readily.

*Strength of Current and Size of Carbons.*—It is important to note that for an equal number of watts an alternating arc requires a much

* From *La Rêtue Technique*. Translated by Mr. John Hesketh.

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lower voltage than a continuous-current arc—28 to 32 volts instead of 45, and consequently an increased current.[56] One may generally assume that for equal power one and a-half times more current is needed with the alternating than with the continuous-current arc, and therefore we are led to the use of 10, 15, and even 20-ampere lamps. This again necessitates the use of larger conductors and carbons of a much larger diameter, which latter are not favourable to luminous efficiency. Instead of increasing the current, it would in most cases be found advantageous to adhere to the maximum value of 10 amperes, and to increase the number of arcs, taking advantage of the lower voltage. For instance, on a circuit of 120 volts, four 10-ampere alternating arcs may be placed; while only two continuous-current arcs could be used. From the point of view of the greater division of the light this is an advantage. Public lighting by continuous and by alternating currents should not therefore be carried out in exactly the same manner. In the case of alternating arcs a greater number of lamps may be used, and these may be fixed closer together.[57] As an alternating-current arc taking 10 amperes is equivalent, as far as wattage is concerned, to a continuous-current arc taking about 7 amperes, there is no need really to endeavour to bring smaller current lamps into use. Besides this, small current alternating arc lamps have the additional inconvenience of a decreased stability

*Helios Alternating Arc Lamps.*

| Current. | Carbons. | | Hours carbons burn. |
|---|---|---|---|
| | Diameter. | Length. | |
| 8 | 10mm. | 320mm. | 14 to 15 |
| 10 | 12mm. | 320mm. | 14 to 15 |
| 16 | 15mm. | 320mm. | 14 to 15 |
| 20 | 18mm. | 320mm. | 14 to 15 |
| 30 | 20mm. | 320mm. | 14 to 15 |

*Details of Alternating Arcs used in Public Lighting.*

| Town. | Current. | Volts. | | Diameter of carbon. |
|---|---|---|---|---|
| | | At terminals. | Total. | |
| Havre (Brianne lamp) | 12 | ... | 36 | 12mm. and 14mm. |
| Clermont-Ferrand... (Brianne lamp) ..... | 12 | 26-28 | 33 | 12mm. |
| | 20 | 26-28 | 33 | 20mm. |
| Cologne (Helois lamp) | 30 | 29 | 36 | 20mm., 320mm. long |

All these diameters are proportionately less than those I have given previously for continuous-current arcs, and it appears as-

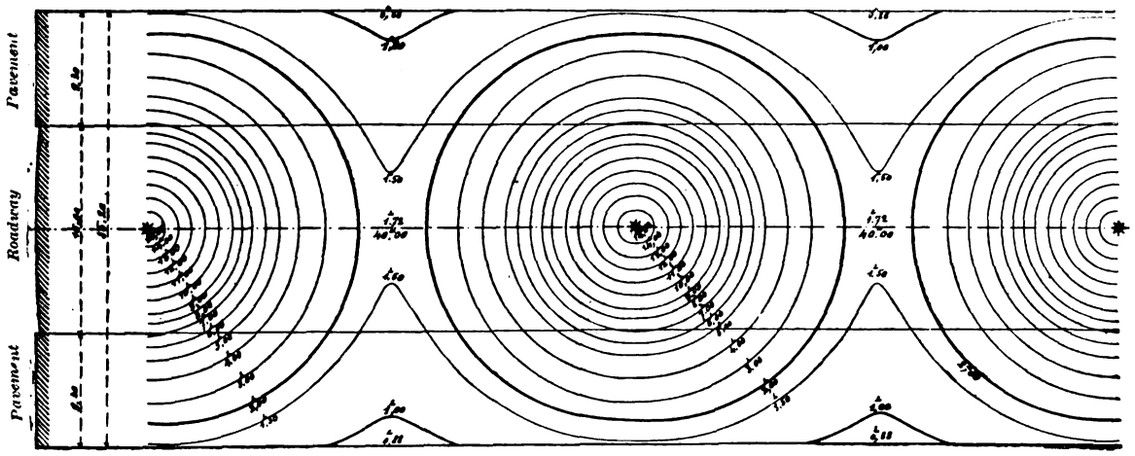


FIG. 59.—Plan of Illumination of the Grand Boulevards, Paris, with 10-Ampere Continuous-current Arcs and Opaline Globes, 6m. high, and on Refuges in the Centre of the Roadway.

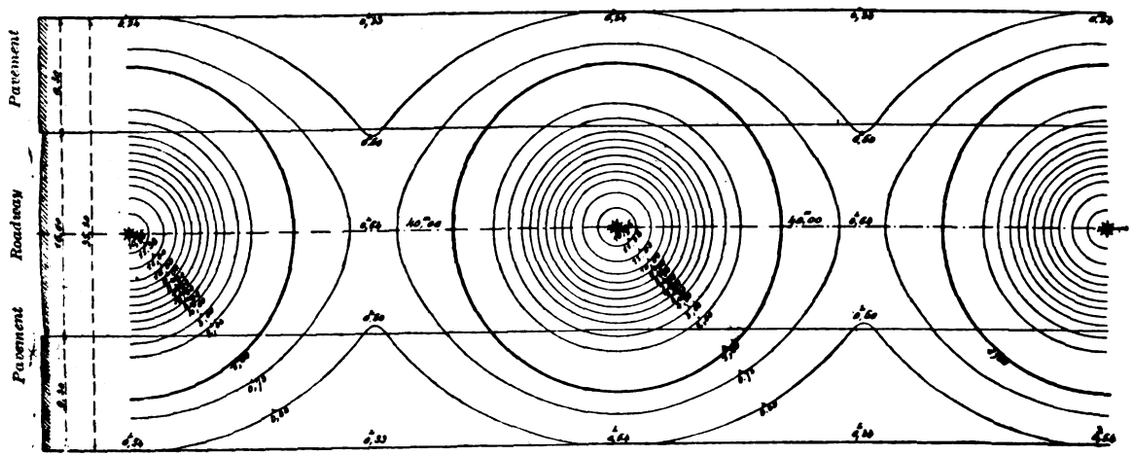


FIG. 60—Plan of Illumination of the Grand Boulevards, Paris, with 10 Ampere Continuous-current Arcs and Holophane Globes, 6m. high, and on Refuges in the Centre of the Roadway.

and a greatly reduced luminous efficiency, two points to which we have already called attention.[58] As examples of public lighting by alternating-current arcs we may cite Havre, Clermont-Ferrand and Cologne. The following are details as to the diameter of the carbons and the currents in use[59]:—

though it might be wise to still further reduce them, using specially adapted globes, or double-carbon lamps, for the same reasons as given in the case of continuous-current arcs. No practical trials have as yet been made in this direction for public lighting. It must not be forgotten that in French electric lighthouses incomparably superior luminous efficiencies were obtained with the alternating currents by the use of higher current densities in the carbons, 2½ amperes per square millimetre being adopted.

*Distribution of the Rays.*—The two carbons are equally consumed, and gradually shape themselves to a conical point terminated by a facet. In consequence of this, the photometric curve of the naked alternating arc has the characteristic form of two butterfly wings with a point of recess. I have elsewhere given the reason for this form.[60] It is sufficient here to say that it is approximately symme-

[56] We shall see later that the number of true watts is really lower than the product of the amperes into the volts; but as this difference is small in actual practice I shall neglect it, although it may be assumed that this involves an actual increase of 5 per cent. to 10 per cent. in the current.

[57] For the lighting of the railway stations at Dresden another equally practical system has been adopted; which is, to distribute at 70 volts, so that incandescent lamps at 70 volts, or two arc lamps in series at 35 volts, (of the Helios pattern) can be used.

[58] *La Lumière Electrique*, October, 1894.

[59] For these we are indebted to MM. Berthier, Coerper and Dalichampt.

[60] *Eclairage Electrique*, May, 1895.

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trical on either side of the horizontal. The upper half is, however, generally, most fully developed because of the more pointed shape of the upper carbon. Under these conditions we see that at least half of the luminous flux is sent upwards, while the rest is distributed on the ground following a law very slightly different from that applying to continuous-current arcs.

*Effect of Diffusing Globes.*—The effect of globes does not alter the symmetry of the curve if the arc is placed in the centre, and consequently the total flux on leaving the globe divides itself into two approximately equal parts, of which one is sent upwards and the other downwards. In addition, the curves are distorted in such a manner as to make them incline towards a circular form more readily than is the case with continuous-current arcs. Figs.

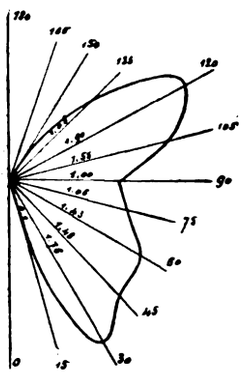

FIG. 61.

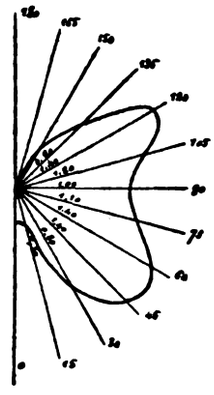

FIG. 62.

61, 62, and 63, for example, give the curves which I have obtained experimentally from a lamp, first with a naked arc, then with opaline and opal globes. In these curves the horizontal intensity has been taken as unity in every case, so that the different curves must not be compared with each other[61]. The comparisons are besides very easy to make without this. For the total loss of light corresponds to that due to absorption only, and the lower hemispherical flux is sensibly the half of the total flux, both before and after this absorption. The figures given previously as to the

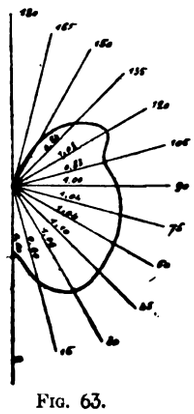

FIG. 63.

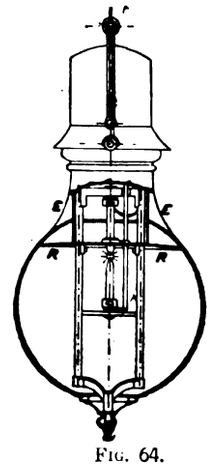


FIG. 64.

absorption with continuous-current arcs enable us to determine the luminous efficiency in the following manner, if we take the flux produced as unity.

| — | Flux produced. | Total flux after absorption. | Hemispherical flux. | Efficiency. |
|---|---|---|---|---|
| Arc under rough glass globe | 1 | 0·69 | 0·345 | 0·345 |
| „ opal „ | 1 | 0·55 | 0·275 | 0·275 |

I cannot give the results with the holophane globe because it has not yet been tried under these conditions and is not comparable with the others by this method. Even with clear opal globes a higher efficiency than 40 per cent. cannot be hoped for. The low efficiency obtained shows that it is a mistake to endeavour to use the alternating-current arcs in the same way as continuous-current arcs, as has been done in France, where alternating-current arcs have been placed in lanterns exactly similar to those used for continuous-current arcs. So long as we consider the lighting of narrow streets we may still consider that a part of the light sent upwards is returned to us by the diffusing effect of the house frontages, but this no longer holds on boulevards which are at all wide. It is still worse when such an arrangement is used along a marine promenade as has recently been done, for instance, at Hastings. Under these conditions, scarcely a third or fourth of the light is utilised. The use of the alternating-current arc does not appear to be rational unless a special equipment of reflectors or a dioptric arrangement is employed.

*Use of Reflectors.*—For a reflector to be satisfactory in actual use its solid angle should be as near as possible a hemisphere. We have previously seen that it is scarcely possible to obtain these conditions with a reflector outside the globe unless we use arrangements which are very ugly and cumbersome, and which are in addition difficult to keep clean. It is far preferable to place the reflectors in the interior of the globe and quite close to the arc. Such was the solution suggested a little while ago by the Helios Company of Cologne. Fig. 64 gives a view of the latest pattern of the lamp constructed by this Company, and one which has been employed with success in the public lighting of the streets of Cologne.[62] A reflector of enamelled iron is fixed to the guide rods. The lamp being of the focussing type, the arc always remains in immediate proximity to the reflector which embraces a solid angle of almost $2\pi$. These conditions are the most perfect for the reflection of the light otherwise sent upwards.

In Fig. 65 we have the result of experiments made by the Helios Company, and also give the curves obtained with and without the small reflector. The curves are for a lamp of 10 amperes taking 310 watts. It will be seen that the distribution of the rays in the lower hemisphere follows approximately the same law

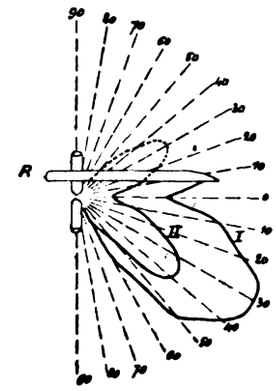


FIG. 65.

in both cases, with the difference that the intensities are almost doubled by the use of the reflectors. The hemispherical intensity is increased from 150 to 372 candles. The mean intensities deduced from these curves are: without reflector 275 spherical candles, without reflector 498 hemispherical candles, for 310 watts, which gives 1·6 candles per watt. The corresponding fluxes are: $4\pi \times 275$, and $2\pi \times 498$ units. The second figure is certainly exaggerated. To prove that this is so it is sufficient to point out that the total flux $4\pi \times 275$ is the sum of the upper hemispherical flux (equal to about $2\pi \times 250$ according to the curve) and of the lower hemispherical flux (equal to about $2\pi \times 300$). The lower flux is thus increased from $2\pi \times 300$ to $2\pi \times 498$ units; and consequently the reflecting power of the small reflector must have a value of

$$\frac{250}{498-300}=\frac{250}{198},$$

that is to say, it is greater than unity. As a matter of fact, it does not appear that a diffuser of this kind can reflect by diffusion more than 70 or 80 per cent. of the light it receives. Assuming that the light of the alternating-current arc is divided into two equal parts, the one above and the other below the horizontal, the luminous efficiency of the lamp with its reflector would be 85 to 90 per cent., which is indeed very good. This light has still, however, to submit to the same losses as those to which the continuous-current arc is subject by the action of the diffusing globe which encircles the arc; but still the small reflector will at least allow us to obtain an increase of light of 70 to 80 per cent. above that obtained from a lamp not so fitted.

In the face of such a result one can but wish to see this arrangement employed in France, where, so far, the use of the light of the

[61] I have, indeed, made a comparison between their intensities on a horizontal plane, but in consequence of the variations of intensity, the result was not sufficiently accurate to warrant me in reproducing it here.

[62] The previous pattern employed only half a globe, covered by the reflector, an arrangement which was scarcely graceful. The present type is much more satisfactory for use in places where some elegance can hardly be dispensed with.

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alternating-current arc has not been properly understood, and where few engineers seem to trouble themselves about the question. The small Helios reflector presents a great additional advantage in not requiring any modification in the ordinary fittings; and externally a lamp so fitted cannot be distinguished from any other unless it is by its greater lighting power.

*Use of Dioptric Globes.*—The holophane dioptric apparatus previously mentioned will also give a good solution to the question; in fact, better from many points of view than the preceding one, but it has not yet been practically tried. It is true that the holophane globe as applied for continuous current could not be applied to alternating arcs, for the arc is so near the top opening that all the light sent upwards would be lost through the opening[63]; this inconvenience could, however, be easily overcome by arranging the lamp rods so as to carry a small reflector above the opening, which shall reflect all the rays which would otherwise pass through.

Another device which appears still more advantageous consists in using a special globe, at the centre of which the luminous point is fixed, the ribs of the globe being so arranged that they direct all the rays towards the ground. This arrangement would appear to be the most perfect for use with alternating-current arcs, but it must not be forgotten that if long carbons are to be used the bottom carbon holder must pass through the bottom of the globe.

*Comparison between Continuous and Alternating-Current Arcs from the Point of View of Luminous Efficiency.*—Now that we have seen what proportion of the light emitted by the alternating-current arc can be used by the aid of dioptric fittings, it is natural to ask whether, since we can conveniently use this light, it is equivalent to the continuous-current arc from the point of view of utilisation of energy. So far the experiments seem to establish that for equal energy consumed the alternating-current arc produces less luminous flux than the other. This is easily explained when we remember that for every alternation the arc really goes out for a greater or less time and is then relighted. During its extinction there is a sensible cooling of the incandescent portion of the carbon, for at these very high temperatures radiation is considerable. Besides which each of the carbons is positive, and therefore raised to its maximum luminosity only during one alternation out of two; and when it is negative its brilliancy is much less.[64] It, therefore, must result that in the alternating arc the mean degree of incandescence, and consequently the luminous output (which varies as the temperature), is much lower than with the continuous-current arc taking the same energy, and that the difference will increase the longer the extinctions. I gave many years ago* this *a priori* demonstration of the difference in the efficiency of the two kinds of arc; and I hope it may be true, though such eminent authorities as Prof. S. P. Thompson think the luminous efficiency depends only on the watts in the arc, and must necessarily be the same when the watts are the same. Among other consequences we have the result that the more powerful arcs have a better efficiency than the smaller ones, and the efficiency increases a little with the frequency of the alternations. It should also be noted that the incandescent portions of the carbons in the alternating-current arc are more eclipsed than in the case of continuous-current arc, and that we have consequently a very appreciable loss of light. This fact is the more important, since for equal power an alternating-current arc requires, as we have seen, larger conductors and larger carbons than a continuous-current arc.

As to establishing what is the relation between the luminous efficiency of continuous and alternating-current arcs, this is a point still very imperfectly settled, owing as much to causes of variation which I will mention as to the imperfect methods by which measurements have been made.

Before quoting figures on this subject I may make the remark that the alternating-current arc may present altogether different properties, according to the nature of the carbons employed, and that the comparison is difficult to establish on a precise basis.

With the homogeneous carbons hitherto used, the voltage at the terminals is 35 to 40 volts, and the power factor very small—that is to say, for a given number of true watts in the arc the apparent watts supplied (*i.e.*, the product of the current into the difference of potential) is appreciably higher. The power factor of the arc sometimes is as low as 0·7 or 0·8. In addition to this arcs taking less than 12 amperes are very unstable[65]. With carbons as used at present, with the core formed of highly conducting material, the voltage required is much lower and may even be as low as 28 or 30 volts (with the Helios lamps.) The power factor may reach 0·95 to 1—that is to say, the apparent watts differ very slightly from the true watts. In addition, the stability is so good as to almost enable one to dispense with impedance coils in the circuit. All these advantages are due to the artificial conductivity of the arc due to the vapourisation of the salts contained in the core, but we must nevertheless notice that this is probably obtained at the expense of the luminous efficiency, for this conductivity is opposed to the attainment of the same brilliant incandescence as in previous arcs.

The alternating-current arc lamp of the Helios Company, which at the present moment is the most prominent type, really presents a phenomenon intermediate between constant incandescence and the phenomenon of the arc properly so called. The luminous efficiency should also be intermediate, and in consequence lower than that of the continuous-current arc.

From measurements made by Prof. Fleming on arcs taking 540 watts[66] the ratio of the efficiency is about 2 : 3. This figure is lower than that arrived at by the Frankfort Commission, which was 4 : 5. Assuming that this figure may be accepted as an average, the flux of light sent downwards for public lighting would be, for equal power, only one-third of that of the continuous-current arc, if a reflector is not employed, and 1·70·3, that is to say, about one-half if a reflector with 0·70 reflecting power be employed. If we may rely upon the recent experiments of Herren Wedding and Roessler, this figure is even then too favourable. By directly measuring the light from a Helios lamp fitted with its reflector and taking 9 to 10 amperes at 25 to 31 volts (about 280 true watts) they found a mean return of 0·7 to 1·1 Hefner unit[67] (mean spherical) per watt, whilst a continuous-current lamp taking the same power (6 to 8 amperes) gave 2·64 units per watt.[68] These figures are confirmed by some recently published by Herr Görges,[69] which indicate about 0·8 to 0·96 Hefner units per watt according to the type of alternator. The ratio of utilisation is thus only 1, 2·64.

The figures given by the Helios Company are much more favourable. I should, however, remark that they apply to more powerful lamps, and that the figure of 2·64 quoted here was obtained with carbons of such small diameter that they could not practically be used. With ordinary carbons only 1 to 1·5 candles per watt can be obtained.

In the face of these very great divergencies we are obliged to admit that experimentally, as well as theoretically, the alternating-current arc has a lower efficiency, and to await special experiments to define the exact ratio. I hope some day to publish results on this point, obtained by the aid of my lumen meter.

*Indirect Ways of Avoiding the Use of Alternating-Current Arcs for Public Lighting.*—Up to the present engineers have, as a rule, avoided the difficulties of the use of the alternating-current arcs

* *Loco citato.*

[63] This really takes place in the globes at present in use. Lampmakers—careful above all things to keep the carbon holders within the globe—almost always place the arc high up in the globe, and since the globe is closed at the top by a non-reflecting surface, half the light is inexcusably lost. This is a beautiful example of the absurdities current in questions of lighting.

[64] A complete study of these phenomena was published by the author in *La Lumière Electrique*, December, 1891, and January, 1892.

[65] For fuller details on this point, see *La Lumière Electrique*, October, 1893

[66] Dr. Fleming found in red light 342 and 217 mean spherical candles, and in green light 646 and 407 (see *Lightning*, October 25, 1894). Since these lines were written another Paper has been published (see *The Electrician*, December 20th, 1895), by Prof. Fleming and M. Petavel, in which they give more information on the subject. According to this most valuable contribution to the study of the alternate current arc, the efficiency of this arc would be about 0·5 mean spherical candle (0·65 pyr), instead of 1 to 1·25 candle (1·3 to 1·62 pyr), as for the continuous current arc. Although the experiments referred to may be not exactly comparable because the lengths of the arc varied between too large limits (0 to 8mm), the results must be relied upon as clearly showing the inferiority of the alternate current arc with low voltage carbons, and giving a confirmation of the measurements of Görges and Wedding alluded to here. The periodic curves of current and P.D. of Prof. Fleming and M. Petavel are also a confirmation of one particular form amongst the many forms I published three years ago; I had already drawn attention, though not so well, in another paper (*La Lumière Electrique*, 1891, Vol. 42, p. 618), to the fact that the brightness of the crater on the carbons is periodically variable, and some of my photographs (*La Lumière Electrique*, Vol. 43, p. 57, No. 25), show its variations during the period with the two unequal maxima, of which the causes are evident. I must add that the light attributed to the arc when the current passes through zero is more probably produced not by the arc but by the *flame* that surrounds it, and comes from the burning carbons. The method of the synchronously rotating disc for observing the carbons and arc was originally indicated by Prof. Joubert five years ago, if not in 1881.

[67] The Hefner unit is 1·04 pyr, or *bougie décimale*.

[68] Herren Roessler and Wedding have laid great stress upon the fact that with machines giving electromotive force curves of another shape, the efficiency might be even still further reduced. This is not surprising, and I long ago pointed out that the duration of the extinction of the arc, and in consequence its mean degree of incandescence, may vary very much according to the constitution, not only of the alternators, but also of the circuit. However, in actual practice the different types of alternators only give rise to very slight differences. If the authors we have quoted found very great variations, it is because they used antiquated types of alternators under conditions which are not generally met with in the distribution of energy. Their conclusions ought therefore to be accepted with a certain reserve. I may note that their mean figure is in every case very much lower than the one I have quoted.

[69] *The Electrician*, December 13, 1895, p. 230.



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by putting down special mains to be supplied with continuous currents for public lighting, even in towns supplied on the alternating-current system. This tendency has been assisted by the fact that special types of arc lighting machines exist (Brush, Thomson-Houston, &c.), and by the preference so long given to series distribution for arc lighting. Therefore, in many towns a special station has been erected or special machines have been fixed in the urban station for arc lighting. But this system has many inconveniences, of which the most important is that it calls for the use of special plant, which is always expensive, and thereby reduces the coefficient of possible use of the principal part of the station. In France we labour under the disadvantage that the use of high pressure along public thoroughfares is not readily permitted, and the series system, which calls for relatively much greater precautions, has therefore fallen more into disfavour. Again, this system does not easily allow of the use of lamps of varying candle-power. It is almost always easier, and quite as efficient, to connect public lamps to the general system of distribution. This arrangement will soon be the only one in use in Paris and in almost all the towns in France. Even in America, the Fatherland of series arc lighting, it has found favour. The beautiful lighting of the Fifth Avenue at New York, for instance, is done by lamps arranged two in series across each side branch of the Edison network. We ought, then, in the same manner to try and use the existing alternating-current mains on account of simplicity and of the load factor. From what we have already seen, to simply place alternating-current arcs on the secondary network—even if this secondary network is a special one—as is done at Havre and Clermont, is a bad solution which can only be improved by the use of special optical arrangements.

Many engineers propose to attain the same advantages by a different method, namely, by eliminating the alternating arc without giving up alternating currents. An important and very interesting development has recently taken place in England, due to Mr. Ferranti, who uses an apparatus called a "rectifier." The alternating current at high pressure and constant voltage is first transformed into an alternating constant-current and varying voltage, such as is required for series arc lighting. This is done by the aid of specially constructed transformers, with a movable secondary circuit. This secondary is repelled or attracted by the primary in such a way as to render the current constant, at the same time as it maintains the electromotive force proportionate to the number of lamps in circuit. This secondary current before being sent into the distribution network passes through a revolving commutator, similar to the old Clarke commutator, revolved by a small synchronous motor, and on which the brushes are so set that the alternating current is commuted at the moment when it is at zero. The result is that a current always in the same direction, but pulsating, is obtained for feeding the arcs. The arcs formed are then practically the same as for continuous currents. A crater is formed on one only of the two carbons and produces the greater portion of light. By making this the top carbon the same distribution of light is obtained as with a continuous current. A point in favour of this system is that, owing to the constant vibration due to the pulsating current, the feed of the carbons is much more regular and even than with constant currents. Installations for public lighting on this system have been carried out at Portsmouth, Cardiff, and Blackpool, where very satisfactory results have been obtained. In reality this system is not so novel as would first appear, for the first electrical machines which were ever constructed—Alliance and Holmes's—were alternators fitted with rectifiers, and the arcs supplied by them in lighthouses where they were used were pulsating arcs. This rectifier was promptly discarded in favour of the alternating arc pure and simple, because of the rapid deterioration of the commutator by reason of the sparking. It must be thought that the Ferranti rectifier will not have the same defect, thought it is very difficult to commute currents in circuits with self-induction without very strong sparking. Unfortuneately, it is quite possible that the luminous efficiency of such arcs will be somewhat less than that of a pure continuous-current arc, for it is liable to short extinctions at each alternation. Two other objections may also be made to this system. One is the low efficiency of the special transformer employed, and the other is the danger resulting from the use of commutators at such high pressure where one has to regulate the brushes by hand. Apart from danger of shock, pulsating currents being about as dangerous as alternating currents, it is to be feared that the least irregularity in the line of commutation will give rise to rather serious arcing. For these reasons it appears to me still preferable to convert alternating currents from high or low tension into continuous currents at constant potential for distribution in parallel. This transformation is easy in the case of a network fed by polyphase currents where rotary transformers of the Lahmeyer or similar type can be employed. To make this transformation possible for simple alternating currents, the author devised a special rotary transformer, which may be useful for public lighting in the numerous towns where distribution is carried out by single-phase alternating currents. The efficiency of this transformer complete is expected to be 87 per cent. to 90 per cent. according to the size, which enables a much greater quantity of light to be obtained with the same amount of energy than could be obtained by the direct use of alternating currents. The solution possesses the advantage of absolute security, and allows lamps which have already been long tried in lighting with continuous currents to be used. The troubles of alternating currents in the regulation of the lamps are avoided. It must be remembered that the properties of these currents are variable according to the form of the curve of the electromotive force of the machine. A lamp which will work well in the factory may do no such thing when placed in service on the network. Nothing of the kind is to be feared with the continuous current.

### Conclusions.

I have shown in this investigation that the question of utilisation of the light of arc lamps is a complex one, and that we are far from having reached a definite solution. Lamps are almost always fitted with carbons of too large a size and too short a travel. Bad globes are very often selected—either they do not temper the brilliance of the arc sufficiently, or they absorb too much light. Finally, we are still not sufficiently advanced for

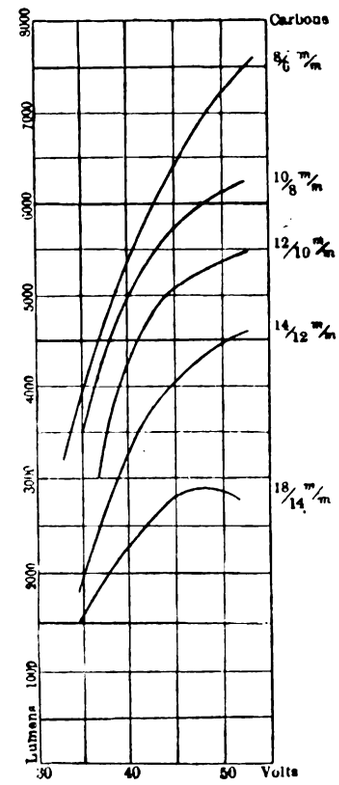


Fig. 66.

the rational use of the alternating arc, though holophane globes and small interior reflectors constitute very important steps forward. There are, nevertheless, many things to be done before we obtain the best luminous efficiency for the energy consumed. One of the most important desiderata is the construction of a good focussing lamp, with multiple carbons, and of such a design as to admit of the use of carbons of greater length. The photometric value of alternating arcs is still very doubtful, but it certainly appears to be mediocre, and it would seem well to replace them by pulsating or continuous-current arcs when possible. I wish these remarks to lead engineers to study the various and interesting problems which public lighting affords, and I hope they will create in them a desire to make really useful progress.

### Appendix I.

During the publication of this work I have, with the assistance of MM. Laporte Coster and Revel, taken at the Central Laboratory a series of measurements of the flux of 10-ampere continuous-current arcs under various conditions. The curves (Fig. 66) here given show the first results attained, and confirm the generalisations made in the first portion of this article. Each curve corresponds to a pair of carbons of the size shown. The abscissæ give the voltage at the carbon points and the ordinates the flux in lumens. (The mean spherical intensity in candles is this figure divided by $4\pi$.) By comparing the number of watts with the number of lumens we

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**Appendix II.**—*Data Relating to Various Public Arc Lighting Plants.*

| Towns. | Nature of current. | Nature of globe. | Current. | Average width of the streets in metres. | Average distance apart in metres. | Average height of posts in metres. | Total number of arcs used. |
|---|---|---|---|---|---|---|---|
| Paris { Grands boulevards / Avenue de Clichy } | Continuous. | Opaline. | 10 | { 35 / 25 } | 40 to 60 / 50 | { 5·95 / 4·45 and 4·95 } | 313 |
| Toulouse | ... | ... | 10 | 14 to 15 | 50 to 70 | 7 | 222 |
| St. Petersburg (Newski-Prosp.) | ... | Roughened. | 11 to 12 | 50 to 60 | 40 to 70 | 10·50 | 80 |
| Milan | ... | Opaline. | 4½, 6, 10, 15 & 20 | 8 to 30 | 40 to 60 | 9 | 341 |
| Hamburg (Jungfernstieg) | ... | ... | 8 | 16 | 25 to 30 | 8 | 68 |
| Berlin { Unter den Linden / Leipzigerstrasse } | ... | ... | 14·15 / 14·15 | ... | (41 (2 rows) / 69 (1 row) / 69 (1 row) | 8 | ... |
| Berne | ... | ... | 12 | 15 to 20 | 60 to 80 | 9 | 42 |
| Munich | ... | ... | 5 and 10 | 15 to 25 | 50 | 8 and 10 | 780 |
| London (City) | ... | Small opaline globe in clear lantern. | 10 | ... | ... | 6·50 | 479 (City 340) |
| Londonderry | ... | Opaline. | 10 | 15 to 25 | 70 to 180 | 7·60 | 170 |
| Glasgow | ... | ... | 10 | ... | 40 to 55 | 5·20 | 101 |
| New York { Avenues / Cross roads } | ... | Clear. | 10 to 11 / 10 to 11 | 30 / 18 | 78 / 90 | 6·10 | 2,621 |
| Chicago | ... | ... | 9·6 to 10 | 20, 22·5, 24·5, 30 | 60 to 100 | 5·40 | 1,486 |
| Atlanta | ... | ... | 10 | 9 to 30 | 23 to 30 | 7·60 to 12 | 416 |
| Havre | Alternate. | Opaline. | 12 to 15 | 30 to 45 | 70 to 80 | 4·50, 5·50, 7·50 | 77 |
| Clermont-Ferrand | ... | ... | 15 and 20 | ... | 35 | 6 | 15 |
| Zurich | ... | ... | 18 | 30 to 40 | 60 | 7 | 53 |
| Cologne | ... | ... | 10 | 7 to 10 | 45 to 60 | 7 | 13 |
| Blackpool | Continuous and rectified. | ... | 10 and 10·5 | 25 | 45 to 50 | 7·60 | 185 |
| Bristol { Continuous. / Alternate. } | ... | ... | 10 / 13 | 15 to 30 | 40 to 50 | { 6·70 / 3·65 } | 97 |
| Yarmouth { Continuous. / Alternate. } | ... | ... | 10 / 15 | ... | ... | 6·70 | 60 |
| Portsmouth | Rectified. | ... | 12 | ... | 80 | 7·60 | 109 |

I am indebted for these data to the courtesy of Messrs. Monmerqué, Quintin, de Joukowsky, C. Cervi, Vermehren, Kirschner, Rothenbach, Uppenborn, J. Christie, W. Arnot, McCormick, J. P. Barrett, J. Harper, Février, Dalichampt, Joly, John Hesketh, H. Faraday Proctor, A. W. Ranken and E. Price.

have a measure of the efficiency. This is a maximum at about 45 volts for the kind of carbons employed. The carbons were furnished for these experiments by the Société de Nanterre, and were of excellent quality. The lamps placed at our disposal by M. Bardon worked with remarkable precision. Thanks to these two favourable factors, we have been able to obtain figures which may be relied upon provisorily, excepting as regards the larger carbons (18mm. and 14mm.), where the arc varied somewhat, and the results are less certain.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, May 8th.**

IRON AND STEEL INSTITUTE.

*10:30 a.m.* General Meeting at 25, Great George-street, S.W. Various Papers to be read and discussed.

KING'S COLLEGE ENGINEERING SOCIETY.

*4:15 p.m.* Meeting at King's College, Strand. Presidential Address by Magnus Mowat on "Horseless Carriages."

PHYSICAL SOCIETY.

*5 p.m.* Meeting at Burlington House. Papers to be read: (1) "On Dielectrics," by R. Appleyard; (2) "On the True Resistance of the Electric Arc," by Messrs. J. Frith and Rodgers.

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Students' Meeting at 28, Victoria-street, S.W. Paper to be read: "Single-Phase Alternate-Current Transformers in Practice," by A. F. Berry.

INSTITUTION OF JUNIOR ENGINEERS.

*8 p.m.* Meeting at the Westminster Palace Hotel. Paper to be read and discussed: "Notes on Belgian Electrical Engineering Practice," by A. Anstruther-Thomson and G. C. Allingham.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Electric Shadows and Luminescence," by Prof. Silvanus P. Thompson, F.R.S.

**SATURDAY, May 9th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

Students' visit to the London Electric Supply Corporation's Station at Stowage Wharf, Deptford.

**MONDAY, May 11th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture III.: "Applied Electro-Chemistry," by James Swinburne.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

*8 p.m.* Meeting at the Palatine Hotel, Hunt's Bank, Manchester. Paper to be read: "The Use and Economies of Rectifiers for Arc Lighting," by John Hesketh.

**TUESDAY, May 12th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture (II.): "Ripples in Air and Water," by C. Vernon Boys.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Papers to be further discussed: (1) "American and English Methods of Manufacturing Steel Plates," by Jeremiah Head; (2) "Four American Rolling Mills," by Samuel T. Wellman.

**WEDNESDAY, May 13th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Tunnelling by Compressed Air," by E. W. Moir.

**THURSDAY, May 14th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Paper to be read: "The Influence of the Shape of the Applied Potential Difference Wave on the Iron Losses in Transformers," by Stanley Beeton, C. Percy Taylor and J. M. Barr.

**FRIDAY, May 15th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*5 p.m.* Students' visit to the Robertson Incandescent Lamp Factory, Brook Green, Hammersmith.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Cable Laying on the Amazon River," by Alexander Siemens.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p m.

**Electric Power for the Hogback Tunnel, Colorado.**—This tunnel, which is to form a portion of the new waterworks system of Colorado springs, is to be 6,400ft. long and will be constructed from both ends. The air-compressors are to be run by a 75 H.P. three-phase motor. The generating station is to be erected a short distance above the Iron Springs Hotel, at Manitou, and the water necessary for the generation of the electric current is to be taken from the pipe line which now supplies Colorado Springs with water, and after being used for this purpose will be again conducted to the pipe line. The water has a fall at the site of the power station of 700ft. The power is to be generated by a 150 kilowatt 3,600-volt three-phase generator. The current will be transmitted about eight miles, and will be used to run the air-compressors, supplying lights and for other necessary purposes.



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## RECEIVERS IN BANKRUPTCY.

Although it is our custom to regularly report all legal cases affecting the interests of the electrical industry, we rarely feel called upon to make any comment upon them from a purely legal aspect. The maxim that a cobbler should stick to his last is indeed a very excellent one, and in transgressing it by the remarks we propose to make on the case of "GASKELL *v.* GOSLING," which was briefly reported in a recent issue, we do so in the full consciousness both of the enormity of the offence and of the fact that it will be condoned by those who have had the misfortune to be "taken in" by our bankruptcy laws. Of course there are superior persons who have never been entrapped by deceptive appearances into contracting a bad debt, and others whose calling in life renders it unlikely that they will ever so far commit themselves; these fortunate ones need read no further.

A new and rapidly-expanding industry is peculiarly liable to financial mishaps, since it invariably attracts a number of sanguine individuals who embark on the venture most inadequately equipped both as regards capital and experience, with the inevitable result that many too confiding friends suffer in consequence. We wish to refer more particularly to cases where, as in the one already alluded to, the business of an insolvent concern is being carried on under the old title, but with the addition of somebody's name, who writes "Receiver" after it, and obtains goods upon credit. We were glad to notice that under the decision of the Court of Appeal in this case the creditors succeeded in getting behind this title, and obtained judgment against the parties on whose behalf the Receiver ordering the goods was held in fact to have been trading, and who proved to be bankers holding debentures. As, however, one of the Lords Justices dissented from the judgment of his two colleagues, and the case is undoubtedly

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one of importance to the trading community, it seems probable that the defendants' declared intention to appeal to the House of Lords will be carried out, so that the law on the subject unfortunately cannot be said to be finally settled. But in the meantime it may be permissible to say a few words about the position of traders supplying goods upon the orders of Receivers. We believe there is a widespread impression that the use of this title implies that the person using it has money behind him which entitles him to better credit than was, perhaps, ever enjoyed by the firm whose business he is carrying on. This is probably a survival of the notion that a Receiver may be presumed to be an official appointed by the Court. In former days this was usually a tolerably safe assumption, and in those cases where it still proves to be correct there may be some grounds for confidence. The Court always requires some evidence as to the credit of its officer before appointing him, and he has to find security for his duly accounting for the funds passing through his hands. He is, moreover, personally liable to those with whom he makes contracts; and, being usually a chartered accountant having a professional reputation to maintain, this is some check against any tendency to trade recklessly. At all events, it is generally not difficult to discover something about his credit and antecedents. It should, nevertheless, be borne in mind that a Receiver appointed by the Court is not allowed to carry on a business, as distinguished from realising it, unless he is specially authorised so to do by order of the Court, when he should use the title of "Receiver and Manager."

Things have, however, progressed a good deal further in recent times, and at the present day it would be most rash to assume that a person calling himself Receiver has any authority from the Court, or that he is a man of any substance whatever. By the Conveyancing and Law of Property Act, 1881, certain powers of appointing a Receiver were given to mortgagees which they did not possess before, and it has also of late years become a common practice to prepare debentures and debenture trust deeds in such a form as to enable debenture-holders or their trustees to appoint anyone they please as Receiver, with full powers of managing the business of the company which has made default. This Receiver may be a man of straw, who, while taking all the benefits of the business on behalf of the debenture-holders, is declared according to the terms of the deed, so far as his liabilities are concerned, to be the agent of the company granting the debentures, which presumably is insolvent when he commences his operations and probably immediately afterwards goes into liquidation. In the present case the Receiver who ordered the goods for which the action was brought is described in the report of the original hearing of the case before the Lord Chief Justice, as being himself a bankrupt. The Lord Chief Justice and two Lords Justices on appeal agreed in the opinion that this bankrupt Receiver was not personally liable for contracts he had entered into, but that some one must be, and accordingly they saddled this liability upon the persons from whom he derived his authority, and for whose sole benefit he was trading. On the other hand, Lord Justice Rigby, in a long and elaborate judgment, explained his reasons why he could not fix legal responsibility upon the bankers, and he avoided the dilemma as to no one being liable on the contract, by expressing the opinion that previously to the liquidation the Receiver was agent for the Company in accordance with the express terms of the debenture deed, and could pledge only its credit, and that afterwards he had in fact no principals, and so could pledge nobody but himself, and incurred personal liability for his contracts accordingly. Which of these doctrines will prove correct is, no doubt, a nice point for legal contention, and we shall have to wait for the answer until the final decision of the House of Lords.

Meantime it is a disagreeable revelation for debenture holders to find that they may, under certain circumstances, be rendered liable for the acts of their Receiver, but should the result of the appeal confirm this view it may lead to some amendment in the pernicious practice which has obtained hitherto, whereby a company having practically no subscribed capital is able to carry on business solely by means of money borrowed from the holders of debentures, to whom the whole of its assets are pledged. Such a company is entitled to no credit whatever, whether its affairs are managed by Directors or a Receiver, and it should get none.

Pending the ultimate issue of this conflict, and perhaps afterwards too, it behoves traders to remember that the safest rule is *caveat emptor*. Our advice for the present to those who desire to enter into contracts with a person using the specious title of Receiver is to inquire whether he is appointed by the Court, and whether he is a person to whom they would be willing to give credit when dealing on his own account. If not satisfied on both these points they will be wise to ascertain who his employers are, whether their credit is good and whether he has authority to pledge it. Failing a sufficient answer to these questions, or an adequate guarantee for the account, there is nothing left but to follow the famous advice given by Mr. Punch to those about to commit matrimony.

## THE ELECTROLYTIC DISSOLUTION OF CARBON.

Under this title has lately been published by Dr. Friedrich Vogel in the *Zeitschrift für Elektrochemie* an article which, on account of its dealing in a spirit fully critical with the work of Dr. A. Coehn, already recorded in *The Electrician*, will probably be of some interest to our readers. In order that the point of Dr. Vogel's criticisms may be the better apprehended, it may be stated that according to Dr. Coehn's results, it appears possible to cause carbon to act as the anode in a cell having sulphuric acid as an electrolyte and lead peroxide as a depolarising cathode, and, further, to obtain by the use of an external current a deposit of matter which, if not pure carbon, is at least richly carbonaceous. Three deductions from these results are made by Dr. Coehn, to wit: (1) It is possible to prepare a solution of carbon by electrolytic means; (2) carbon can be precipitated at the cathode from such a solution; (3) a cell can be prepared, of which the soluble electrode is carbon.

Dr. Vogel considers that the nomenclature used by Dr. Coehn is not sufficiently precise. Carbon has long been known to be capable of forming part of an ion acting in accordance with Faraday's law, but has not hitherto constituted such an ion. In the present case there is no evidence that this important gap has been bridged. Similarly, the carbon deposited at the cathode is associated with the elements of water, and cannot be considered as affording evidence of the previous existence of a carbon ion. Analytical data are also extensively lacking in Dr. Coehn's Paper. The figures on which the deduction of the composition of the deposit on the cathode is based should be given, and similarly an analysis should have been made of the products of the disintegration of the carbon anode (which is said to take place when the electrolyte is used at the ordinary temperature) and of the red-brown solution containing carbon (stated to be formed when the electrolyte is used hot). In Dr. Vogel's opinion the production of electrical energy by the electrolytic dissolution of carbon is not novel, for it has been described by Bartoli and Papasogli ("Nuov. Cimento," Vols. 8 to 13); the fact that Dr. Coehn has obtained better results than have these observers is to be attributed to his use of a cathode of lead peroxide.

The following amended version of Dr. Coehn's conclusions is therefore proposed:—(1) It has not yet proved possible (and the possibility is remote) to bring carbon into electrolytic

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solution; (2) carbon has not hitherto been precipitated on the cathode as a chemical individual, but only as an integral part of a more complex ion; (3) cells having carbon as their soluble electrode have been devised by Bartoli and Papasogli and improved by Dr. Coehn.

The situation seem to present polemical possibilities.

## SOME ELECTRIC SUPPLY DATA.

Facts are stubborn things, and when once their certainty is fully proved there is no disputing the conclusions to which they directly lead. Gradually, year by year, the electric supply industry is piling up an immense quantity of facts, from which, it is to be hoped, we shall ultimately arrive at the truth as to the relative merits and demerits of the various systems of supply, and as to their suitability for particular kinds of localities and classes of work. And not only are the systems, as a whole, passing through the refining furnace, but each item in their management and working is being subjected to ultimate analysis; so that in the end we may expect

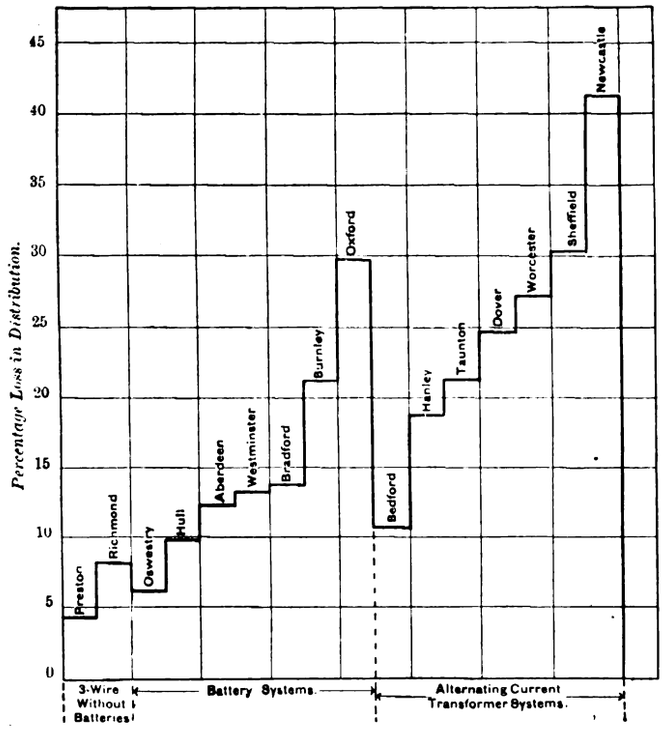


FIG. 1.—Percentage Loss of Energy in Distribution in some Electric Supply Systems.

to separate the elements of good from the elements of evil, and to be able to say with a high degree of assurance what particular combination of elements will form the best system for any given set of conditions. This, in fact, is the ideal towards which each year's additional experience carries the electric supply industry. The data now published at frequent intervals greatly assist in this process of "separating the sheep from the goats," and the accompanying Table I., showing what is done with the units generated, at a number of electric supply stations, should prove of further use in this respect, especially in regard to the relative efficiencies of the systems of distribution. It will, of course, be understood that a system is not necessarily condemned because it happens to show a lower efficiency of distribution. That would be but one factor to take into consideration. For instance, one alternate current system may have a lower distribution efficiency than another, not because it is intrinsically inferior, but because the load factor has been lower, causing the all-day idle and magnetising current losses in the mains to assume a greater relative importance. Or, again, in a battery system a higher efficiency may imply, not simply that better batteries and mains are in use, but that a better load factor and a more nearly constant load have reduced the call made upon the batteries and diminished the losses which have taken place in them.

As will be inferred from the foregoing remarks, one of the most important and instructive factors which can be brought into juxtaposition with the distribution efficiency of a system of supply, is the annual load factor of the station. Another useful factor is the ratio of the maximum actual demand on

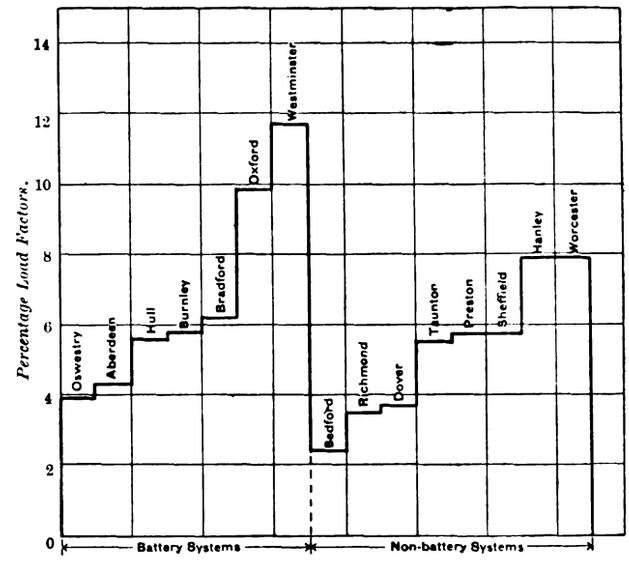


FIG. 2.—Percentage Load Factors of some Electric Supply Systems.

the station to the total capacity of the station. We have named this the "maximum demand factor." In a battery station this factor may, of course, exceed 100 per cent., though as a matter of fact it rarely does so; in a non-battery station it cannot, of course, exceed 100 per cent., unless the rated capacity of a plant is below its real capacity, and it is usually very much below 100 per cent. The maximum demand factor partly assists in showing to what extent there is superfluous

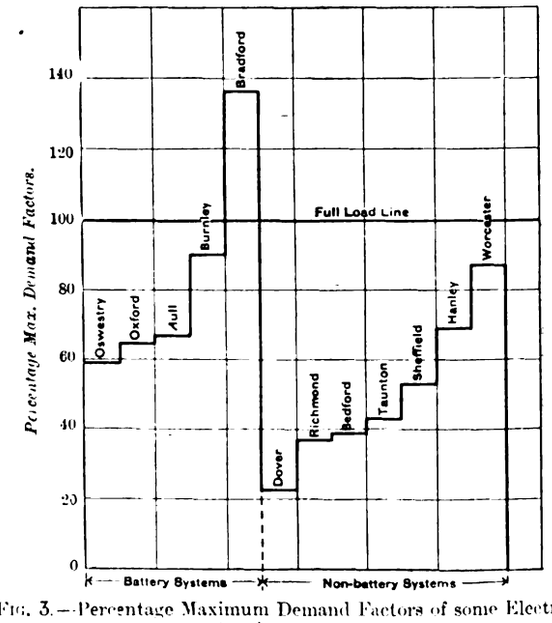


FIG. 3.—Percentage Maximum Demand Factors of some Electric Supply Systems.

generating plant; while the load factor indicates the extent to which the hours have been filled up by work. Table II. gives the load factors and maximum demand factors for a number of stations, arranged as far as possible to correspond with Table I.

A matter which is indicated in Table I. is deserving of further notice. We refer to the number of units used on the works. In the annual accounts of one or two of the electric

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**Table I.**—*Showing the Distribution Efficiency of Some Electric Supply Stations for the Year ending December 31, 1895.*

| System. | Place. | Units generated. | Units used on works. | Units wasted in system and unaccounted for. | Units sold. | $\eta = \frac{\text{Units sold} \times 100}{\text{Units sent into mains}}$. | Percentage loss in system. |
|---|---|---|---|---|---|---|---|
| Systems employing batteries. | Westminster.. | 3,371,327 | 52,281 | 488,650 | 2,882,677 | 86·9 | 13·1 |
| | Aberdeen.. ... | 159,777 | 1,769 | 19,635 | 138,372 | 87·6 | 12·4 |
| | Burnley ..... | 168,637 | 10,189 | 33,515 | 124,933 | 78·8 | 21·2 |
| | Bradford ..... | 753,766 | 20,010 | 60,057 | 673,699 | 86·3 | 13·7 |
| | Norwich ..... | 343,530 | .. | 43,880 | 299,650 | 87 2 | 12·8 |
| | St. Pancras ... | 1,063,322 | 54,807 | 158,528 | 849,987 | 84·3 | 15·7 |
| | Oxford..... | 295,185 | ... | 87,552 | 207,633 | 70·3 | 29·7 |
| | Hull..... | 273,213 | 26,936 | | 246,277 | 90·1 | 9·9 |
| | Oswestry..... | 5,901 | 355 | | 5,546 | 93·9 | 6·1 |
| Continuous current systems without batteries. | Preston ..... | 300,699 | 13,362 | 16,261 | 271,076 | 95·6 | 4·4 |
| | Richmond ... | 89,698 | 2,200 | 7,042 | 80,456 | 91·9 | 8·1 |
| Alternate-current transformer systems. | Newcastle ... | 782,768 | 27,650 | 311,106 | 444,012 | 58·8 | 41·2 |
| | Hanley ..... | 225,575 | 3,309 | 41,797 | 180,469 | 81·1 | 18·9 |
| | Worcester ... | 348,251 | 8,955 | 92,384 | 246,912 | 72·7 | 27·3 |
| | Sheffield ..... | 418,097 | 14,559 | 115,132 | 288,406 | 69·7 | 30·3 |
| | Dover ..... | 77,851 | 2,768 | 18,425 | 56,658 | 75·4 | 24·6 |
| | Bedford ..... | 56,272 | 5,418 | 5,354 | 45,500 | 89·4 | 10·6 |
| | Taunton ..... | 143,876 | 6,364 | 29,226 | 108,286 | 78·7 | 21·3 |

**Table II.**—*Showing the Load Factors and Maximum Demand Factors of Electric Supply Stations for year ending December 31, 1895.*

| System. | Place. | Capacity of generating plant in kilowatts. | Units generated. | Station load factor, per cent. | Maximum demand factor $= \frac{\text{Max. demand} \times 100}{\text{Station capacity}}$. |
|---|---|---|---|---|---|
| Systems employing batteries. | Westminster ..... | 3,305 | 3,371,327 | 11·70 | ... |
| | Aberdeen..... | 430 | 159,777 | 4·24 | ... |
| | Burnley .. ..... | 334 | 168,637 | 5·77 | 89·99 |
| | Bradford ..... | 1,390 | 753,766 | 6·19 | 135·90 |
| | Norwich ..... | 543 | 343,530 | 7·19 | 71·85 |
| | St. Pancras ..... ..... | 1,380 | 1,063,322 | 8·79 | 89·89 |
| | Oxford..... | 340 | 295,185 | 9·90 | 64·72 |
| | Hull..... | 560 | 273,213 | 5·56 | 65·36 |
| | Oswestry..... | 60 | 5,901 | 3·88 (for 15 weeks) | 58·67 |
| Systems not employing batteries. | Preston ..... | 602 | 300,699 | 5·70 | ... |
| | Richmond ..... | 290 | 89,698 | 3·53 | 37·04 |
| | Hanley..... ..... | 324 | 225,575 | 7·94 | 68·52 |
| | Worcester ..... | 500 | 348,251 | 7·95 | 86·54 |
| | Sheffield ..... | 835 | 418,097 | 5·72 | 50·29 |
| | Dover ..... | 325 | 77,851 | 3·64 (for 9 months) | 22·77 |
| | Bedford ..... . ..... | 270 | 56,272 | 2·38 | 38·70 |
| | Taunton ..... | 302 | 143,876 | 5·44 | 43·04 |

**Table III.**—*Showing a Comparison between the Load Factors, Maximum Demand Factors, Distribution Efficiencies, Generating Expenses, and Total Costs of some Electric Supply Stations for the year ending December 31, 1895.*

| Place. | Load factor. | Maximum demand factor. | Distribution efficiency. | Generating expenses in pence per unit generated. | Total costs, in pence per unit sold. |
|---|---|---|---|---|---|
| Westminster | 11·70 | ... | 86·9 | 1·18 | 3·43 |
| Oxford ..... | 9·90 | 64·72 | 70·3 | 1·20 | 3·69 |
| St. Pancras | 8·79 | 89·59 | 84·3 | 1·52 | 3·49 |
| Worcester... | 7·95 | 86·54 | 72·7 | 1·60 | 3·89 |
| Hanley ..... | 7·94 | 68·52 | 81·1 | 1·61 | 3·81 |
| Norwich ... | 7·19 | 71·85 | 87·2 | 1·61 | 3·38 |
| Bradford ... | 6·19 | 135·90 | 86·3 | 1·19 | 3·90 |
| Burnley... .. | 5·77 | 89·99 | 78·8 | 0·78 | 3·07 |
| Sheffield ... | 5·72 | 50·29 | 69·7 | 1·74 | 4·48 |
| Preston..... | 5·70 | ... | 95·6 | 1·19 | 3·30 |
| Hull ..... | 5·56 | 65·36 | 90·1 | 1·69 | 3·91 |
| Taunton ... | 5·44 | 43·04 | 78·7 | 2·02 | 5·60 |
| Aberdeen ... | 4·24 | ... | 87·6 | 1·08 | 4·26 |
| Oswestry ... | 3·88 | 58 67 | 93·9 | 2·49 | 3·77 |
| Dover ... . | 3·64 | 22·77 | 75·4 | 3·34 | 8 80 |
| Richmond . | 3·53 | 37·04 | 91·9 | 3 21 | 7·08 |
| Bedford..... | 2·38 | 38·70 | 89·4 | 3·08 | 5·49 |
| Newcastle... | ... | ... | 58·8 | 0·87 | 2·93 |

supply concerns these appear to have been confused with the units *wasted* on the works (mains, transformers, batteries, &c.). This is a highly original interpretation of the word "use"; and we have transferred units so "used" to a parallel column, which gives the units wasted or unaccounted for. In two or three cases where it has been impossible to separate the two items, these have been taken conjointly as units wasted. A literal interpretation of the returns of one concern could mean nothing else than that absolutely no units had been wasted anywhere; *all* were accounted for as "used." In the data for Oxford no account is taken of units used on the works, and the 87,552 units given are stated in the accounts to have been lost in the mains or unaccounted for. It is surprising to what a large extent some supply concerns consume, not their own smoke, but their own units. So important an item, indeed, is the amount used on the works that we have deducted it in every case from the total units generated before calculating the efficiency of, and percentage loss in distribution.

Finally, to afford some comparison between the load factors, maximum demand factors and the total and works costs of the concerns, we have compiled Table III., in which the stations in Tables I. and II. are arranged in the order of their respective load factors. We have also arranged the more important data diagrammatically, Fig. 1 showing to scale the percentage distribution losses, Fig. 2 the load factors, and Fig. 3 the maximum demand factors for a number of supply stations.

## BOOKS RECEIVED.

"Elektrochemie: Ihre Geschichte und Lehre." By Dr. Wilhelm Ostwald. (Leipzig: Von Veit and Co.)

"The Slide Rule." By Charles N. Pickworth. Second Edition. (London: Emmott and Co. Price 2s.)

"The Magnetic Circuit in Theory and Practice." By Dr. H. du Bois Translated by Dr. Atkinson. (London: Longmans, Green and Co. Price 12s.)

"Argon and Newton." By Lieut.-Colonel W. Sedgwick. (London: Whittingham and Co.) Price 7s. 6d.

"*Journal* of the Institution of Electrical Engineers." No. 121, Vol. XXV. Edited by F. H. Webb. (London: E. and F. N. Spon.) Price 3s. 6d.

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## HORSELESS CARRIAGES.

(FROM A CORRESPONDENT.)

The promoters of the Carriage Exhibition at the Crystal Palace have shown some ingenuity in advertising the show, as witness the fact that a number of people—a limited number, it is true—were induced to visit it one day this week, notwithstanding the unattractive character of the exhibits to all but the lucky few who possess carriages of their own. I count myself among the unlucky ones, and perhaps my views may be warped and jaundiced for that same reason. But I know a good deal about advertising, if little about carriages, and I cannot congratulate the management on their methods of pleasing their visitors after getting them on the spot. To begin with, "horseless carriages" has something alarming about it, like riderless horses; and this illusion is actually encouraged by the exhibitors themselves, who have profusely dotted the Palace grounds with warnings calculated to impress all pedestrians with the dangers of horseless carriage traffic. Passing along the winding roads which lead to the broad terraces, we thought at first that a novel kind of decoration had been introduced to ornament the borders, for at every 20 yards or so gaily painted poles with what appeared to be a little flag at the top of each, displayed themselves in long processional order like miniature venetian masts at a festival. What could this mean? Remembering, however, the object of our visit, I quickly divined that these gaudy indicators were to mark the track of the vehicles, to show them where they might go, and where not. Alas! for my discrimination; when near enough to examine one of these flags, which proved to be notice boards, imagine my horror to find myself face to face with the legend

"BEWARE THE HORSELESS CARRIAGE."

The next was the same, the next, and the next. Evidently there was no safety anywhere, whether I turned to the right or to the left, whether I hurried forward or retreated backward, the warning finger post admonished me to Beware! Stricken motionless with fright, and expecting to see the remorseless horseless carriage dart somewhere out of the shrubberies on either side of me, I was on the point of crying aloud for help, when happily I heard a noise in the distance, as if somebody or something were coming to my rescue. Turning a corner a little way ahead it proved to be something on wheels, which at first sight I mistook for an escaped perambulator, but which proved to be nothing less than the horseless carriage itself, careering along in fine style, and almost as intelligently as if a horse had been pulling it...

I say *almost*, and I use the word "careering" advisedly. A man was in it manipulating levers and wheels, and by his side were two or three passengers supposed to be enjoying carriage exercise. As to the exercise, there could be no doubt; but I am not so sure about the enjoyment. The creature swayed about and rocked in a rather alarming way—for the passengers; and the thumping of its machinery, to say nothing of the smell, could hardly conduce to the making of a "pleasant drive." My first impulse was to direct the passengers' attention to the warning on the boards, thinking it must have escaped them; but by this time the horseless carriage was nearly upon me, and I got out of the way for fear of upsetting it. I own to being afraid of carriageless horses, and always step aside for the stately steam roller; but this horseless carriage! Why am I to beware of the likes of it—and why, especially, if I am asked to buy one?

Making my way to the grand parade I read, and again read, the minatory notices as I go along, but now without any emotion save wonderment at the ineptitude of the people who placed them there. One of the horseless vehicles had just come to a standstill while fresh passengers, at a shilling per head, were being embarked. But I am wrong; it is not at a stand*still*; on the contrary it stands very noisy, and shakes itself to pieces almost with the effort of keeping going without going forward. Evidently this is a creature panting to be free—free to rush along and make the slavish pedestrian beware! I am given to understand that its spirits are kept up in this way because if allowed to run down, it requires a man to turn a wheel or something to make it start—like a certain perpetual-motion machine of Artemus Ward renown. On the whole, I fancy that if this affair were weighted with a good load of commercial travellers' samples, and the driver himself not too particular as to his seat, it might be found useful in a land where no horse is procurable.

Inside the Palace the carriages for horses had much the best of the show; and all the modern carriageless horses were greatly discounted by the presence of an ancient sample of locomotive, with cog wheels, compacted with a travelling carriage and guard's van all in one. Fancy travelling with the engine, furnace and boiler in the next compartment! Fancy also the egregious folly of people who want to recommend carriages of that *type* exhibiting such a monster by way of example!

There was an interesting display of ancient bicycles, but the most entertaining thing of all was a tricycle carrying appliances which are said to propel it at a great speed—a benzoline gas engine ignited by electric spark, we understood, was the motive power. But there was the usual saddle, as well as a pair of pedals! Nobody could tell us why. I suggested that a bath chair would be more comfortable, but the attendant seemed to think I was joking. He told me the owner's name, which at once accounted for the defective sense of humour betrayed in the concocting of this truly droll machine, and I came away with a suspicion that he must have had a good deal to do with the general arrangements, including the notices to "*Beware* of Horseless Carriages."

## ELECTRIC TRAMWAYS AND TELEPHONIC DISTURBANCES.*

BY JUL. H. WEST.

The disturbances which electric tramways generate in telephone circuits, especially those with earth returns, can be traced back to several causes. There is first of all the fluctuations of current which are unavoidable in the generation of continuous current by generators. Further, and perhaps the principal, cause of disturbance is the periodic variation of the resistance in consequence of the short-circuits at the commutator. Of the further causes Dr. Wietlisbach, in his article,† lays great stress upon the variations of resistance between trolley and wire, and states from experience that this variation is more marked in trolley lines than in tramways with slide contacts. The differences, however, which were shown in this respect by the trolley lines, made me suppose that the variations of the resistance between car wheels and rails, owing to the vibrations of the latter, were of far greater importance than the resistance variations between trolley and wire. In the *Elektrotechnische Zeitschrift*‡ of April 23rd the same opinion was expressed, and mention was made of some experiments which had been carried out in Berlin. The following is a description of these experiments:—

If the principal cause of disturbance be the vibration of the car wheels and rails, the noise created should vary considerably, according to the construction of the line. The noise should be greater on lines with hard foundations, such as concrete, than on lines constructed on elastic foundations, such as wood. The variations in the resistance in the former case must be far more marked than, and of a different frequency to, those that occur in the latter case.

To test this a line of the Berlin Tramway Company offered a splendid opportunity, as it possesses three different structural arrangements. Two small one-horse tramcars were connected by ordinary ropes—that is to say, by a non-conducting material. The two trucks were connected to a battery of two dry cells and the primaries of three induction coils, these latter being in parallel. The circuit was completed by the rails. The secondaries of the three coils were connected in series, and were in circuit with a Siemens telephone. The reason for using three induction coils with primaries in parallel was to make the resistance of the primary circuit as small as possible with the view of having any variation of the resistance between car wheels and rails brought out as distinctly as possible. It has now to be ascertained whether in running over sections of different construction the variations of the resistance between car wheels and rails exhibit a marked difference in character and intensity.

* From the *Elektrotechnische Zeitschrift*.
† See *The Electrician*, March 27, 1896, p. 725.
‡ See also *The Electrician*, May 1st, p. 22.

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The experiments were carried out at night time from April 17th to 18th. The preceding day had been dry, and therefore the rail surface was dry, but as there had been a period of wet weather the bottom surface of the rails must have been moist.

The line selected consisted of the following sections :—

No. 1. 880 yards of line on longitudinal wooden sleepers.
„ 2. 88 „ „ stone paving.
„ 3. 900 „ „ asphalt.
„ 4. 330 „ „ stone paving.
„ 5. 220 „ „ asphalt.

In No. 1 section the line consists of girder rails mounted on longitudinal sleepers of pine wood of a section of 10 × 16cm. (4in. × 6½in.) The line here has a gradient of 1 in 28. Sections No. 2 to No. 5 have Haarmann ordinary tramway rails. Sections No. 2 and No. 4 are laid on a gravel basis as used in ordinary road construction. Sections No. 3 and No. 5 are laid on asphalt and concrete, the rails resting on a layer of concrete 12cm. to 16cm. (5in. to 6½in.) thick, on the top of which there is a 15cm. (6in.) layer of concrete and a 5cm. (2in.) layer of asphalt.

It was expected that the noise in the telephone would be weakest in the section with wooden sleepers, stronger in the sections with gravel foundation, and strongest in the sections laid on concrete. This assumption was later on confirmed.

The car travelled first over section No. 1 up the gradient, and a fairly strong noise could be heard in the telephone, like a quick repetition of the cracking noise a diaphragm makes when an interrupted current passes it. Now and then the noise ceased, which was probably owing to a fault in the conductor connecting the two cars. After this being adjusted the same section was again run over, but at higher speed. The noise was now continuous and of the same intensity as before. On entering section No. 2 a slight increase in the noise was noticed. A further, but much more marked increase in the noise occurred when section No. 3 (concrete foundation) was reached. Not only did the intensity increase considerably, but also the frequency of the sounds was distinctly greater than before. A decrease in the noise was noticed when entering section No. 4 (gravel), and again an increase in the noise when section No. 5 (concrete) was reached.

The end of section No. 3 forms a curve. But whether a further increase in the noise occurs here could not be ascertained with certainty. However, it must be remarked that the noise on this section was already so great that still louder emissions from the telephone were impossible.

On the return journey the second line was used. On passing the sections No. 5 and No. 3 at a speed of about 12 to 14 kilometers (7½ to 8¼ miles) an hour, a slight metallic tone could be noticed. At some points, curiously, the noise disappeared partly or altogether, especially so at the curve mentioned above. Most likely water covered the rails at these points.

The experiments show plainly *that the periodic variations of the resistance between car wheels and rails depend to a large extent upon the construction of the road bed.* It is desirable to further investigate this point and to arrive at a line construction which shall obviate the variation of resistance, and thus get rid of one of the causes of telephonic disturbances.

## ON RAILWAY TELEGRAPHS, WITH SPECIAL REFERENCE TO RECENT IMPROVEMENTS.*

BY W. LANGDON.

The subject with which this Paper deals is one which has not, for some time, claimed the consideration of members of this Institution. The progress which has attended the application of electricity to railway telegraph work is in no way comparable with that which has in recent years marked its progress in relation to lighting and power. Such advances as have been achieved are to be found more in minor details than in any radical change. Probably the most noticeable fact presides in the greater freedom from serious breakdowns which we now enjoy, and in the growth of the telegraph service—a striking testimony of its increasing utility. Competition is a stern and exacting master. The train service of to-day must not only be well equipped, but it must work well to time. That which yesterday was thought ample, is to-day found wanting. Each day ushers in fresh demands, greater elaboration, greater exactitude! How useful a factor the telegraph becomes in enabling this to be accomplished is probably known only to those in whose hands rests the responsibility of that which has to be done.

In the year 1880† the late Mr. Edward Graves, one of our Past-Presidents, and for many years our honorary treasurer, brought under the notice of members some extremely interesting statistics in relation to the progress of telegraphy, in which he produced a comparison between the mileage of wire and the number of instruments in use on the various railways in Great Britain in 1869 and 1879.

By the courtesy of the controlling officers of practically the entire railway service of the country—to whom my acknowledgments are gratefully tendered—I am, with the exception of the data of some two or three of the minor companies, enabled to bring forward this information another decade and a half. Accepting Mr. Graves's figures as a basis, and making allowance for the expansion of those systems, the returns for which are not to hand, we get the following approximate results :—

| —— | Year. | Miles. | Increase. |
|---|---|---|---|
| Mileage of wire employed for railway purposes ..... | 1869 | 27,204 | ... |
| | 1879 | 62,099 | 34,895 |
| | 1889 | 84,423 | 22,324 |
| | 1894 | 99,296 | 14,873 |
| | | Instruments. | Increase. |
| Number of instruments employed for railway purposes... | 1869 | 10,121 | ... |
| | 1879 | 46,847 | 36,726 |
| | 1889 | 100,590 | 53,743 |
| | 1894 | 130,339 | 29,749 |

It will be understood that these figures are not put forward as absolutely correct; they may, however, be accepted as fairly representative, and as a very near index of the progress and increasing influence of the telegraph service.

Prior to 1870 block signalling was but sparsely employed. During the decade 1869-79 it met with general adoption, which accounts for the large increase in both instruments and wire during that period. The increase during the half-decade 1894 is, in relation to that of the preceding decade, remarkable, as indicating that the expansion is still in active operation. These figures tell their own tale of utility in the management and regulation of railway traffic; while, from the mileage of wire maintained by the railways for the Postmaster-General, amounting approximately to some 67,000 miles, it may be reasonably inferred that the railways are in no small degree contributing to the convenience of that branch of the public who, from day to day, seek the service of the Post Office wires. Let us pause but a moment to consider how the present enormous traffic of our railways, or the mass of matter which daily passes over the various telegraph services of the country, could possibly be dealt with without these aids, or how the conditions of commercial life would be affected by their cessation, and we at once become sensible of their value.

Individually, possibly few railways afford a more forcible illustration of the rapid growth of a railway telegraph service than that to which the author is attached. In 1878 the total mileage of wire on the line amounted to 9,816 miles, and the number of instruments to 7,702. The mileage of wire to-day exceeds 22,000, and the number of instruments closely approximates to 19,000.

This large expansion is naturally calling for increasing accommodation for wires, and, in the interest of economy, for a careful study of the cost in both construction and maintenance.

### Poles.

One of the chief factors to which we are indebted for the greater stability of our lines of telegraph at the present time is the employment of poles which have been charged to a certain extent with creosote.

In the session of 1873-74 a Paper,* "On the Preservation of Telegraph Poles," was read before this Institution, then the Society of Telegraph Engineers, in which the various processes for the preservation of timber were discussed. Of the several methods there referred to, the creosoting process may be regarded as the sole survivor.

Creosoted poles are now almost universally employed. Their life, or the period they may remain in position without deterioration from decay, is still, to all intents and purposes, undetermined. Given a properly seasoned pole, fairly dry when placed under the process, its life may reasonably be relied upon to cover the period the pole is required to stand before additions or alterations call for its replacement. It is neither necessary nor desirable that the timber of telegraph poles should be completely charged with creosote. The quantity of creosote impressed into telegraph poles is usually 8lb. to the cube foot of timber; and this quantity, where the wood is properly seasoned and well dried, will be found to have penetrated to the core or heart-wood of the pole. It will thus form a complete protective shell, impervious to moisture; and in this lies the main advantage of the application. Timber which is thoroughly impregnated or saturated with creosote becomes, as soon as the oil is dissipated, devoid of much of its elasticity, and is then more easily broken than if the heart-wood of the timber is allowed to remain uncreosoted.

There are points where creosoted poles are objectionable—such, for instance, as station platforms. Here, whereas in former years

* Paper read before the Institution of Electrical Engineers, April 30th.
† *Journal* Institution Electrical Engineers, Vol. IX., p. 249.
* *Journal* Institution Electrical Engineers, Vol. III. p. 181.



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Memel timber was usually employed, it is preferable to use pitch pine. Pitch pine is more durable than Memel. It is more resinous, and thus more antagonistic to the reception of moisture; and it is the moisture which, traversing the fibre of that portion of the timber in the soil, under the influence of the warmer atmosphere above the ground line, disintegrates it at, or about, the ground level, and so destroys it.

The number of wires which have now to be accommodated, in many instances, call, not merely for stout poles, but for structures, such as "H" poles. These structures (Fig. 1) consist of two poles, A, B, braced together at the foot by a slab of wood, C, as nearly as possible at right angles to the poles, and a further slab, D, some 4ft. from the butt end of the poles, arranged diagonally; the arms, E, at the top of the poles act as the tie-pieces at that end of the structure. These are sometimes, especially in high poles, supplemented by a stiff iron rod, F, passing through the two

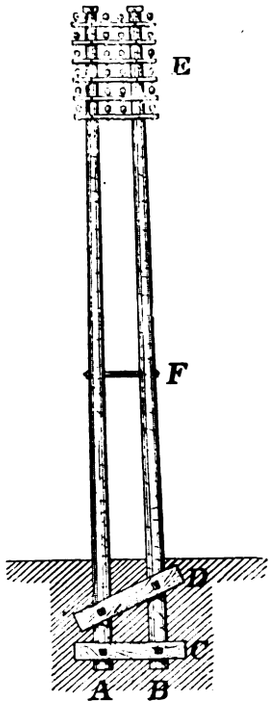


Fig. 1.—"H" Pole.

poles, at right angles to them, or by rods, crossing one another diagonally, tied together in the centre.

The practice has been to allow the two poles forming the basis of this structure to have a slight spread at their butt ends; *i.e.*, taking a centre line down the poles, the distance between these lines at the top of the poles being some 12in. less than that between the centre lines at their butt ends. When poles become crowded with wires, this, with respect to the lower arms, detracts from the regularity of the insulators and wires. It is better that the poles should be equidistant throughout. You have then merely to provide for the increasing thickness of the timber in order to ensure perfect regularity in the position of the wires from top to bottom.

The Midland Railway having recently been called upon to construct for the Postmaster-General a section of an important trunk line to Scotland, it has been necessary to convert an existing line of single poles into an H line. To construct these H poles, braced together at the foot, as shown in Fig. 1, would have meant the replacement of the entire line—a most expensive operation. Under these circumstances the existing line of poles has been allowed to stand. At the proper distance a pole, B (Fig. 2), to match the standing pole A has been placed in position, care being taken to cut off the butt end so as to ensure a flat basis. It has then been allowed to stand some days, so as to become well settled in its position, after which slots for the arms are cut to correspond with those on the original pole. The short arms are then, one by one, removed from the latter, and replaced by arms 56in. long, which are bolted to the two poles. Where the old line of poles has been systematically constructed, with the arms, say 12in. apart, centre to centre, the appearance of such a combination is in every way agreeable to the eye.

It will be evident that without the diagonal tie-piece the pole might, under stress of wind, work themselves out of position. This has to be met by staying them in the same manner as a single line. Where, from exceptional causes, the poles cannot be stayed, the diagonal tie-piece should be employed. Photographs of sections of the line of poles thus treated are on the table.

H poles are destined to be of great service. There is no reason why the number of wires should be limited to four on an arm. The 56in. arm may be replaced by a 72-in. arm, accommodating six wires, thereby increasing the capacity of the poles one-third. We may even venture beyond this where the need for it exists, employing either iron arms, or wooden arms of larger scantling, in order to meet the weight of the wires standing on the outer side of the poles. The structure is one which, if well stayed, will withstand gales far better than single poles with half the number of wires, arranged for two on an arm. Moreover, it will be observed that H poles, with six wires on an arm, lend themselves to telephone requirements. With the wires arranged two outside each pole, and two between the poles, three groups, or squares, may be formed by each pair of arms—each wire of each "square," or "group," being maintained 1ft. apart. A photograph of poles so armed is on the table.

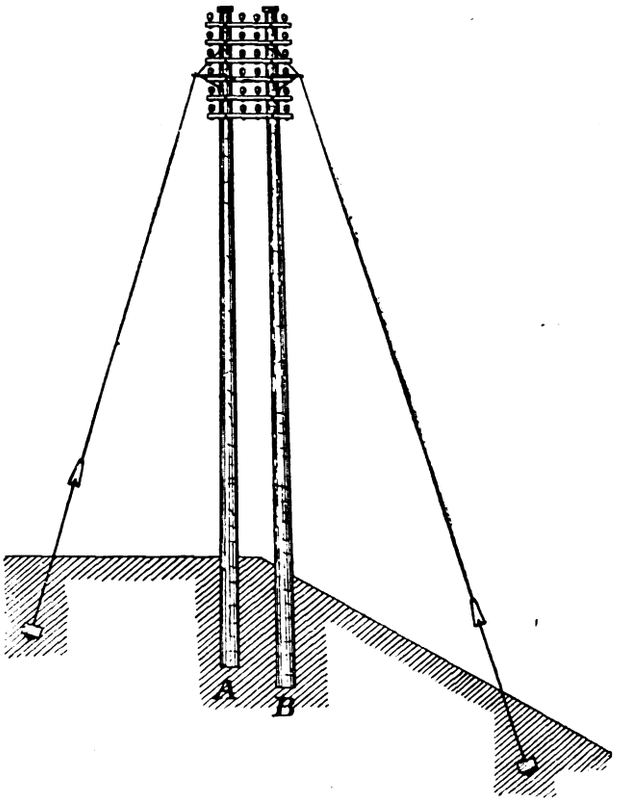


Fig. 2.

Telegraph poles seldom commend themselves to the observer as an æsthetical subject; but uniformity in construction, with the poles well in line, or regularly following the contour of the road, evenly graduated for height, and uniformly armed and wired, with, perhaps, an ornamental top in exceptional places, will do much towards removing those objections which are not unfrequently raised against their presence.

### Arms.

In the trimming of poles the most novel feature is the introduction of iron arms; 40in. tubular iron arms, specimens of which are before the meeting, have been employed for some 100 miles of the trunk telephone line recently erected by the Midland for the Post-

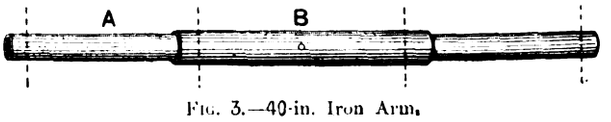


Fig. 3.—40-in. Iron Arm.

master-General. Some years prior to this, shorter arms—tubular and rectangular, for carrying two wires—were experimentally employed by the author. No inconvenience whatever has, so far, attended their employment.

The longer (40in.) arm (Fig. 3) is composed of 1¾in. galvanised iron tubing, A, ⅛in. thick, strengthened by a piece of larger gauge tubing, B, of same thickness, 2in. in diameter, carried over the centre portion of the 1¾in. tubing. The two tubes thus combined are practically homogeneous and very strong.

The employment of these arms admits of a slight reduction in the length of the insulator bolt, which may with advantage have the shoulder of the bolt, as also the washer, hollowed out to fit the

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arm. Thus arranged, there is no possibility of the insulator twisting round. These arms should be very durable, and it is worthy of remark that they do not require so much of the pole cut away as is necessary for the wooden arm.

The earth-wiring of wooden arms has, the author believes, in some quarters, been abandoned. That course has not been pursued on the Midland. Earth-wiring, as illustrated by the sample placed upon the table, is still followed. With iron arms the need for earth-wiring disappears. It is merely necessary to lay the main earth wire securely under the washer of the arm bolt.

Clearly, where iron arms are employed, failure in insulation such as that produced by a broken or cracked insulator will readily make itself known. To what extent this will operate with respect to the iron arms experience must show. In a trunk telephone line discrepancies in the insulation of the four wires forming a square would appear to be undesirable factors. Whether such failure may be more readily traced with iron than with wooden arms has yet to be proved. The iron arms ought, where "earth" is the cause of failure, to give a more defined fault, and thus lead to its more ready removal. Iron arms and brackets, as well as iron poles, have, in various forms, been in use for years, especially for foreign lines; and probably no member of the Institution has a more intimate knowledge of their value than our Past-President, Mr. Alexander Siemens.

In slotting round poles for these iron arms it was at first thought that a V-shaped cut would readily lend itself to the reception of the arm; but experience has shown that it is better to slightly slot the pole, as though for a rectangular arm, and gouge out the base of the slot. The pole being round, the V-shaped cut fails to retain the arm in that rectangular position in relation to the pole, which is necessary to give the line that trim and uniform appearance so acceptable to a good workman.

In the employment of wooden arms there is nothing of a novel character to record. They are to-day very much as they have been during the last 20 years. It may not, however, be inopportune to raise the question whether English oak is the only timber from which they should be made. Doubtless English oak is more durable and stronger than other timber; but it is a question whether foreign oak—say Stettin—if cut under the conditions applicable to English oak, viz., well seasoned, free from knots, and free from sap, is not sufficiently durable and strong for the purpose. Arms cut from this description of timber have been in use on the Midland system for many years, and nothing has transpired to create a want of confidence in its suitability for such work.

Another point worth considering is that of painting the arms. Paint, if applied when the timber is properly seasoned and dry, is, no doubt, beneficial; but paint applied to wood which does not possess these qualifications produces dry rot, and is, consequently, absolutely injurious to the timber, and dangerous to workmen when on the poles. Where the arms can be stacked by the user until thoroughly seasoned, they may with advantage be painted.

### Staying.

It is no exaggeration to say that to the more perfect manner of staying the telegraph lines of the present day, and to the employment of machine-stranded staying wire, are we indebted for that greater immunity from heavy breakdowns which we enjoy at the present time. It is, in cases of snow falling under those conditions which cause it to cling to the wires, a question of strength of pole *versus* strength of wire. Needless to say it is preferable the wires, rather than the poles, should suffer; and, as a rule, such is the *status* at which well-built telegraph lines of the present day have arrived.

On railways there is usually more room for staying poles than is the case on roads. The greater the spread of the stay the greater its advantage. In order to be of the greatest service its attachment to the pole should be somewhat above the centre of the full complement of wires which the pole is designed to carry. It is seldom, however, one can determine the number of wires which a line shall ultimately support, and thus it is well to fix that point which may be most serviceable under any condition. The practice pursued by the author has been to fix the upper stay behind the third and fourth arm, and where a second stay is required—as is frequently the case with heavily wired lines—between the eighth and ninth.

Formerly the practice was to form the stay on the pole, wire by wire. A single wire was first attached to the pole and strained up tightly to the stay-rod; then a second wire was attached and strained up, as nearly as could be judged, to the same degree of tension; and so on, till the necessary strength was attained. The objection to such stays is the absolute improbability of so arranging the several wires of which the stay is composed, that each shall bear its share of the strain. As a rule the strain falls upon one wire more than another. Under great stress this wire is the first to give way. The rest follow in like manner.

With machine-stranded staying wire, each wire bears its own proportion. If properly stranded—*i.e.*, with a long lay—it is easily handled. Where attached to the stay-rod it should be passed around a pear-shaped eyelet. To Mr. W. H. Preece, C.B., F.R.S. Past-President, we are indebted for the introduction of machine stranded wire for this purpose. Staying wire should be of a steely character. The Midland specification provides that each No. 8 gauge wire (which is the only gauge used for stranded staying wire) shall stand a strain of 1,800lb., with a maximum stretch of 4 per cent., without breaking, and that it shall bear 12 twists in a length of 6in. without fracture and without scaling.

An excellent device for binding stranded stay-wire has recently been introduced by Mr. Roberts, of the Postal Telegraph Department, which enables the workman to accomplish his task well and with ease. The tool itself will be found upon the table.

The strand wire is first bent so as to form the loop around the stay thimble, A (Fig. 4), the splicing tool B being employed to draw it closely into the groove. The free end of the stay-wire is then unstranded and the wires straightened out as shown at C. One wire, D, is picked out for the purpose of forming the first lap of the binding; the tool is then employed to arrange the remaining wires symmetrically parallel with and around the main strand, so that they may bind into it without spoiling its circular shape. The free wire is now placed under the hook of the stay tool, which is revolved around the stay and the remainder of the wires. When the first selected wire has been used up another is chosen, and the same course followed with each until all have been evenly bound around the main stay.

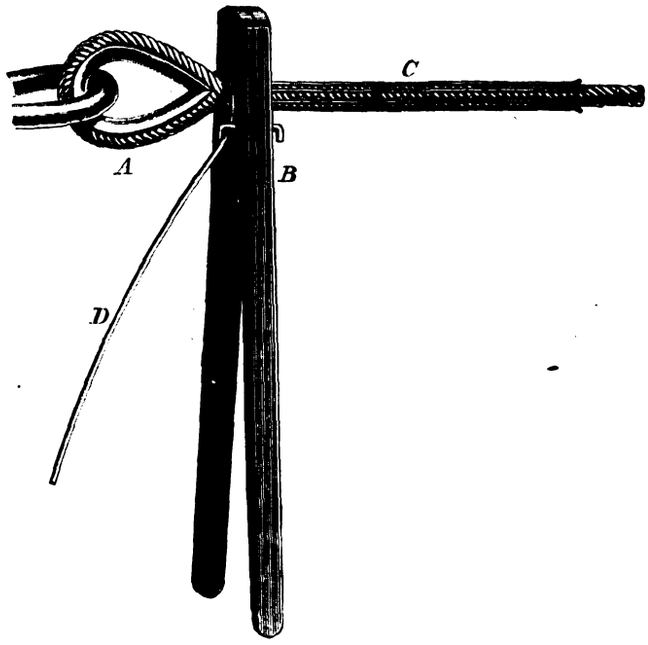


Fig. 4.

All stay-rods planted in soil formed of cinders or ashes should be protected by fillets of creosoted wood, or they will rapidly succumb to the electrolytical action set up by the ashes and the galvanised iron. On railways it frequently happens that the top ballast is composed entirely of refuse cinders or ashes.

### Insulation.

For many years a practice has prevailed of using a minor form of insulator for short circuits or block signalling wires. The author raises the question whether such a degree of refinement is desirable. It is inconvenient, inasmuch as it does not admit of interchange of wires where such changes are desirable. On the Midland the practice has long been abandoned. But one class of insulator and one gauge of iron wire—viz, No. 8, is employed. Thus, when required, through wires may be joined in with the shorter lengths, and the uniformity of the line preserved by maintaining the shorter lengths below the longer ones. Moreover, it would appear that, however important other wires may be, none can be more important than those which govern the movements of the trains.

It is believed that the best insulators are those known as the "Post Office" and the "corrugated," samples of which are on the table. Samples of the form of terminal insulator and leading-in cup, employed largely by others, as well as by the author, are also before the meeting. The terminal insulator is made in two sizes, the smaller kind being employed where the strain is small, as, for instance, for leading across from one side of the line to the other for signal box and other like purposes. The larger kind is employed for terminations of line wires.

The great advantage of this insulator resides, not merely in the shape of the ware, but in the extent of the bolt, A (Fig. 5), which,



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it will be seen, passes far beyond the corrugations at which point the line wires are attached—a provision which renders it practically impossible for a wire to fall, even when the porcelain is from any cause broken. Another advantage is that these corrugations, or grooves, not only help the insulation, but make provision for the attachment of different gauges or different descriptions of wire, as, for instance, if it is desired to attach a No. 11 to a No. 8. If the No. 8 is placed in the lower groove, and the No. 11 in the upper groove, the strain on the bolt will be about equalised, and the insulator will retain its vertical position. They are equally useful for joining two descriptions of wire, say iron and copper, the one being terminated on one ring, and the other on another, the two wires being joined by a loop.

At the termination of all important wires, and, in many instances, at important signal boxes, "leading-in" cups are employed. They are formed (Fig. 6) of a porcelain tube, A, in which the G.P. wire is threaded, the tube being contracted at B so as to keep the wire central and free from the edges of the tube. This tube is protected by an iron hood, C, perforated so as to admit of the rain cleansing the porcelain tube.

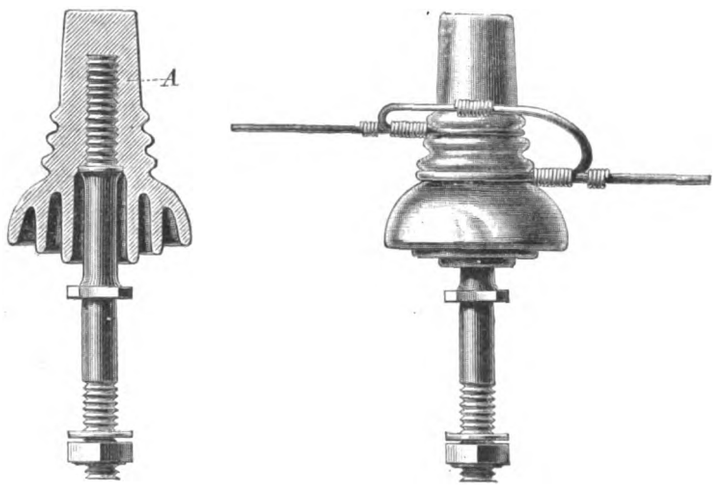


Fig. 5.

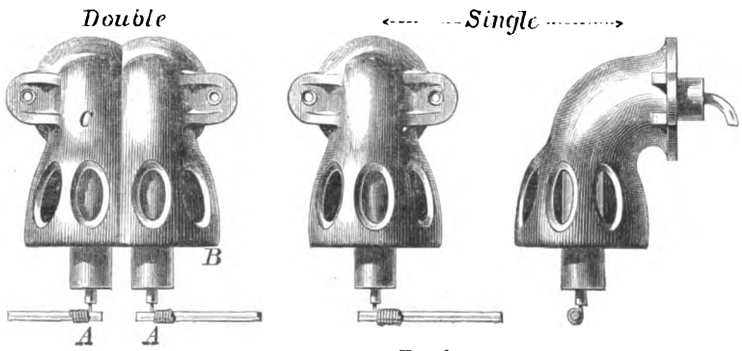


Fig. 6.

Where round creosoted poles are employed for leading-in wires, it is necessary to carry the G.P. wires in boxing fixed between the arms. If this boxing is strongly made it will admit of the leading-in cups being fixed to either side of it, and will thus form a very complete and durable termination.

### Wire.

Considerable progress has of late years been made in the employment of copper wire. The first copper wire erected for telegraph purposes was, it is believed, that erected by Mr. A. Graves, of the North-Eastern Railway, at York, about 1877. Mr. Graves on that occasion employed No. 14 gauge (0·080 S.W.G.); and shortly afterwards, in 1880, copper wire of the same gauge was erected on the Midland. The copper wire of various gauges in use on the Midland now extends to some 5,000 miles, of which 3,000 odd is maintained for the Post Office.

The objection to iron wire is the shortness of its life and—in comparison with copper—its higher electrical resistance and greater inductive capacity. Under the auspices of the Post Office a class of iron wire largely superior to that formerly in use has for some years past been obtainable. This improvement—embracing conductivity and the general construction and character of the wire—does not, however, extend to prolongation of life. In a few years, more or less, dependent very much upon the condition of the atmosphere, the galvanising is gone, rust sets in, and thereafter the strength of the wire, as also its conductivity capacity, rapidly degenerates. Covered iron wire is frequently found to be of great service in smoky localities. The best is that served with what is known as West's compound. The wire is lapped with cotton, and then passed through a special liquid composition, so that the cotton covering may become saturated by it. It differs from all other covering processes in that the composition hardens when exposed to the air, is unaffected by changes of temperature, and when hardened is impervious to wet. So long as the covering remains sound the wire beneath it retains its original condition, and when the covering is removed appears as fresh as when new. A sample of some of this wire which has been in use on the Midland for some years will be found on the table.

The conductivity resistance of a 12½ gauge (0·097) copper wire is 5·034 ω per mile; that of No. 8 (0·160) gauge galvanised iron wire is 12 ω per mile. The breaking strain of the 12½ copper is 490lb.; that of No. 8 galvanised iron, 1,100lb. The cost of a mile of 12½ copper is about £4. 4s.; the cost of a mile of No. 8 galvanised iron wire, £2. 10s. The difference in price is considerable, but against this we are able to place many advantages, durability—which means less cost in renewal, a saving of certainly two out of three, which at 20s. a mile more than covers the additional cost; reduced strain, and less load on poles, which admits of their reception of a greater number of wires: and last, though not the least important, less liability to fracture.

It is probable that 12½ copper, or possibly a slightly larger gauge, will entirely supersede galvanised iron wire; for, although when new the galvanised iron wire has the advantage in tensile power, it retains that power a portion of its life only, and during the latter part of its existence its tensile strength is even less than that of the 12½ copper. Its electrical resistance is, even when new, more than twice that of the copper wire.

It is desirable in using 12½ gauge copper wire, where possible, to slightly reduce the length of span—to limit it to 70 yards on the curve and 75 on the straight—say 24 poles to the mile instead of 22. In all newly constructed lines for the Midland Company's own purposes, copper wire is now used; and in the renewal of existing wires, iron is, as a rule, being replaced by copper.

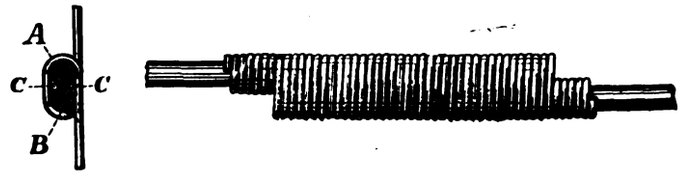


Fig. 7.—Joint as used by P.O.

In the erection of either copper or iron wire, the degree of tension to which the wire is pulled up is a factor which plays an important part in its durability. Wiremen, until they are taught otherwise, have a profound contempt for the effect of temperature upon the material they are using. On a hot summer day, or a bleak winter morning, they will pull the wire up to the same degree of tension. The consequence is that the wire erected under its maximum expansion in the hot noontide, is either broken or stretched under the influence of a lower temperature. The dip, or the stress, imparted to a wire must always be governed by the temperature, for which purpose a thermometer, placed in a position analogous to the wire must be used.

Where wires are run on the parallel system, if the top wire is erected to the required degree of tension, the eye of the wireman can, by it, readily regulate other wires in the same span. To impart to this wire the proper degree of tension, its stress must be determined by its "dip," or by what is known as an indicating tension-ratchel—the latter by preference.

Where wires are erected on the "revolving" system, it is impossible to avoid the use of the tension-ratchel if the wires are to enjoy a uniform degree of tension.

To Mr. W. H. Preece, C.B., F.R.S., we are indebted for much careful investigation of this important question, and by his courtesy I am enabled to add, in the appendix to this Paper, tabulated statements adopted by the Post Office showing the stress at which both copper and iron wires should be erected at various temperatures.

### Jointing.

The "Britannia" joint still holds its own, whether for iron or copper wire, but the ends, or "tails," which for years have been left bent up, are now cut clean off, it being evidently better for a joint to *draw* than to form an intermittent fault. The Post Office, with regard to copper wire of large gauge, before soldering fill the insterstices between the two wires, A, B (Fig. 7), and the binding, by two pieces of smaller gauge wire, C. The object is to facilitate the soldering of the joint, and so prevent overheating the copper.

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The joint when completed is wiped clean and allowed to cool. It should not be overheated, and it should not be chilled.

Where joints are made in this manner a jointing frame becomes necessary. This consists merely of a couple of clips, C, C (Fig. 8), in which the ends of the wire are held. It can with convenience be fixed by the legs L L to the wiring barrow, or the legs may be thrust into the ground : and here, perhaps, although a minor matter, it may not be out of place to call attention to an improved "wiring barrow" which has recently been brought into use. These

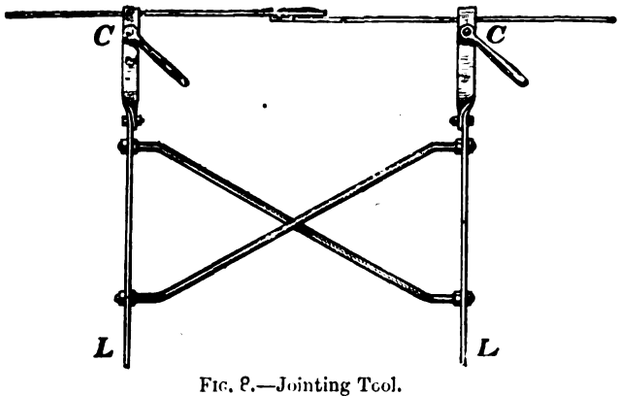


Fig. 8.—Jointing Tool.

barrows are made with a frame similar to that of a garden barrow, but longer. The drum for the reception of the wire is made of sheet iron, and works vertically, instead of horizontally as hitherto. Ordinarily the barrow is wheeled along the sides of the line by one man, as on a public road ; but where it cannot be wheeled, two portable arms, provided for the purpose, are placed in position, and the barrow is then carried in the usual manner by two men. The arrangement will be understood by reference to the photographs on the table.

### Binding.

For many years the author has abandoned the use of No. 16 galvanised iron wire for binding, and has employed in its place a specially made No. 11 G.I. wire. It is necessary this class of binding wire should be more ductile than the ordinary conductivity No. 11 G.I. wire, and that it should be capable of being lapped around a No. 8 wire without scaling. If it scales it will rust, and the oxide will be carried by the rain down the outside of the insulator cup, to which it will adhere to such an extent as may, in damp weather, materially affect the insulation of the wire.

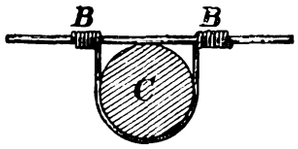


Fig. 9.

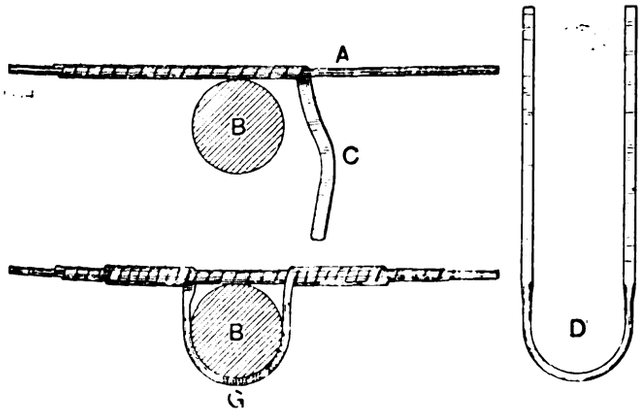


Fig. 10.

In Fig. 9, C represents a cross section of an insulator, at the point at which the binding wire is attached. The binder is merely lapped some five times around the line wire, as shown at B. It will be found that this form of binder will prevent a broken wire from running back quite as well as any form of binding with No. 16 gauge wire. Its advantages are : great durability, absence from stretch under influence of gales, less cost in construction and maintenance, and greater freedom from chafing—the line wire being much more firmly held.

The practice thus pursued by the author has, in a modified form, been adopted by the Post Office with respect to copper wire. That portion of the line wire, A (Fig. 10), which rests against the insulator, B, as well as the portion which is to be lapped by the binder, is first overlaid by a copper tape, C—a piece of copper wire rolled out flat. The binder, D, is formed of a large gauge wire which has its two ends flattened so as to be readily laid around the taped portion of the line wire. Both the tape and the binder are first laid on by hand, the copper strip being exceedingly ductile, and finally tightened by the aid of a suitable pair of pliers, the complete binding being as shown by G (Fig. 10). Samples of these binders and tapes, as well as of the complete form of binding, are on the table.

The author is of opinion that wherever a sufficiently ductile wire can be obtained for the purpose, it is better to employ a binder of a gauge equal, or nearly so, to that of the line wire.

The Post Office, under the direction of the engineer-in-chief, have recently issued tables of sizes, weights of tapes and binders for the different gauges of copper wire, which, by Mr. Preece's permission, I have the privilege to append to this Paper.

*(To be concluded)*

## LONDON COUNTY COUNCIL.

*New Electric Supply Stations.*

At the weekly meeting of the London County Council it was agreed, on the recommendation of the Building Act Committee, that approval be given to the plans submitted on behalf of the Chelsea Electricity Supply Company for the construction of a generating station at the corner of Alpha-place of greater extent than 250,000 cubic feet, subject to the usual conditions ; that the plans submitted by the Charing Cross and Strand Electricity Supply Corporation for the construction of a generating station at Commercial-road, Lambeth, be deviated from in some particulars ; and that sanction should be given to the plans submitted by the Vestry of Hampstead for the construction of a boiler house and engine room addition to the electricity station at Lithos-road.

*Tramway Syndicate.—Electric Traction.*

The Highways Committee reported on the suggestion made by the County of London Tramway Syndicate that arrangements should be entered into between the Council and the Syndicate for the immediate transfer to the Council of all the tramways in the county of London, such tramways to be afterwards leased to the Syndicate for a term of 28 years. The combined rents, the Syndicate estimated, would be about £200,000 a year. The Syndicate proposed that an underground system of electrical traction should be adopted on all the lines, the cost of the necessary works of reconstruction being borne by the Syndicate, and all such works immediately on completion becoming the property of the Council. The entire cost of equipment and plant for electrical power, it was suggested, should be borne by the Syndicate, but should at the expiry of the lease be purchased by the Council at a valuation to be determined by arbitration. The Committee considered it inadvisable that the Council should allow such a Syndicate to act as intermediaries, and as to the 28 years' lease, as the whole of the tramways would come under the Purchase Clause of the Tramways Act by 1910, it would be undesirable to extend the lease beyond that period. As regarded the statement that the Syndicate would be prepared to pay a rent equal to the net earnings of the line during the years preceding the grant of the lease, they were in some doubt as to how it could be done. The proposed reconstruction of the lines to adapt them for electrical traction would of necessity take considerable time, and would interfere with traffic and cause a diminution in the receipts. The Committee further pointed out that it had not yet been demonstrated that the principle of electric traction on the underground conduit system was capable of being worked successfully, and it would be a serious matter for the Council, if after the alteration of the lines had been carried out, the system were found to be a failure. There was another point in connection with the system proposed, namely, that it would involve the placing in the streets of rails with a slot varying from ⅛in. to ¼in. wide, which might cause accidents to the ordinary vehicles using the roads. It appeared so doubtful whether the system would prove successful that they ventured to think that the anticipation that by its adoption the leasing syndicate would be in a position to pay a rent equal to the present net earnings of the lines was somewhat sanguine. They therefore recommended that no arrangements should be entered into with the Syndicate with reference to the tramways in the county of London.

Mr. WESTACOTT (Chairman of the Committee) asked permission to postpone the matter for a fortnight, and this was agreed to.

The same Committee reported having received a letter from the North Metropolitan Tramways Company stating that under an arrangement between the Directors of that Company and those of the London Street Tramways Company the Council were asked if they were prepared to consider a proposal for the immediate sale to the Council of the two companies within the county, and for a subsequent lease to the first-named Company, the Companies to sell the lines for £437,000 to which had to be added the £101,788 already paid by the Council for parts of the line now leased to the Company. In the opinion of the Committee the purchase of the line at £10,000 a mile would be a favourable transaction to the Council, and put an end to all disputes and litigation. The Company were willing to lease the lines for 14 years, and pay a fixed rent of

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£45,000. The Companies' representatives stated that if the Council should consider that some form of electric traction should be adopted the Company will be prepared either to carry out the necessary works on terms to be arranged, or, should the Council itself execute the works, to pay either a fixed rent or a share of the extra profits which might be derived from the use of such traction. The Committee recommended that the Council should enter into a provisional agreement for the purchase of the property of the two Companies, and for the subsequent lease to the North Metropolitan Tramways Company on the terms set forth in an accompanying agreement. The clause in the agreement relating to electrical traction was as follows:—"Not to use, except with the consent of the Council in writing, other than animal power upon any of the lines included in the lease; provided that if the Council shall hereafter consider that the adoption of electric or other mechanical power is advisable, the Company or the Council, at the option of the latter, shall carry out the necessary works on terms of payment by the Company of a fixed rent on the expenditure, and either with or without a share of extra profit derived from the use of electric or other traction, or otherwise as may be agreed."

Mr. WESTACOTT asked that this report might also be postponed for a fortnight. Agreed to.

*Estimated Expenditure on Electrical Works.*

Amongst the other estimates of expenditure for 1896-97 the Highways Committee reported that they would require £1,538 for expenses in acting otherwise than as local authorities under the Electric Lighting Acts and Orders, towards which it was estimated that they would receive £500 for electric meter testing fees. The estimated expense showed an increase of £275, and fees £300. For the purposes of the London Overhead Wires Act of 1891 it was estimated that £550 would be required, and for the cost of inspection and maintenance of subways £765, of which amount £700 was estimated to be recoverable from companies using such subways.

Mr. WALTER EMDEN asked when the motion with regard to subways referred to the Highways Committee (and reported at the time in *The Electrician*) would be considered, for at present they had heard nothing of it.

Mr. WESTACOTT replied that a joint committee which had been formed would, he believed, discuss the matter at their next meeting.—The statements were agreed to.

*Lighting of the Thames Embankment.*

On the question of voting £10,555 for the maintenance of the Victoria, Albert and Chelsea Embankments.

Mr. DICKINSON asked what had been done with the £1,000 voted for the purposes of electric lighting.

Mr. WESTACOTT said the Council applied for an Act of Parliament to put an electric lighting station on the Thames Embankment for the lighting of the embankment and bridges. The question as to whether that should be done or not had been before the Council on many occasions. Some time ago the Committee agreed to do it, but the Council referred the matter back. The whole matter would be considered by the Committee at their next meeting, and then it was for the Council to say when the Committee reported if they should go into the expenditure or not.

Lieut.-Col. FORD said that under an Act of Parliament which they got seven years ago the Council were empowered to light Westminster and Waterloo Bridges by electricity, and he would like to know if that matter was being considered.

Mr. WESTACOTT replied that the matter would be considered by the Committee at its next or following meeting.

*Fire Alarms and Telephones.*

The Fire Brigade Committee estimated that £8,750 would be required in the coming year for the telephone (about 120) and electric fire alarms (about 580). This showed an increase of £750. It was further estimated that £500 would be required for electric bell work at the stations.

## CORRESPONDENCE.

### CURRENT MEASUREMENT BY MEANS OF STANDARD RESISTANCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of the 1st inst., an article by Mr. W. C. Fisher on the measurement of current by means of a standard resistance and a determination of potential difference. It is interesting to note that such resistances were used by Dr. Hopkinson in 1879 for this purpose (*see* his book on "Dynamo Machinery," p. 15), and to my knowledge Messrs. Siemens Bros. were using them in the form of plates for central station work in 1889; but the method is much older than either of these dates, and is, I believe, due to Poggendorff. During the last five years I have impressed upon the students in this laboratory what was already well known, viz., the importance of current-flow in such resistances, illustrating my remarks by the curves as shown in Fig. 36 of Mr. Fisher's article, which were obtained in this laboratory in 1891 on a plate measuring 26in. by 8in. and 3·5mm. thick.—Yours &c., E. WILSON.

Siemens' Laboratory, King's College, W.C.
May, 4, 1896

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Wilson's letter, proof of which you have kindly sent me, I have only to say that whether the method of measuring current by means of the fall of potential over a standard resistance is due to Poggendorff, or is anterior to that gentleman, I do not know; he is usually credited with it, and as I do not recollect ever having seen any contradiction I presume the statement is correct. By stating that Messrs. Crompton were the first makers of large standards—that is to say, having a current capacity of 1,500–2,000 amperes—I did not for one instant intend to advance *their* claim as *originators*; on the contrary, the context proves otherwise, and the statement, such as it is, is, of course, open to correction. With reference to the last paragraph, I can only say that the potential curves shown in Fig. 36 formed the concluding portion of the investigations, and were completed, I believe, before or about the commencement of the period of time mentioned, and up to the present the writer was utterly unaware that *similar* curves were in the possession of Mr. Wilson, or that he had investigated, or even advocated, the use of such standards.—Yours, &c., WM. FISHER.

Crompton Laboratory, Thriplands, Kensington-court,
London, W., May 6, 1896.

## LEGAL INTELLIGENCE.

### Electric Construction Corporation v. South Staffordshire Tramways Company.

The further hearing of this case (fully reported in last issue) was duly resumed on Friday last before Mr. Justice Romer.

At the close of the evidence for the defence,

Mr. EVE decided not to call rebutting evidence, as Sir F. Lockwood said he limited that part of the case affecting the evidence of Mr. Thomas Parker to the evidence of Mr. Courtenay.

Sir F. LOCKWOOD said that whatever view might be taken on the main features of the case, it was one that required thorough investigation. The two men Ebbsmith and Wain had admittedly conspired together to defraud the South Staffordshire Company, and that being so the whole thing must be looked at with suspicion. It seemed to him a most extraordinary thing that any company could have been found to accept a contract such as the one in question.

His LORDSHIP said he should like to ask what Mr. Wain's object could have been in entering into a contract which he must have known would mean bankruptcy to the Company.

Sir F. LOCKWOOD pointed out that at this time (1891 and 1892) Wain was absolutely at the mercy of Ebbsmith.

His LORDSHIP said he should doubt whether Wain was so absolutely at the mercy of Mr. Ebbsmith as to do an injury to a Company out of which he was to get no benefit for himself.

Sir F. LOCKWOOD said that in this particular case they had conduct that was absolutely inexplicable otherwise than by accepting the explanation he had. In conclusion, he submitted that they had here a contract impossible of performance. The evidence as to that was in the hands of those who had accepted it. They accepted it with their eyes open, and they agreed to obligations that were most extraordinary. The question which should be asked in this case was, would it have been possible for such a contract to have been entered into by the South Staffordshire Company unless that Company had been betrayed? The answer to that was, No. He contended that it was a fraudulent contract brought about by fraudulent means, and whether the Directors of the plaintiff Company knew it or not they were not on their guard, and did not make inquiries, and therefore they could not take the benefit of the frauds of their agent.

In replying on the whole case Mr. EVE said that the real point and practically the only one, was that the contract was brought about by a chain of fraud, and was so tainted with fraud that it could not stand.

Mr. OSWALD, Q.C., said there remained the question of penalty and its being *ultra vires* under the Act of Parliament, and mentioned certain cases on which the defendants relied on those points.

Mr. EVE said that on the question of *ultra vires* he should rely on the case of the Attorney General *v.* the Great Eastern. On the question whether the contract was tainted with fraud, he submitted that the evidence did not support any such contention, for up to the end of 1893 there was no suspicion that the men with whom the Company were dealing were not only perfectly honest, but these men were at the very head of their profession, and it was not until just before the trial of these men this year that the details of the frauds were discovered. It was said that the terms of the purchase were onerous.

His LORDSHIP said that it was first said it was not their interest to have electricity at all.

Mr. EVE replied that his Lordship would be guided in that by the evidence.

His LORDSHIP said that the first point was that, being in want of money, the plaintiff Company must be taken to have known that the defendant Company could not have performed the contract.

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Mr. EVE pointed out that the defendant Company had obtained power to provide electricity, and having the power they set to work to find a Company to supply the motive power, and when the plaintiff Company entered into the contract they knew the Company could not purchase for cash, and it was under these circumstances that the contract was made both a working and financial one. He submitted that, taking everything into consideration, it was not a case in which the plaintiff Company should be so far put upon inquiry that they would impute fraud. If that was disposed of, then the question whether it was an onerous contract was not before the Court. He submitted that the charge of fraud had not been proved. The onus of proof rested with the defendants in this case, and though they had properly raised every conceivable suggestion against those who had acted dishonourably to them, they had not brought home to the Corporation any knowledge of or responsibility for those acts. He asked, therefore, for a declaration that the contract was binding on the defendant Company, that an account be directed on that footing, and that the counterclaim be dismissed with costs.

His LORDSHIP intimated that he should reserve judgment.

### Goodman v. Smith.

The importance of a clear understanding at the start was shown in an action at the Westminster County Court on Wednesday, in which the plaintiff, a dealer in electrical appliances, sought to recover payment of an account of £14. 10s. in respect of electrical fittings supplied to the order of defendant. The plaintiff was called and said the defendant ordered the goods in question quite in the ordinary way, and never said a word about their being for a third party until payment of the account was pressed for. There was no foundation for the suggestion that he stated that he was acting as the agent of a Mr. Hooper, and had he done so the goods would not have been supplied on credit. For the defence Mr. William Smith was called and said he had previously done business with the plaintiff on his own account, and had always paid him for the goods supplied; but in this particular instance he distinctly told the plaintiff that he was giving the order on behalf of a man of the name of Hooper, who was well known to him. In giving judgment his Honour said it was a question of oath against oath, and he was not prepared to say that either party was saying anything which they knew to be false. At the same time he was not satisfied that the defendant made it clear that he was giving the order in the capacity of agent for a third party, and therefore judgment would be for the plaintiff for the amount claimed, with costs.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations**

### NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

"COMPREHENSIVE INTERNATIONAL WIRE TABLES FOR ELECTRIC CONDUCTORS."—By W. S. Boult, price 5s., post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated; price 12s. 6d. Will be ready first week in June.

TENDERS INVITED.—The vestry of Hammersmith require tenders for (*a*) supplying and laying high-pressure and low-pressure cables and pipes, (*b*) supplying and erecting arc lamps and lamp posts, (*c*) supplying and erecting transformers and sub-station equipment, (*d*) supplying and erecting a 5-ton overhead travelling crane. Specifications, &c., can be obtained of Mr. A. H. Preece, 39, Victoria-street, London, S.W., and tenders must be delivered at the vestry offices, 57, Fulham Palace-road, Hammersmith, by noon of Wednesday, May 27th. Mr. W. P. Cockburn is vestry clerk. Some further information was given in our advertisement columns last week, and will appear in next issue.

——— The Bray Town Council invite tenders for the supply and delivery of a 75-kilowatt steam alternator, a 200 H.P. Lancashire boiler, a 100 H.P. vertical high-speed engine, a fuel economiser, feed pump, &c. Tenders to Mr. P. MacDonnell, Town Hall, Bray, by the 18th inst.

——— The Municipal Authorities of Medina de Rioseco (Valladolid) invite tenders for the concession for the electric lighting of the town for 20 years. Tenders to El Ayuntamiento de Medina de Rioseco (Valladolid), Spain.

——— The General Direction of the Bulgarian Posts and Telegraphs require tenders for the supply of a quantity of porcelain insulators, bronze and iron wire and iron hooks, of a total value of about £6,130. Tenders to the Direction, at Sofia, by the 13th inst.

——— The Municipal Authorities of Penaranda de Bracamonte require tenders for the concession for the electric lighting of the town for 15 years. Tenders to El Secretario del Ayuntamiento, Penaranda de Bracamonte, Spain, by the 28th inst.

——— The General Direction of the Roumanian Posts and Telegraphs, Bucharest, invite tenders for the supply of 21¾ tons of copper and bronze wire. Tenders by the 15th inst.

——— The Municipal Authorities of Voghera invite tenders for the concession for the electric lighting of the town on the expiration of the present gas concession (1898). Particulars from L'Amministrazione Communale, Voghera, Italy.

——— The Secretary of State for India invites tenders for iron telegraph posts. Tenders to the Director-General of Stores (Mr. J. Parker), India Office, Whitehall, S.W., by 2 p.m., on the 19th inst.

——— Tenders are required for the lighting of the City of Bucharest for five years. Tenders must be sent in to the Town Council by June 24th.

——— The Great Eastern Railway Company require tenders for the supply of various stores, including telegraph materials, india-rubber, &c. Tenders to the Secretary, Liverpool-street Terminus, E.C., by 10 a.m. of the 14th inst.

——— The Oldham Town Council require tenders for the supply of a Lancashire boiler 28ft. long by 7½ft. diameter, to work at a pressure of 125lb. Tenders to Mr. A. Andrew, Gas and Water Offices, Oldham, by the 12th inst.

——— Tenders are invited for the installation of the electric light at "Woodlands," Gisburn (Lancs.), for Mr. C. J. Massey, J.P. Specifications from Mr. C. Parsons, architect, 9, Grimshaw-street, Burnley.

——— Tenders are required by the Portsea Guardians for the wiring of part of the workhouse for the electric light. Tenders to the Clerk (Mr. S. R. Ellis), Guardians' Offices, Portsmouth, by the 15th inst.

TENDERS ACCEPTED.—The Derby Town Council have ordered two further transformers from Messrs. Siemens Bros. and Co., at £268, and a 1½ H.P. motor for coal hauling at £32. The tender of the British Insulated Wire Company for the supply of cables, junction boxes and jointing at £2,185, has also been accepted.

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TENDERS ACCEPTED.—The Hammersmith Vestry have accepted the tender of Messrs. S. Z. de Ferranti (Limited) for the supply of three rectifiers for £1,044. 15s.

——— The Shoreditch Vestry have accepted the following tenders for the supply of electrical plant and machinery for their electricity station: Section A, steam engines (Willans type) and dynamos, Electric Construction Company (£14,879); Section B, steam and exhaust pipes, boiler pumps and cast-iron work, Thames Ironworks Company (£4,500); Section C, motor transformers and sub-station apparatus, Electric Construction Company (£2,890); Section D, battery of accumulators, Pritchetts and Gold (£610).

——— The tender of Messrs. Benham and Sons (Limited) has been accepted by the Metropolitan Asylums Board for steam-piping work at the Brook Fever Hospital. The amount of the tender is £1,200.

——— Twenty-five tenders were received for the supply and erection of generating plant, &c., for the lighting at Ferniehurst, Baildon (Shipley Station) ranging from £630 to £1,461. The work has been let out in three sections to different contractors.

——— The Great Grimsby Town Council have ordered a dynamo from Messrs. P. R. Jackson and Co. for lighting the Town Hall for £145. 10s.

TENDERS RECEIVED.—For putting down electric light installations (including four steam engines, four dynamos, 174 arc lamps, &c.) at the Elberfeld and Barmen railway stations, tenders were submitted by German firms exclusively as under (in marks):—

| | |
|---|---|
| Union Elektricitäts Gesellschaft | 124,683 |
| Siemens and Halske | 121,223 |
| Körting Gebrüder | 116,000 |
| Edward Herhahn | 114,126 |
| Rd. Beckmann | 105,596 |
| Allgemeine Elektricitäts Gesellschaft | 104,015 |
| M. Schorch and Co. | 100,181 |
| Naglo Gebrüder | 97,988 |
| L. Brandes | 96,142 |
| Lahmeyer and Co. | 90,115 |
| Schuckert and Co. | 88,848 |
| Eggersmann and Lang | 88,841 |
| Helios Company | 86,920 |

The above was for Lot 1 (Elberfeld-Döppersberg station), and the list shows that the same differences between the highest and lowest tenders prevail in Germany as here. For Lot 2 (Barmen-Rittershausen station) the difference was not so marked—highest 89,922, against 61,202 marks=28,718.

——— The Hampstead Vestry have received tenders from the following firms for the supply and erection at the electricity supply station of steam alternator, switchboard, &c. The tenders are under consideration:—Babcock and Wilcox, Wm. Boby, Brush Company, Crompton and Co., Davey, Paxman and Co.; Easton, Anderson and Goolden, S. Z. de Ferranti, W. J. Fraser and Co., K. and H. Lupton, C. A. Parsons and Co., J. Penn and Sons, Siemens Bros. and Co., J. E. and S. Spencer, and Wright's Patent Heater Condenser Company.

WESTINGHOUSE ENGINES FOR SALE.—An important list of engines for sale by the Metropolitan Electric Supply Company will be found in our advertisement columns, including engines of 320 I.H.P., 250 I.H.P., and 85 I.H.P., all fitted with variable expansion gear controlled by flywheel governors.

APPOINTMENT VACANT.—The Governors of the People's Palace require a professor of physics. Salary £150 per annum, with a capitation fee. Applications to People's Palace, London, E., by 31st inst.

DISSOLUTIONS OF PARTNERSHIP.—Messrs. Frank Catt and Herbert Ellis Hall, electrical engineers, New Wharf, Tonbridge, Kent, have dissolved partnership.

——— The partnership business hitherto carried on under the style of Alfred Arculus and Co., electric light globe and shade makers, Birmingham, has been dissolved.

NEW FIRM.—Mr. J. Hermann Field has joined Mr. F. H. Taylor, late of 17, Ironmonger-lane, London, E.C., and the firm have taken offices at 14, Victoria-street, Westminster, S.W. Both gentlemen have been engaged for many years in electric light and power work, Mr. Taylor in London and Mr. Field in Ireland and Scotland.

BUSINESS CHANGES.—An amalgamation has been effected between the Nalder and Harrison Construction Syndicate (Limited) and Swinburne and Co. (Limited). For the purposes of this amalgamation it has been found advisable to dissolve the Syndicate, and the amalgamated businesses will in future be carried on as a private firm under the title of Messrs. Nalder and Hilton, who have purchased the two businesses. This arrangement is to date from March 1st, 1896, and a special resolution for the above-mentioned voluntary liquidation of the Syndicate has been passed. It is anticipated that the combination of interests and the concentration of the business will be of advantage to the firm and to their numerous clients.

LIQUIDATION.—It has been decided to wind up the Tramways Electrical Traction Company (Limited) voluntarily, and Mr. J. Barber Glenn, 7, Poultry, E.C., has been appointed liquidator.

FAILURES.—Charles Alfred Fletcher, described as an electrician, late "victualler," of Ashton-under-Lyne, has filed a deed of registration with his creditors.

THE HOTEL CECIL.—In connection with the opening of this hotel, we are informed that upwards of 6,000 electric lights have been fitted, together with telephones, and an electric system of ventilation, under the supervision of Mr. Morgan William, C.E., of 39, Victoria-street, S.W. Current is taken from the mains of the Charing Cross and Strand Company until a separate plant is erected under the supervision of Mr. R. Hammond. The electric fans, which are placed in the dining, smoking, coffee and billiard rooms, are of the Blackman Company's make. Those in the dining room are capable of dealing with nearly 1,000,000 cubic feet of air per hour, and those in the coffee and billiard rooms about half a million feet in each case. The lavatories are similarly ventilated.

DOULTON CONDUIT SYSTEM.—It has been decided to employ Doulton conduits for the entire system of mains at Shoreditch (London) and Leyton (Essex), the work of laying in both cases having been commenced by the contractors.

PRICE LISTS WANTED.—Messrs. Swete and Baker, electrical engineers, Johannesburg, notify in our advertisement columns that they wish to receive price lists of electrical plant, apparatus and fittings.

AN AMERICAN SUNBEAM.—The "Sunbeam" Incandescent Lamp Company of Chicago, who are the makers of a large variety of incandescent lamps for various purposes, are making a speciality of their 20-watt 4 c.p. lamp, which is made for voltages from 50 to 120. The advantage of this choice of voltage is that several lamps may be grouped in series on distributing mains of any pressure and controlled by one switch. This is a useful arrangement where the lights are required to be in groups, as in shops and other business interiors, and especially where they are employed for decorative purposes. Another out of many uses for this style of lamp is found in illuminated advertising signs.

THE "ENGINEERING MAGAZINE."—The contents of the May number of this excellent magazine are of the usual varied and interesting character, and include:—"The Present Value and Purchasing Power of Gold," by H. M. Chance; "Quackery in Engineering Education," by Edgar Kidwell; "The Vast Importance of the Coke Industry," by John Fulton; "Development of Electric Lighting Engines," by H. Lindley; "Are British Railroad Stocks Good Investments," by Thos. F. Woodlock; "Electricity and the Horseless Carriage Problem," by Wm. Baxter, jun.; "Points in the Selection of Steam Engines," by W. H. Wakeman; "Modern Machine Shop Economics," by Horace L. Arnold; "Minor Mineral Products of the United States," by David T. Day; "Restraints upon the Practice of Architecture," by John Beverley Robinson. The usual exhaustive review of the world's Press is also given. This number, as well as all the back numbers, may be obtained at the offices of the European Edition, 1; 2 and 3, Salisbury Court, Fleet-street, London.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from April 29th to May 5th, with the ports of destination:—

*Argentina*—Buenos Ayres, £547. *Australasia*—Adelaide, £1,210; Brisbane, £6; Melbourne, £236; Newcastle, £5,455 (Electric Mining Machinery); Sydney, £367. *Belgium*—Antwerp, £20; Brussels, £384. *Canary Islands*—Teneriffe, £9. *Ceylon*—Colombo, £66. *Denmark*—Copenhagen, £1,771. *France*—Paris, £643. *Holland*—Amsterdam, £30; Rotterdam, £28. *India*—Bombay, £47; Calcutta, £178. *Panama*, £261. *Portugal*—Lisbon, £32. *Russia*—Odessa, £333. *St. Helena*, £4. *South Africa*—Cape Town, £730; Durban, £134. *Straits Settlements*—Penang, £24; Singapore, £56. *Sweden*—Stockholm, £12. *Uruguay*—Monte Video, £46.

*Foreign-Made Electrical Apparatus and Material.*—Foreign made goods have been exported from this country, as follows:—

*Argentina*—Buenos Ayres, £55. *Australasia*—Brisbane, £80.

EXPORTS OF TELEGRAPHIC WIRE, &c.—The Board of Trade returns show that the exports of telegraphic wire and apparatus connected therewith, for the month of April, were £23,066, against £35,544 in April, 1895, and £186,739 in April, 1894. For the four months of 1896, the exports have been of the value of £211,368, against £99,746 in the corresponding period of 1895, and £452,018 for 1894.

TRAMWAY REQUISITES.—We have received a copy of a paper on "Self-acting Rain-proof Seats and Signal Bells for the Outside of Tramway Cars and Omnibuses" by Mr. C. Challenger, the traffic manager of the Bristol Tramways and Carriage Company. Everything bearing on tramway equipment has an interest at the present time, and Mr. Challenger's paper will therefore be appreciated.

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NOTES ON ALUMINIUM.—The British Aluminium Company (Limited) have recently issued a handy pamphlet entitled "Notes on Aluminium and its Alloys." The contents comprise a brief history of the development of the aluminium industry, some useful notes on the properties of the metal, descriptions of the processes of melting, casting, forging, rolling and other treatment in working the metal into its finished shape, and a number of useful tables. As the treatment of this the newest of commercial metals is in many respects of a special character, metal workers and others might derive useful information by a perusal of this pamphlet.

WILLING'S PRESS GUIDE.—The extremely useful and compact "British and Irish Press Guide," issued by Messrs. Willing, of 162, Piccadilly, and 125, Strand, London, is just published, and will be found as replete as ever with condensed information of service to those who have occasion to consult such publications. Much more ambitious and less accurate "Press Guides" are issued than the shilling book of Messrs. Willing.

"ANUARIO DE LA MINERIA, METALURGIA Y ELECTRICIDAD DE ESPANA."—We have received a copy of the 1896 issue of this Anuario, now in its third year of publication. To those having business connections with Spain, and to exporters of mining and electrical machinery, the work cannot fail to be of assistance. Naturally the greater part of the book is devoted to mining matters. Government Departments (Agriculture, Interior and Marine), and their chief officials, mining undertakings and their engineers, commercial treaties, tariffs, railway charges, &c., are included in the book. The work has been carefully revised by Don Román Oriol, Professor of the Madrid School of Mines, and is issued by the *Revista Minera, Metalurgia y Electricidad*.

"CASSIER'S MAGAZINE."—The May number of this magazine contains articles on "Electric Power from the Montmorency Falls in Canada," by C. C. Chesney; "An Historical Electric Central Station," by John W. Lieb, jun.; "Cooling System for Condensing Water," "Power Distribution in the Cylinders of Compound and Triple-Expansion Engines," "Fire Boats," "American Naval Engineers, their Rank and Title," "Economies in the Foundry," and "The Washing of Gold Placers in South America."

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ABERDEEN.—The report on the extension of the electricity works recently presented by the Electrical Committee has been considered by the Council, and it has been decided to make certain extensions at the station at an estimated cost of £4,500. It has further been decided to put in two new boilers, with feed-water heater and feed pumps, at an outlay of £3,000. Some small extensions of the electric light mains were also agreed upon at a cost of £580. The question of extending the mains to the West End and to the Harbour District was deferred.

BANGOR.—The Board of Trade having decided not to sanction the Council's application for an electric lighting licence, a Provisional Order is to be applied for.

BATH.—Prof. A. B. W. Kennedy, who was recently appointed to value the works and mains of the City of Bath Electric Lighting and Engineering Company, has now presented his report, which states that, with the exception of the arc lamps and pillars, the whole of the buildings, plant and mains are in excellent working order. The Company has spent £38,359 on land, buildings, plant and mains, and it had been suggested that the Corporation should offer £15,000 for these. The site is described as an excellent one, capable of easily carrying additional direct-driven plant which would double the present capacity of the station. As to the plant, although this is not of the newest type, it has been kept in admirable order and condition by Mr. Metzger, the Company's engineer. Summing up, Prof. Kennedy considers that the proper sum to be paid by the Corporation for the buildings, plant, mains, &c., is £24,533, leaving for separate consideration the question of the arc lighting plant with lamps and lamp-posts. The Corporation's advisers had strongly objected to the arc lighting as it stood, and he had no doubt a considerable amount of the feeling against it had been caused by the excessive distance between the lamps, and that if the same lamps were used at half the distance apart, as they ought to be, the lighting would be more satisfactory. On the other hand, there had been a number of serious failures of the arc lighting, and in practically every case it had been proved that this was due to causes connected with the defective construction of the lamp-posts or their connections. The actual design of the lamp-post had been chosen by the Corporation, but he considered them so defective that he was bound to decide that they were entirely obsolete and unsuitable, and therefore he could put no value upon them. The Electric Lighting Committee have decided to recommend the purchase of the Company's undertaking on the basis of the figures in the report. In case the Corporation should also decide to take over the arc lighting plant, Prof. Kennedy stated that his valuation will be increased by £1,954, in which figure no value is placed upon the lamp-posts. The report and Committee's recommendation were considered by the Urban Sanitary Authority at their meeting yesterday.

BELFAST.—In moving the adoption of the minutes of the Electric Light Committee at the last meeting of the City Council, Councillor Andrews said that his Committee had under consideration the question of the erection of a steam generating station so that they might be in a position to supply electric current to the whole of the city, and they hoped to lay a report before the Council on June 1st. They would, however, be compelled to ask the Corporation for land, or for money to purchase land, to serve as a site for the new station.

BOLTON.—The Joint Committee of the Streets and Electric Lighting Committees have decided to recommend the introduction of electric traction on the local tramways, that the overhead system be adopted, and that the lessees of the tramways be invited to confer with the Committee as to commencing the adoption of the system.

BRISTOL.—The report recently presented by the Electric Lighting Committee on the question of extensions was considered by the City Council on Friday last. An abstract of the Committee's recommendations was given in our issue of the 24th ult. The Chairman (Mr. Pearson) moved the adoption of the report, and referred to the difficulties they had at first encountered, but the conveniences of the present station far outweighed the initial difficulty they had in piling the site, and justified the heavy expenditure they were thenc alled upon to incur, and he was satisfied that no blunder had been made. He had no hesitation in asking the Council to go on with the works on that site, which would involve an ultimate but not an immediate expenditure of £75,000. The result would be that, whereas with the original station the cost per lamp was about £3, with the suggested increase the cost would only be about £1. 16s. When the proposed works were completed the available power would be equal to about 5,000 H.P. The number of lamps connected in March, 1894, was 9,750; in March 1895, 16,362; and in March, 1896, 29,210. During the last half year, after paying expenses and interest on the sinking fund, there was a profit of about £1,500, which they proposed to utilise for making good the deficiency that would arise during the current half-year, the period of their lightest load. They had every reason to anticipate that the revenue for the year ending September next would be not much under £12,200. Therefore, he felt justified in saying that they were not costing the city anything this year, and he believed that the future demand upon the rates (if any) would be very trifling. It was proposed to spend £5,000 during the year on buildings, and in 1897 £3,000 more, and £11,500 on additional machinery. In 1898 they contemplated spending a further sum of £8,000 to complete their buildings, and about £7,600 for further machinery; and in 1899 a further expenditure for equipment of about £5,700 would be necessary. A sum of £16,000 would be required to carry out the extensions of mains in streets which the Committee had in their minds at the moment, but it was not intended that the whole of this money should be spent straight off. £4,000 has been set aside for contingencies, and £8,000 for house connections, the entire aggregate being £74,000 odd. The report did not deal with the arc lights, as the Committee were not directly responsible for the city lighting; but Mr. Pearson said if the lamps were doubled or trebled it would be a very small matter for the Committee. He would, however, remind the public that they could not expect a street magnificently lighted with the electric light for the same price as they would get the darkness rendered visible, which was the usual accompaniment of gas, although candle for candle electricity was infinitely cheaper than gas. In the discussion which ensued various members put in pleas for the extension of the mains to particular thoroughfares, and one or two councillors dealt with the tramway question. In reply, Mr. Pearson said he had no ambition to see Bristol lighted with incandescent electric lamps, which he considered did not do justice to the electric light in the streets. As to the Tramway Company he had no desire to anticipate a report which they would be called upon to consider later on, but the Committee were able to supply a large amount of current for motive power if required. The report was adopted.

BURNHAM (ESSEX).—A scheme for the electric lighting of this village has been submitted to the Parish Council by Messrs. Donnison and Co. A meeting of ratepayers is to be held to discuss the matter.

BURY ST. EDMUNDS.—The National Telephone Company have decided to establish a telephone exchange in this town.

CANTERBURY.—The Town Council have decided to establish an electricity supply station and to apply to the Local Government Board for sanction to borrow £20,000 for that purpose. Electric light will be introduced into the cathedral as soon as current is available. Mr. R. Hammond has been appointed consulting engineer to the Committee.

CENTRAL LONDON ELECTRIC RAILWAY.—The contractors for the construction of this railway (the Electric Traction Company, Limited) have let the sub-contracts for the construction of the various tunnels, and it is stated that work will be commenced on

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all the sections early in July next, and be completed about October, 1897.

CHELMSFORD.—At the last meeting of the Town Council the minutes of the Lighting Committee stated that they had considered the offer of the Chelmsford Electric Lighting Company to sell their undertaking, including the Provisional Order, works, machinery mains, &c., for £34,828, but were unable to make any recommendation on the matter without the advice of an expert, and asked for the assistance of a consulting engineer to advise them. The whole question is shortly to be considered by the Council in Committee. A contract has been entered into with the Company for lighting the town for five years upon the same terms as heretofore, viz., £20. 10s. per arc and £2. 6s. 10d. per incandescent lamp per annum.

COLCHESTER.—The Town Council have selected a site for their electricity works, and tenders have been invited for the supply of the necessary plant from the Brush Company, Messrs. Christy Bros., Crompton and Co., Messrs. Siemens Bros. and Co., John Fowler and Co., and C. A. Parsons and Co.

COUNTRY HOUSE LIGHTING.—Messrs. Drake and Gorham have recently secured contracts for the electric lighting of "Woolton" for Capt. Wingfield, Stratford, and also for fitting-up Mr. Frank Barlow's county house at Lynchmere.

CROYDON.—The County Council intend to apply to the Local Government Board for sanction to borrow a further sum of £5,000 for electric lighting purposes.

DERBY.—The Local Government Board have declined to sanction the Council's application to borrow, amongst other sums, £419 for costs incurred in obtaining their Provisional Order.

DOVER.—At the next meeting of the Town Council Mr. Fry will move that a sub-committee be appointed to visit Rouen for the purpose of inspecting and reporting upon the electric traction system employed on the tramways of that city. Several members of the Council are anxious that the town should possess efficient tramways, and are favourably disposed towards the overhead electric traction system.

EXETER.—The Board of Trade have revoked the Exeter Electric Light Company's Provisional Order.

EXHIBITIONS.—We have to chronicle the formal opening of no fewer than six exhibitions during the week, and of this number three are British—viz., the International Horseless Carriage Exhibition at the Crystal Palace, the Motor Car Club display at the Imperial Institute (London) and the Cardiff Exhibition, which promises to be a great success. The other exhibitions are being held at Berlin, Budapest and Geneva, and are of international and industrial importance.

FULHAM (LONDON).—The consideration of a report by Mr. F. H. Medhurst on the question of the adoption of a joint electric lighting and refuse destructor scheme has been adjourned until after the forthcoming Vestry elections.

GATESHEAD.—The Town Council recently received an application from a firm of electrical engineers for authority to lay electric light mains, and the matter was referred to the borough engineer (Mr. James Bower), who recommends the Council to themselves apply for a Provisional Order. If the Corporation decides to adopt the electric light, he suggests they should start on a small scale so that the initial capital outlay may not exceed £20,000. If they commence with the installation at the Town Hall and Public Library a capital outlay of £2,500 would be sufficient.

GLASGOW.—At a meeting of the Tramways Committee of the Corporation on Wednesday the methods of mechanical tramway traction which the Committee had witnessed during their recent visits to Bristol, Coventry, and places on the Continent, were discussed, and it was decided to recommend the Corporation to adopt the overhead electric system, the cars to be provided with seats on top.——The City Fathers are much exercised over what is called the "disgracefully-lighted condition of the streets," and it has been decided to instruct the Watching and Lighting Committee to consider the matter, and report at an early date. Mr. Primrose said his Committee had been considering how to improve matters, and they recognised that the operations of the near future in connection with the tramway service and the improvement of the electric light system would probably deal with the principal thoroughfares, but the subsidiary streets would have to be lighted by gas lamps for some years to come, and for that reason he would like to see them a great deal better illuminated than they were at present. The gas bill for the present year was undoubtedly a heavy one, but he thought there should be a lower rate for the supply of gas for street lighting than for private. He held that the financial position of the Gas Committee was unsound.

HALIFAX.—The electric light has been installed at the Belle Vue Public Library. The work has been carried out under the superintendence of the borough electrical engineer (Mr. T. P. Wilmshurst). About 110 incandescents are employed.

HALIFAX.—The Gas Committee of the Halifax Corporation hold an exhibition of electrical appliances in the Northgate Hall in about a fortnight's time, to include electric motors suitable for small tradesmen and electric heating and cooking appliances.

HOSPITAL LIGHTING.—The Borough Electrical Engineer of Glasgow is preparing plans and specifications for the electric lighting of Ruchill Hospital. Current is to be obtained from an independent plant.——It has been decided to introduce the electric light into the Devon and Exeter Hospital at a cost of about £1,200. The annual upkeep expenses are put at £190, or £50 less than the sum at present paid for gas.

KILLARNEY.—At Killarney Petty Sessions on Tuesday a number of summonses arising out of the surcharging of four members (Messrs. J. Duckett, D. O'Sullivan, J. Kelly, and D. Hurley) of the Town Commission with the sum of £85. 2s. 3d. in connection with the electric lighting of the town, were down for hearing. The defendants having failed to comply with the order to pay the amount to the credit of the Town Commissioners' account the present proceedings were instituted by the auditor, Mr. Calvert. It will be remembered that in 1893 the Commissioners entered into a contract for the lighting of the town by gas, but after the elections in October, as there was a majority in favour of the electric light another contract was entered into with the Killarney Electric Lighting Company for lighting the town by electricity. The gas contractor continued to fulfil his contract, while the Electric Lighting Company put in an installation for lighting the streets electrically, and various cheques were passed by the Commissioners in favour of both contractors. The auditor, however, held that the gas contract being in existence, it could not be set aside by the Commissioners, and decided that the resolution revoking it and consequently the contract with the Electric Company was invalid. As the defendants have applied to the Queen's Bench Division for the purpose of having the auditor's order quashed the hearing of the summonses was adjourned.

LAMBETH (LONDON).—After a discussion extending over three evenings the Vestry have finally decided by 44 votes to 15 to adopt the recommendation of the Electric Lighting Committee to transfer their Provisional Electric Lighting Order to Mr. C. W. SAX.

LIVERPOOL.—The City Council have consented to the application of the National Telephone Company to lay their telephone wires underground.

LURGAN (IRELAND).—A proposal for the lighting of the streets by electricity has been submitted to the Town Commissioners, and is at present under consideration.

MANCHESTER.—For the purpose of extending the electric lighting plant, mains, &c., the Town Council have decided to apply to the Local Government for sanction to borrow an additional sum of £100,000. It was explained that this large amount was required in order to keep pace with the increasing demand for the electric light.

MILL LIGHTING.—The electric light is being extensively employed for mill lighting in India, one of the latest installations being that at the mills of the Marajee Goculdas Spinning and Weaving Company, at Parel, Bombay. Messrs. Nowrosjee Wadia and Sons, of Tardeo, Bombay, were the contractors.

NEWINGTON (LONDON).—The refusal of the Board of Trade to accede the Vestry's application for a Provisional Order was discussed at the last meeting, and it was decided to oppose any future application by a company for a Provisional Order.

NEWPORT (MON.).—The provision market is now lighted electrically by means of 2 arcs and about 250 incandescents.

OXFORD.—It has been decided to considerably increase the generating power at the station of the Oxford Electric Company, and on the advice of the Company's engineer, Mr. J. Hardie McLean, orders have been placed with Messrs. J. and H. McLaren for a 500 I.H.P. triple expansion surface condensing engine, and with the Electric Construction Company for a 260-kilowatt machine. Up to the present 100 and 80 unit machines have been used. The makers' guarantee is calculated to maintain the economy in working for which the Oxford station possesses a good record. The capacity of the plant will be raised from an equivalent of 19,000 to 33,500 8 c.p. incandescents connected.

PARLIAMENTARY.—In the House of Commons on Monday last the Chairman of Ways and Means (Mr. J. W. Lowther) moved the suspension of Standing Order 171 for the remainder of the Session. He explained that this Standing Order prevented corporations from working their own tramways. The Grand Committee on Trade had recently passed the third clause of the Light Railways Bill, which gave corporations, county councils and district councils power to construct and work their own light railways, and in view of that decision no case could be made out for preventing corporations from working their own tramways, and various corporations had Bills before Parliament asking for leave to work tramways. The motion was agreed to.

——— In the House of Commons yesterday Mr. Ritchie, in reply to a question from Sir J. Leng, calling attention to the sug-

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gestion made by Lord Justice Kay in a recent patent trial, that it was desirable there should be some functionary holding in relation to patents, a position analogous to that of the Comptroller in relation to trade marks, stated that the subject had engaged the attention of Parliament on and off for some years, and that the Bill of 1885 made some provision in this direction. It would, however, require so large a staff to report on the novelty or otherwise of patents that the Board of Trade were not in a position to make any recommendation on the subject.

PETERBOROUGH.—A Local Government Board inquiry was held at Peterborough on Wednesday into the application of the Town for leave to borrow £20,000 for the purpose of establishing Council electricity supply works in the town. The Council were represented by Mr. W. Mellows (town clerk), Mr. J. C. Gill (borough engineer), Prof. J. A. Fleming (consulting electrical engineer), and Mr. J. W. Walshaw (borough surveyor). Mr. H. Percival, barrister, appeared for the opponents. The Great Northern Railway Company, who are large ratepayers, were separately represented, and also opposed the scheme. The Town Clerk having given particulars of the application and of the financial condition of the borough, Prof. Fleming gave technical details of the scheme, and described the system proposed to be adopted, which he said had been successfully introduced in other towns. The ground of opposition was that the scheme would not prove a financial success.

STOCKPORT.—At the meeting of the Town Council, on Wednesday last, the Gas Committee recommended that £43,000 be voted for gasworks extensions. Alderman W. Atherton urged the Council to make an effort to introduce the electric light, as he understood several tradesmen would be willing to take electric current if it were available. The Chairman of the Gas Committee (Mr. T. Webb) gave the result of some inquiries he had made as to the success of the electric light at Manchester and Huddersfield, and stated that "he had not yet found any system of electric lighting which he could recommend as likely to be financially successful"! This is another case where (as at Stockton, &c.) the electric light clashes with the gas interest—which is in possession.

STOCKTON-ON-TEES.—The Town Council have at length decided to make a move in electric lighting matters. Application is to be made to the Local Government Board for sanction to borrow £18,000 for electricity supply purposes.

STORES LIGHTING.—The central stores of the Great Horton (near Bradford) Industrial Society are to be lighted electrically.

ST. HELENS.—The salary of the gas manager (Mr. S. Glover), who is to have the superintendence of the new electricity works, has been increased from £400 to £450.

ST. PANCRAS (LONDON).—The Electricity and Public Lighting Department of the Vestry have just presented their statement of accounts in respect of the Regent's Park station for the year 1895. The accounts are of a most satisfactory character, and prove that the department continues to make excellent progress. The total capital expenditure amounted to £113,889. 2s. 1d., an increase of £4,522. 18s. 4d., mainly caused by extensions of mains, services to consumers' premises, meters and switches. The total revenue amounted to £18,921. 17s. 5d., a net increase of £1,990. 0s. 10d., but as the charge for public lighting for the year showed a reduction of £857. 7s. 4d., the actual increase from private consumers amounted to £2,847. 8s. 2d., or nearly 23 per cent. increase. The total generating expenses amounted to £6,737. 14s. 5d., an increase of £561. 4s. 6d. There was an increase of £1,623. 13s. 11d. in the distribution expenses, this large increase being chiefly attributable to the necessity of replacing the whole of the insulators and bearers in the manholes in consequence of the explosions in culverts that occurred early in the year. Nearly £600 was paid for this work, in addition to a sum of £300 for extra staff employed in cleaning the incrustation off the old insulators and other work during the time the new insulators were being put in. After providing for the whole of these expenses there remained a profit of £6,575. 15s. 4d. (equivalent to nearly 6 per cent. on the capital expenditure) to meet repayments, interest, &c., which absorb £5,640. 10s. 9d., leaving a net profit of £935. 4s. 7d. This sum, added to the balance on last year's accounts of £1,768. 6s. 7d. (less £554. 4s. 7d. written off for preliminary expenses), leaves a net balance of £2,149. 6s. 7d. to be carried forward. The yearly progress of the station since the commencement of supply is shown by the following table :—

| Dec. | No. of consumers. | Current sold to private consumers. | | No. of lamps, &c., applied for. | | |
|---|---|---|---|---|---|---|
| | | 3d. per unit. | 6d. per unit. | Incandescent, 16 c.p. | Arc. | Motors. |
| 1892 | 172 | ... | £8.167 7 8 | 9.990 | 82 | 11 |
| 1893 | 238 | £384 11 6 | 9.161 6 0 | 12.851 | 110 | 19 |
| 1894 | 349 | 1,236 13 9 | 10.819 15 0 | 15,532 | 129 | 22 |
| 1895 | 447 | 2,142 9 6 | 12,682 6 0 | 19,195 | 139 | 37 |

TELEPHONE EXTENSION IN THE HIGHLANDS.—The Post Office have decided to erect a trunk telephone line between Aberdeen, Elgin and Inverness.

WALSALL.—The Town Council will consider, at their next meeting, a resolution in favour of the purchase of the tramway lines within the borough.

WELLS.—Mr. J. A. Tate has given notice that he will move at the next meeting of the City Council "That plans and specifications be at once prepared for an electric light installation."

WORCESTER.—A Local Government Board inquiry was held at Worcester on Tuesday last into the application of the Council for sanction to borrow £6,580 for electric lighting purposes. The Town Clerk (Mr. S. Southall) gave particulars of the application, and stated that the present loan was required for the extension of the mains and additional lamps.

YORK.—The greater part of the last sitting of the City Council was devoted to a discussion on the electric lighting question. Mr. Lambert moved the recission of the resolution passed in May, 1892, whereby the Council decided to keep the electric light in their own hands. He made a lengthy speech in support of this motion, and quoted various figures from the returns of electric supply undertakings, recently published in *The Electrician*. Mr. Purnell delivered an able speech in opposition, and the motion was lost by 9 votes to 17.

ELECTRO-HARMONIC SOCIETY.—The balance sheet of this Society is to be presented at the annual general meeting to be held on Friday next at the Institution of Electrical Engineers, 28, Victoria-street, London, S.W. During the past season 35 new members have been presented, 30 have resigned, eight have been struck off the register, and the Society has lost two members by death. There are now 300 members. The balance sheet, subject to audit, shows a credit balance forward of £95. 14s. 1d., against £73. 15s. 8d. for last year.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Publishe is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

April 18, 1896.

8,169. P. MEYER. London. Electric lighter for incandescent gas lamps. [Date applied for under Patents, &c., Act, 1883, Sec. 103, September 20, 1895, being date of application in United States.]

8,185. P. C. EBBUTT. Birmingham. An improvement or improvements in the method of raising or lowering electric light fittings, gas fittings, and the like.

8,203. J. ROW. Manchester. A new or improved make of housing or troughing for electric wires.

8,210. H. J. FISHER. London. Improvements in means for automatically controlling the carbon feed in electric arc lamps.*

8,216. W. E. GRAY. London. Improvements in electric motors and dynamos.

8,228. SIEMENS BROS. AND CO. (LIMITED) and E. F. H. H. LAUCKERT. London. Improvements in armatures for electric generators or motors.*

April 20, 1896.

8,262. M. COMMICHAU. Saxony. Apparatus for fastening and tightening wires for electric streams to insulators by means of a lever.

8,269. G. WILKINSON. London. An improved system of running and insulating concentric electrical conductors and appliances in connection therewith.

8,271. W. S. BOULT. London. Improvements in or relating to electric traction.

8,308. V. A. FYNN. London. Improvements in or connected with electrical resistances.

April 21, 1896.

8,316. E. H. WRIGHT, J. J. HECKMAN, A. H. GRAVES, C. C. CARNAHAN, and W. H. CARNAHAN. London. Improvements in electric switches.*

8,320. G. FABBRO. London. Support or bearing for electrical accumulators or other apparatus, having for its object the minimising of vibration.

8,338. W. E. KENWAY. Birmingham. Improvements in the mode of connecting the car with the overhead wire in tramways worked by electricity.

8,362. E. J. DEVINE. London. Improvements in and relating to electric signalling devices between cars of railway trains.

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## SPECIFICATIONS PUBLISHED.

**NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.**

1895.

3,864. SPERRY. Electromotors.
6,565. TEE. Electrolysis of chlorides, &c.
6,565A. TEE. Electrolysis of chlorides, &c.
7,075. FLETCHER and OTHERS. Electric cooking and heating grills, &c.
8,306. SHREWSBURY and OTHERS. Electric batteries.
9,796. HART and LUCAS. Electric conduits.
9,967. MOODY. Electric regulators.
10,334. PRICE. Electric call apparatus.
10,433. DORMAN. Dynamo electric generators and motors.
10,538. DORMAN. Dynamo electric generators and motors.
10,539. DORMON. Dynamo electric generators and motors.
10,614. SLOPER and BECKETT. Electric telephone systems.
10,687. GOULD. Arc lamps.
11,016. BLACKMAN. Electrolytic decompositions, &c.
11,025. SIEMENS BROS. AND CO., LIMITED (Siemens and Halske). Electrically working railway switches and signals.
11,032. EREMIN. Secondary batteries.
15,114. ERBEN and BERGMANN. Electric current meters.
19,304. WISE (Moore Electrical Company). Producing electric light.
20,801. VON MORSTEIN. Electrically lighting gas jets.
20,924. THOMPSON (Higgins). Electric annunciators.

1895.

2,915. CZARNIKOW. Electric gas igniting and extinguishing apparatus.
4,076. THOMPSON (Porzellanfabrik Kahla, Filiale, Hermsdorf-Kloster lausnitz). Incandescent electric lamp holder.
4,238. DEVONSHIRE (Knight). Dynamo electric machines and motors.

# COMPANIES' MEETINGS AND REPORTS.

## Submarine Cables Trust.

The twenty-fifth ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held at the offices, Winchester House, Old Broad-street, on the 1st inst., the Marquis of Tweeddale presiding.

The SECRETARY (Mr. A. G. Brodrick) read the notice convening the meeting and the minutes of the last meeting, and the report of the Trustees was taken as read.

The CHAIRMAN: In asking you to adopt the report and accounts I cannot help referring to the absence of Sir John Pender, who has occupied the chair ever since this Trust was formed. I think I am the only one left now of those who were present when the Trust was originally established, and I am sure that the regret I express will be shared by everyone present and everyone connected with the Company, whether present or absent. The year on the whole has been a prosperous one for the Trust. The revenue for the past year amounted to £22,313, as against £21,464 in 1895, or an increase of £849. This increase is entirely due to our having received a larger dividend for the current year from our investment in the Anglo-American Telegraph Company. I hope we may look forward to a continuation of this increase in the Anglo-American Company's dividend, as their receipts are showing increases every day. The total expenses for the year amounted to £1,099, or a decrease compared with those of 1895 of £95. It will be seen with satisfaction on reference to the accounts that the cost of administering the Trust is £900 less than the amount provided by the trust deed. Our revenue for the past year, including the £224 brought forward from the previous year, has enabled us to pay the equivalent of two coupons of £3 each, and clear off an additional 5s. of the remaining portion of the overdue coupon. This still leaves a balance of £1 in arrear, which will be gradually paid off should the present income derived from our investments be maintained or increased in future. There is every reason to look forward to an increase which would very soon wipe out this amount in arrear. The present mean market value of the investments held by the Trust as compared with the cost price shows an appreciation of over 60 per cent. The 3,381 certificates remaining in the hands of investors are, therefore, worth on this basis about £164 each, whereas, I understand that their market price is about £130. I think this may be regarded as a very satisfactory feature in the position of our Trust. With these remarks I beg to move—

"*That the report and accounts of the trustees to April 15, 1896, submitted to this meeting, be and the same are hereby received and adopted.*"

Mr. J. DENISON PENDER: I second that.

The motion was carried unanimously.

Mr. SHUTER proposed the re-election of Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. Cane, Jackson, and Jefferys as auditors of the Trust for the ensuing year.

Mr. BEDWELL seconded the motion.

Mr. LAMONT inquired whether two firms of auditors were wanted.

The SOLICITOR referred to the trust deed, and said he thought that it certainly contemplated two firms.

The CHAIRMAN: "Each of the auditors shall receive such payment not exceeding," &c. That clearly indicates that two auditors were contemplated. He then put the motion, which was carried unanimously.

Mr. ANSELL afterwards proposed, and Mr. SHUTER seconded, a vote of thanks to the Chairman and Trustees, which was carried unanimously.

The proceedings then terminated.

## China and Japan Telephone Company (Limited).

The thirteenth ordinary general meeting of this Company was held at the offices, 14, Austin-friars, London, on Tuesday, Henry Grewing, Esq., the Chairman of the Company, presiding.

The SECRETARY (Mr. Alex. B. Chalmers) read the notice calling the meeting and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, you will see by the figures of the report that the Company has gone on doing an improving business during the past year, and we have every reason to hope that it will continue to do so. As you are aware, the sphere of operations of this Company is a rather limited one, but recent events in China have led the Government there to adopt a more liberal treatment towards foreign enterprises generally. I do not mean to say that this will benefit us directly, but it will certainly do so indirectly, because machinery, for instance, which has been prohibited from entering the country for many years, is now admitted freely, and consequently there are factories springing up all round, and wherever activity increases it means, of course, that our telephone will certainly be wanted. If figures speak for themselves, I cannot do better than mention the increase in the number of our subscribers compared with ten years ago. At the present moment we have something over 470 subscribers, while ten years ago we counted not more than about 100. That is a satisfactory increase. I take this opportunity of freely and fully acknowledging the services that have been rendered by our managers in China, and especially by Mr. Porter at Shanghai, where the greatest improvement and development of our business has taken place, and will most probably continue to take place in the future. I can assure you that your business will in the future be watched with the same interest and the same close attention as has been the case in the past. I have nothing further to add, and I beg to move—

"*That the Directors' report and the audited accounts for the year ended December 31, 1895, be and the same are hereby approved and adopted.*"

Mr. THOMAS LLOYD seconded the motion, which was carried.

Mr. THOMAS LLOYD then moved the re-election of Mr. Henry Grewing as a Director of the Company.

Mr. W. ADDISON seconded the motion, which was agreed to.

Messrs. Price, Waterhouse and Co. were re-elected auditors.

A sum of 200 guineas was voted to the Directors as remuneration for their services during the past year.

A vote of thanks to the Chairman and Directors closed the proceedings.

The Directors' report for the year ended December 31st last states that the profit and loss account, after charging debenture interest and bringing £361. 8s. 5d. from 1894, shows a credit balance of £1,295. 5s. 3d. £750 is placed to reserve, and £545. 5s. 3d. is carried forward. The result of the working of the exchanges for the past year, both at Shangai and Hong Kong, is satisfactory, and the income at both stations has been considerably increased at but small additional expense to revenue, although it has necessarily involved further capital outlay. The bond for £5,000, issued in 1891 to secure the debentures held by the Oriental Telephone and Electric Company (Limited), fell due on December 31, 1895, and has been extended for a further period of five years with the consent of that Company.

## Western and Brazilian Telegraph Company (Limited).

The following report of the Directors of this Company for the half-year to December 31st last will be presented at the general meeting to be held at Winchester House, London, E.C., on Thursday next, at twelve o'clock:—

The total earnings amount to £80,315. 2s. 10d., against £82,815. 11s. 11d., a decrease of £2,500. 9s. 1d. compared with the half-year to December 31, 1894. The working expenses amount to £38,122. 9s. 11d., against £36,403. 17s. 3d., an increase of £1,718. 12s. 8d. Including the amount brought forward (£5,803. 7s. 5d.), and the dividend received upon the shares held in the Platino Company, the balance to the credit of the revenue account is £52,614. 2s. 10d., from which has been deducted £11,148 for debenture interest and £7,952 for the debenture redemption fund, leaving £33,514. 2s. 10d., of which £3,000 has been placed to reserve. The Directors now recommend the payment of 5s. 3d. per share, free of income tax, for the half-year on the Ordinary shares, making, with the dividend paid in November last, £3 per cent. for the year, the same as paid for 1894, leaving a balance of £4,952. 13s. 7d. to be carried forward. In the case of shares which have been divided into Preferred and Deferred, the 5s. 3d. per share now recommended will be payable, viz., 3s. 9d. to the Preferred shareholders (making up the full dividend of £5 per cent. on these shares for the year 1895) and 1s. 6d. per share to the Deferred shareholders.

There is no change in the position of affairs between the Government of Brazil and the Company as to the purchase of the cables. The Directors have to report the sale of the ss. "Viking" to the Amazon Telegraph Company for £12,300; £1,329. 18s. 2d. had to be spent upon the vessel. After adding this to the amount the "Viking" stood at in the last accounts—viz., £8,500—there remained a balance of profit of £2,470 1s. 10d., which amount the Directors have applied in reduction of "Norseman" No. 1; and as, since the close of the year, the vessel has been sold at a loss, they have written this off against the reserve fund. In the accounts for the current half-year the matter will be finally dealt with. "A" and "B" Debentures, amounting to £15,900, have been paid off at par. The dividend warrants will be posted on the 15th inst.

Lord Richard H. Browne and Mr. John Coppen will offer themselves for re-election as Directors, as will the auditors, Messrs. Turquand, Youngs, Bishop and Clarke.

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## Brazilian Submarine Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ended December 31st last, to be submitted to the general meeting to be held at Winchester House, London, E.C., on Wednesday next, at 12 o'clock :—

The revenue amounted to £106,167. 13s., and the working expenses to £21,623. 7s. 3d. After providing £3,200 for debenture interest and sinking fund, and £1,705. 12s. 10d. for income tax, there remains a balance of £79,638. 12s. 11d., to which is added £4,410. 9s. 3d. brought forward from June 30th last, making £84,049. 2s. 2d. First and second interim dividends (amounting to £39,000) have been paid, and £30,000 transferred to reserve, leaving £15,049. 2s. 2d. to be carried forward. The receipts for the half-year include £1,500 dividend to June 30th last on the Company's shares in the African Direct Telegraph Company (Limited). The various sections of the Company's lines are in good working order.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**ALDERLEY AND WILMSLOW ELECTRIC SUPPLY (LIMITED).**—This Company was registered on April 24th with a capital of £30,000, in £1 shares, to take over the Provisional Order of the Urban District Council to carry into effect an agreement made with the said Council, to carry on the business of electrical engineers and suppliers of electricity, and to construct, let, use and maintain telegraph and telephone lines. The first subscribers, with one share each, are :—F. B. Ross, A. Crewdson, C. Duckworth, A. Midgley, E. Agnew, J. Royle and P. Whyman. The first Directors are :—E. Agnew, A. Crewdson, F. B. Ross and William P. J. Fawcus.

**INTERNATIONAL IMPROVED ELECTRIC COMPANY, (LIMITED).**—This Company was registered on April 22nd with a nominal capital of £75,000 in £1 shares, to aquire the benefit of certain inventions relating to the manufacture of improved electric glow lamps, together with a process of the manufacture of same, and the letters patent granted to or to be granted in respect thereof; and also to enter into an agreement with Ferdinand Fanta, and to carry on the business of electrical engineers, manufacturers of, dealers in and agents for lamps, fittings, plant, &c. The first subscribers, with one share each, are :—G. W. Putman, W. F. Smith, electrician, W. R. McAthy, F. L. Koch, F. Royce. C. J. Hupfeld and W. Dunz.

**KNOEFERL-BONN DENTAL AND MANUFACTURING COMPANY (LIMITED).** This Company was registered on May 1st with a nominal capital of £10,000, in £1 shares, to acquire the business of a manufacturer of dental appliances and mechanical engineer carried on by F. Knoeferl at Bolsover-street, London, W., and also the business of an electrical engineer formerly carried on by Jacob Bonn under the style of "J. Bonn and Co.," at Holborn-place, London, W.C., but recently purchased by the said F. Knoeferl, to carry on the business of manufacturers, dealers in and repairers of mathematical, scientific and dental appliances and apparatus, electricians, electrical and mechanical engineers, machinists, wire drawers, &c. The first subscribers, with one share each, are G. Gibbs, S. B. Saunders, J. H. Gartrell, Jacob Bonn, electrical engineer, F. Knoeferl, engineer, J. H. Greenwood, and E. A. Robinson.

**PERFECTA SEAMLESS STEEL TUBE COMPANY (LIMITED).**—This Company was registered on May 4th with a capital of £145,000, in £1 shares, to acquire the business carried on at Birmingham, under the style of "The Perfecta Seamless Steel Tube Company," and to carry on the business of mechanical engineers, wire drawers, tube makers, electro-platers, &c.

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**APOSTOLOFF AUTOMATIC TELEPHONE PARENT SYNDICATE (LIMITED).** The statutory return to March 26th has been filed. The whole capital of £10,000, in £1 shares, has been taken up, and 6,500 have been issued as fully paid. The full amount has been called and paid on 2,100, but no calls have as yet been made on the remainder.

**I.E.S. ACCUMULATOR COMPANY (LIMITED).**—The statutory return to December 20th was not filed until April 11th. Out of a nominal capital of £100,000, in £1 shares, 50,000 have been issued as fully paid.

**KAMM'S ZEROGRAPH SYNDICATE (LIMITED).**—The statutory return to March 23rd has been filed. The nominal capital is £24,000, in £10 shares. 840 shares have been taken up, and 800 of these have been issued as fully paid to Mr. Leo Kamm. The full amount has been called on the remainder.

**MADEIRA ELECTRIC LIGHTING COMPANY (LIMITED).**—An agreement has just been entered into with Messrs. Ullathorne and Hartley, electrical engineers, Bradford, for the acquisition of a concession for the electric lighting of Funchal, Madeira. This consideration for the transfer, together with a complete electric lighting plant, is £33,000, stated to be satisfied as to £6,000 thereof by the allotment of fully paid shares, Nos. 1,801 to 7,800 inclusive.

**MEXICAN GAS AND ELECTRIC LIGHT COMPANY (LIMITED).**—The annual return to January 6th has only just been filed. The nominal capital of £100,000, in £20 shares, has been taken up, and all have been issued as fully paid.

**NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return to January 28th has just been filed. The nominal capital is £50,000, in £5 shares, of which 9,126 have been taken up, and 168 issued as fully paid; £4 per share has been called on 8,108, and £2 per share on the remaining 850.

**OGMORE VALLEY ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).**—The annual return to April 14th has been filed. Of a nominal capital of £10,000, in £5 shares, 710 have been taken up, and the full amount has been called.

**PONTYPRIDD ELECTRIC LIGHTING AND POWER COMPANY (LIMITED).**—The annual return to April 10th has been filed. 1,143 shares have been taken up out of a nominal capital of £10,000, in £5 shares. The full amount has been called on 669, and £4 per share on the remaining 474.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31d. per oz. (May 7th). Consols (2¾ per cent.) 111⅛—111⅛ for money, 111⅜—112 for account; 2½ per cent. 105¼—105⅜ (May 7th). Stock Exchange Settling Days: Consols, June 1st; Stocks and Shares Continuation Days, May 12th and 27th; Ticket Days, May 13th and 28th; Pay Days, May 14th and 29th; Mining Share Carry-over Days, May 11th and 26th.

**AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).**—A list will be found in our advertisement columns of 120 Debentures of £100 each, which have been drawn for payment at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, London, on July 1st next.

**CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).**—This Company invite applications for 12,000 Ordinary shares of £5 each, at a premium of £2 per share, payable: 10s. on application, £2. 10s. on allotment, £2 on October 1st, and £2 on January 1, 1897. The additional capital is required for the extension of the mains, for erecting and equipping a new generating station and for providing necessary sub-stations. The lists opened yesterday, and close to-day (Friday).

**CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).**—The revenue return of this Company for the quarter ended March, 1896, is as follows :—Sale of current for public lighting £3,161, against £3,191 in the corresponding quarter last year; private lighting, &c., £38,280, compared with £26,622; estimated revenue from other sources £750, against £340; total—£42,191, compared with £30,153, an increase of £12,038. There was an equivalent of 8 c.p. lamps connected on March 25, 1896, of 207,268, an increase of 11,951 during the quarter, compared with 13,134 last year.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended May 3rd were £878, against £864 in the corresponding week of 1895, an increase of £14. The total receipts for the half-year amount to £17,027, against £16,983 for the corresponding period of 1895, an increase of £44.

**DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the month of April are £2,422.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the month of April amounted to £72,824, against £67,046 in the corresponding period last year.

**EASTERN EXTENSION AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the month of April, amounted to £47,436, against £38,C80 in the corresponding period of 1895.

**GENERAL ELECTRIC COMPANY OF AMERICA.**—In a supplement particulars are given by the *Electrical Engineer* of New York of the year's transactions of the General Electric Company. The sales show a figure of about 12¾ million dollars. The annual report of the president, Mr. C. A. Coffin, states that the business of the year, including royalties, amounted to $13,315,667, against cost of goods and all other expenses and taxes $11,759,857, a credit surplus of $1,555,810., less interest on debentures, sundry losses, depreciation and other charges, bringing the balance down to $1,388,967, from which $511,322 is written off plant, patents, &c., leaving a net balance of $877,645. Since the closing of the fiscal year a contract has been completed with the Westinghouse Electric and Manufacturing Company which embodies a recognition of the patents of each company by the other, and the right, subject to certain exclusions, to a joint use thereof. A number of valuable patents have been acquired by the Company during the year. The revenue derived from interest and dividends was found nearly sufficient to provide for the interest on the Company's outstanding debentures.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company in April, 1896, were £23,200, and the total receipts from January 1st to April 30th £90,000, against £83,000 and £95,600 in the corresponding months of 1894 and 1895 respectively.

**LIVERPOOL GAS FITTINGS COMPANY (LIMITED).**—The annual general meeting of this Company was held on Wednesday last, Mr. J. B. Smith presiding. In moving the adoption of the report and accounts, the Chairman said that the profit on the past year's working amounted to £1,637, against £1,576 last year. During the year they had taken up agencies, which he thought would be of considerable benefit to the Company. In consequence of the increase in their business more capital was required, and the Directors proposed to issue Four per Cent. Debentures to the extent of £4,000 for a period of 10 years, redeemable at three years on six months' notice. The motion was adopted, and a dividend at the rate of 10 per cent. was declared. It has been decided to alter the name of the Company to the Liverpool Gas and Electric Fittings Company (Limited).

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 3rd inst. amounted to £1,145. The amount for the corresponding week last year was £1,148. Decrease £3.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended May 1st, after deducting 17 per cent of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,583.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half-month ended April 30th are £2,776, against £2,656 in the corresponding period of 1895

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share | Last Dividend. | Name | Previous Week's Price, Apr. 29. | Price Wednesday, May 6. | Rate per Cent. Yielded. £ s. d. | Dividend Due | Business Done During Week Ending May 2. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS** | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 49 51 | 50 52 | 4 16 2 | Jan., Apr., July, Oct. | 49½ | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 92 93 | 92½ 93½ | 5 6 11 | " " " | 93 | 91½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 10 10½ | 9¾ 10¼ | .. | .. .. | 10⅛ | 9¾ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 1¼ | 100 104 | 3 17 10 | January and July .. | 101 | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10½ 11 | 10½ 11 | .. | .. .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 14½ 14¾ | 14½ 15 | 4 13 4 | Mar., June, Oct., Dec. | 14¾ | .. |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 117 | 113 117 | 4 6 7 | June and December | .. | .. |
| 10,000,000 | $100 | $3½ | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 2 7 | Jan., Apr., July, Oct. | 163½ | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 13 | 12 13 | 6 3 1 | February and August | 12¾ | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20½ 21½ | 20½ 21½ | 4 13 0 | | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 4 5 | 4 5 | 4 0 0 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 15 3 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 103⅞ 109⅞ | 106⅞ 109⅞ | 4 3 9 | " " | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10 | 9½ 10 | 4 0 0 | Jan., Apr., July, Oct. | 10 | 9¾ |
| 400,000 | 10 | 2/6 | Eastern | 17 17½ | 17 17½ | 3 14 4 | " " | 17¼ | 17¼ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18 18½ | 18 18½ | 3 4 10 | " " | 18½ | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock ..xd | 129 132 | 129 132 | 3 0 7 | May and November | 132½ | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 106 109 | 4 12 10 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 18½ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅜ | 17⅞ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 7 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 101 105 | 101 105 | 4 16 7 | January and July .. | 103 | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 16 7 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 108 | 105 108 | 3 14 9 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) ..xd | 112⅝ 115⅝ | 110⅞ 113⅞ | 3 10 10 | May and November | .. | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust | 10½ 11 | 10½ 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅞ | 10½ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 16½ 17½ | 16½ 17½ | 3 9 7 | " " | 17⅜ | 16½ |
| 150,000 | 10 | 10/0 | Great Northern | 23 23½ | 23 24 | 4 3 4 | Jan., April, and July | 23½ | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 14 1 | March & September | .. | .. |
| 17,000 | 25 | 12/6 | Indo-European | 53 53 | 53 55 | 4 10 11 | May and November | 55 | 54 |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 109 112 | 5 8 1 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 11 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 5 6 | 5½ 6½ | .. | April and October .. | .. | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 133 138 | 133 138 | 4 6 11 | " " | .. | .. |
| 15,609 | 10 | 2/0 | West African Telegraph | 5½ 6½ | 6 7 | .. | January and July .. | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 105 | 102 105 | 4 15 11 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. | January and July . | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 97 102 | 97 102 | 8 0 0 | June and December | .. | .. |
| 88,321 | 10 | 1/3 | West India and Panama | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | .. | 1⅜ | 1⅜ |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 11¾ | 11½ 11¾ | 5 2 2 | May and November | 11¼ | 11¼ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 11 1 | June and December | .. | .. |
| 64,248 | 15 | 3/9 | Western and Brazilian | 9 9½ | 9 9½ | 5 2 9 | May and November | 9⅜ | 9¼ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6½ 7 | 6½ 7 | .. | — | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 3 | 2½ 3 | .. | — | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 104 108 | 104 108 | 5 12 8 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 104 108 | 104 108 | 5 12 8 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds..xd | 113 118 | 110 115 | 6 1 9 | May and November | 1'6½ | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 105 | 102 105 | 5 15 5 | March & September | 102¼ | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3 3½ | 3 3½ | .. | — | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Maintenance | 1/16 1/8 | 1/16 1/8 | .. | May and November | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) ..xd | 1/16 1/8 | 1/16 1/8 | .. | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7⅞ 8¼ | 7⅞ 8¼ | 3 7 8 | June and December | 8⅛ | 7 3/16 |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 18 | 16 18 | 3 6 8 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16½ 17½ | 16½ 17½ | 3 8 7 | " " | 17½ | 17½ |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6½ 7 | 6½ 7 | 3 11 5 | — | 6¾ | 6¼ |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 4½% (red.) | 108 111 | 108 111 | 3 3 6 | January and July .. | 108½ | 107½ |
| 58,000 | 5 | 3/0 | United River Plate | 3½ 4 | 3½ 4 | .. | " " | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 97 102 | 97 102 | 4 19 6 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ 15½ | 14½ 15½ | 3 4 6 | — | 15 | 14¾ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ 17 | 16½ 17 | 3 10 7 | — | 16½ | 16¼ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 138 | 134 138 | 3 13 3 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | — | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 7½ 8 | 7½ 8 | .. | — | 7 3/16 | 7 3/16 |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | .. | — | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. | — | .. | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ 13½ | 12½ 13½ | .. | — | .. | .. |
| 8,322 | £5 | .. | House-to-House Electric | .. .. | .. .. | .. | — | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. .. | .. .. | .. | — | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. | January and July .. | .. | .. |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 7⅞ 7⅞ | 7⅞ 7⅞ | 3 16 2 | — | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | .. .. | .. .. | .. | — | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13 14 | 13 14 | 2 17 2 | — | 13¼ | 13⅜ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 119 122 | 120 123 | 3 14 1 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9 9½ | 9 9½ | .. | — | .. | .. |
| .. | .. | .. | Rand Electric | ⅜ ½ prem | ⅜ ½ prem. | .. | — | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 10¼ 10⅞ | 10¼ 10⅞ | .. | — | 10⅜ | 9⅞ |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 3 6 | — | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9¼ 10¼ | 9½ 10 | 3 8 4 | — | 10 | 9⅜ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/3 | Brush Electrical Engineering | 1½ 1⅝ | 1½ 1⅝ | 5 8 8 | — | — | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅝ 1¾ | 1⅝ 1¾ | 3 4 0 | — | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 114 | 111 114 | 3 19 6 | March & September | 114 | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pre' | 2¼ 2½ | 2 2½ | .. | January and July .. | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United | 1¼ 1⅜ | 1¼ 1⅜ | .. | .. | 1⅜ | 1⅜ |
| £100,000 | Stock | 4½% | Do. 4% Mortgage Debenture Stock | 104 107 | 104 107 | 4 5 4 | .. | — | — |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. .. | — | .. | — | — | — |
| 110,000 | 2 | .. | Electric Construction | 1⅜ 1⅝ | 1⅜ 1⅝ | .. | — | .. | .. |
| 12,815 | 2 | 2 9/20 | Do. 7 per Cent. Cumulative Pref. | 2¼ 2⅜ | 2¼ 2⅜ | 5 1 10 | — | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | 9/16 5/8 | 9/16 5/8 | .. | — | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | ½ ⅝ | .. .. | .. | — | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23½ 23½ | 23½ 24½ | 4 1 8 | February & August | 24 | 23 |
| £200,000 | 100 | 4½% | * Do. 4½ per Cent. Debentures, 1896 | .. .. | .. .. | .. | March & September | .. | — |
| 15,995 | £10 | .. | International Okonite Ordinary | .. .. | .. .. | .. | — | — | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. .. | — | .. | December and June | — | .. |
| 20,000 | 9 | .. | Manchester Edison-Swan "A" (£1 5s. paid) | ⅛ ¼ | ⅛ ¼ | .. | .. | .. | — |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 41 | 38 41 | 4 7 10 | March and July.. | 40½ | 39½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 105 | 102 105 | 4 16 7 | January and July . | .. | — |
| 37,514 | £5 | .. | Woodhouse and Rawson Ordinary (£3 16s. paid) | .. .. | .. .. | .. | — | — | — |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. .. | .. .. | .. | — | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16½ 17½ | 16½ 17½ | 3 8 7 | — | 17⅛ | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 16½ 17½ | 16½ 17½ | 4 0 0 | — | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mort ge Debenture Stock | 107 112 | 108 113 | 4 0 2 | — | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 40 42 | 41 43 | 2 18 2 | May and November | .. | .. |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15 | 14½ 15 | 3 6 8 | .. | 15 | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture xd | 133 135 | 133 135 | 2 19 3 | May and November | 137½ | .. |
| 87,500 | £10 | 3½% | Liverpool Overhead Railway | 14 14½ | 14 14⅝ | 1 18 7 | — | — | — |
| 10,000 | 10 | 5% | Do. 5% Preference | 16⅜ 16⅝ | 16⅜ 16⅝ | 2 19 3 | — | — | — |
| 118,000 | Stock | 4% | Do. 4% Debenture | 114½ 116½ | 114½ 116½ | 3 10 2 | January and July .. | — | — |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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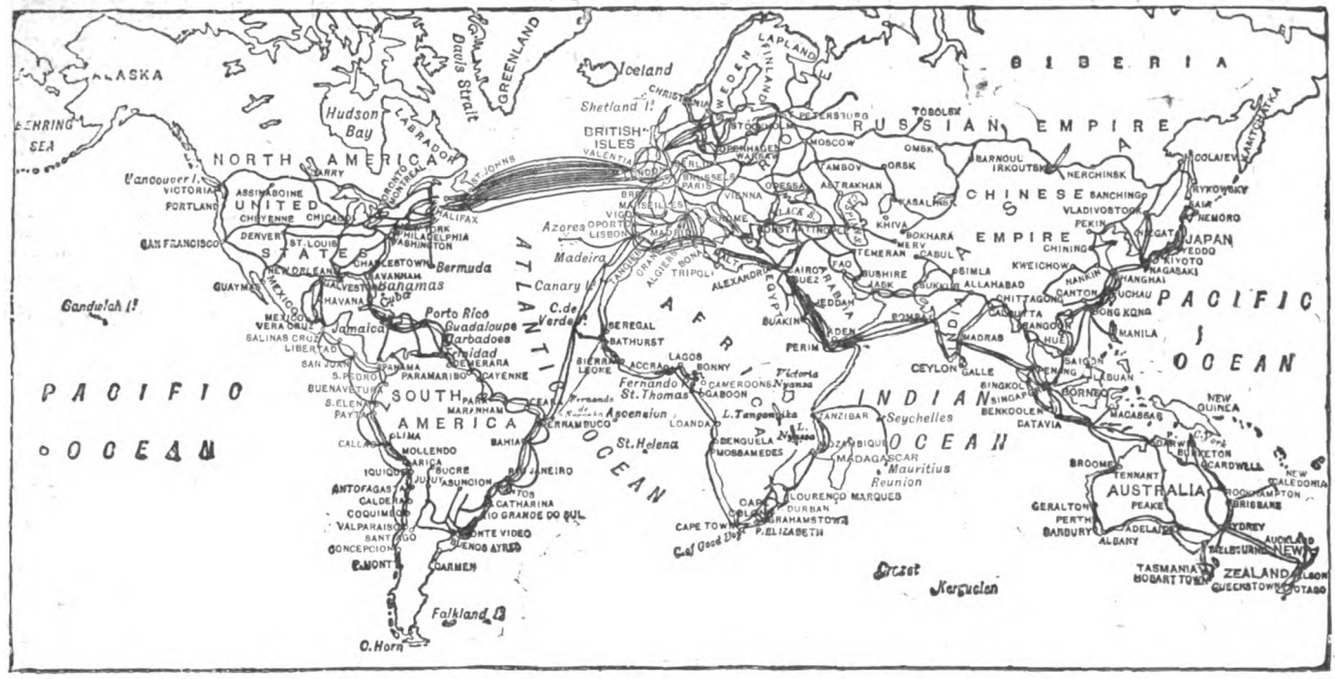


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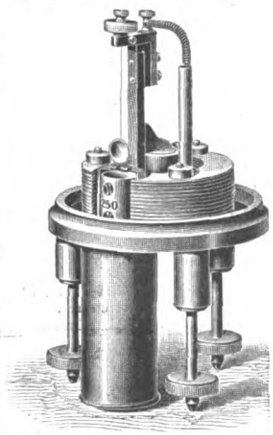

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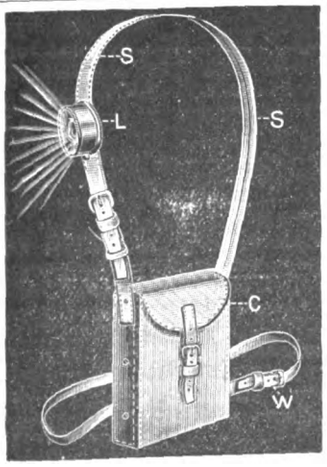


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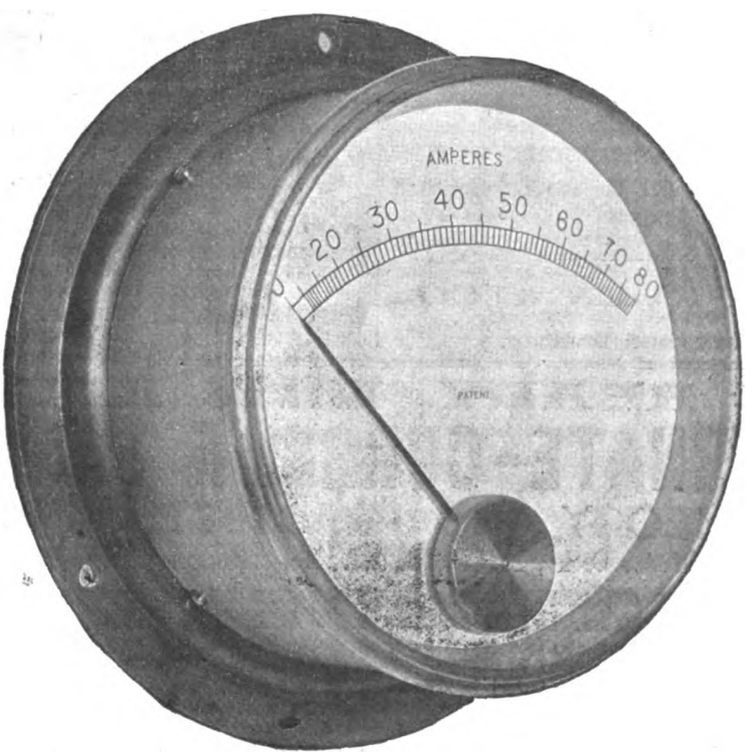


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## PROSPECTUS.

OBJECTS OF THE COMPANY.—This Company was registered on 30th June, 1891, for the purpose of undertaking the supply of Electricity in the County of London, and elsewhere in the United Kingdom.

PREVIOUS ISSUES.—Of the authorised number of 40,000 Preference and 40,000 Ordinary Shares of £10 each, 10,000 Preference and 30,000 Ordinary Shares have been issued, of which the whole of the Preference and 22,475 Ordinary have been subscribed and called up.

PRESENT ISSUE.—The present issue of 10,000 Preference Shares is made in order to provide funds for the further development of the Company's business, and in allotting, applications received from registered holders of the existing Preference and Ordinary Shares of the Company will be preferentially considered.

FUTURE ISSUES.—It is not intended that the balance of 20,000 Preference Shares shall be issued except at a higher premium than that at which the present issue is offered.

CAPITAL EXPENDITURE.—The audited Balance Sheet of the Company at 31st December, 1895, shows Capital Expenditure as follows:—

| | |
|---|---|
| COUNTY OF LONDON STATIONS— | |
| Land, Buildings, Machinery, Plant, Mains, &c. .... | £137,065 3 9 |
| PROVINCIAL STATIONS— | |
| Investments in and Advances to Associated Electricity Supply Companies..... | 156,019 4 2 |
| | £293,084 7 11 |

This figure has been increased by expenditure incurred since the above-mentioned date.

REVENUE.—Dividends at the full rate of six per cent. per annum have been paid on the existing Preference Shares for the year ended the 31st December, 1895, and the Directors consider that the earnings of the Company during the present year will be sufficient to pay the dividend on the Preference Shares, including the present issue.

PARLIAMENTARY POWERS HELD BY THE COMPANY.—The Company holds Provisional Orders, confirmed by Acts of Parliament, for the following districts in the County of London:—

**The United Parish of St. James and St. John, Clerkenwell.**

**The Parish of St. Luke, Middlesex.**

**The District of the Wandsworth District Board of Works, including Parishes of Wandsworth, Putney, Clapham, Balham, Tooting, and Streatham.**

**The Parish of St. George the Martyr, Southwark.**

**The District of the St. Olave District Board of Works.**

COUNTY OF LONDON.—*St. Luke and Clerkenwell.*—In the St. Luke and Clerkenwell Districts the whole of the street work in the compulsory areas has been completed, and the station buildings are far advanced. Applications have been received for the equivalent of 7,000 8-c.p. lamps, of which 6,000 are connected to the Company's mains, and the Directors anticipate that there will be a sufficient number of lamps applied for by the time the station is completed, to ensure a profit being earned from the commencement of working the plant.

*Wandsworth.*—In the Wandsworth District the cables are being drawn in, the transformer sub-stations are in course of construction, and the generating station on the river Wandle is making rapid progress.

The plant now on order for the St. Luke and Clerkenwell and Wandsworth Stations will be capable of supplying 60,000 8 c.p. lamps, and the buildings for these stations will be sufficiently large to accommodate plant of more than double this capacity.

*Camberwell.*—The Company has applied to the Board of Trade for a Provisional Order for other areas in South London, and an Order has been granted for the Parish of Camberwell, subject to confirmation by Parliament.

PROVINCES.—In the Provinces the Company holds controlling interests in the following Electricity Supply undertakings:—

BOURNEMOUTH.—*The Bournemouth and District Electric Supply Company, Limited.*—The station buildings at Bournemouth have been remodelled and enlarged, and considerable extensions of mains have been carried out within the past year. The plant is capable of supplying 27,500 8 c.p. lamps, and connections equivalent to 21,000 8 c.p. lamps have been made.

DOVER.—*The Dover Electricity Supply Company, Limited.*—The Dover station was completed last year, and an uninterrupted supply of current has been given since April, 1895. The plant is capable of supplying 11,000 8 c.p. lamps, and 5,800 8 c.p. lamps are already connected.

RICHMOND, SURREY.—*The Richmond (Surrey) Electric Light and Power Company, Limited.*—Considerable extensions of mains have been made during the past year, and further extensions are now in progress. The plant is capable of supplying 9,500 8 c.p. lamps, and 5,900 are now connected.

CONTRACTS.—Particulars of the Contracts entered into at the time of the formation of the Company are given in the Prospectus dated 28th March, 1894, inviting subscriptions for the first issue of Ordinary Shares of the Company, copies of which Prospectus and of the Contracts therein specified can be seen at the Offices of the Company. Various other Contracts, relating to the business of the Company, have since been entered into. These are too numerous for particulars of them to be given but they can be seen at the Offices of the Company. Every person taking shares under this Prospectus shall be deemed to have had due notice of all such Contracts, and to have waived all rights to further particulars thereof, whether under section 38 of the Companies' Act, 1867, or otherwise. A Contract relating to the present issue, contained in letters dated respectively the 27th, 29th and 30th April, 1896, has been made between the Company and the Electric and General Investment Company, Limited, and the same can be seen at the Offices of the Company.

APPLICATION FOR SHARES.—Copies of the Memorandum and Articles of Association can be seen at the Offices of the Company and of the Electric and General Investment Company, Limited. Applications for Shares must be made on the form accompanying the prospectus and forwarded to the Bankers of the Company with the full amount of the deposit. If no allotment is made the deposit will be returned in full; and where the number of Shares allotted is less than that applied for, the available balance will be applied towards the payment due on allotment, and any excess returned to the applicant.

OFFICIAL QUOTATION.—The Preference and Ordinary Shares already subscribed are quoted in the Stock Exchange official list, and in due course application will be made to include the present issue in the quotation.

Prospectuses and Forms of Application can be obtained from the Bankers, the Brokers, the Electric and General Investment Company, Limited, and at the Offices of the Company.

*7th May*, 1896.

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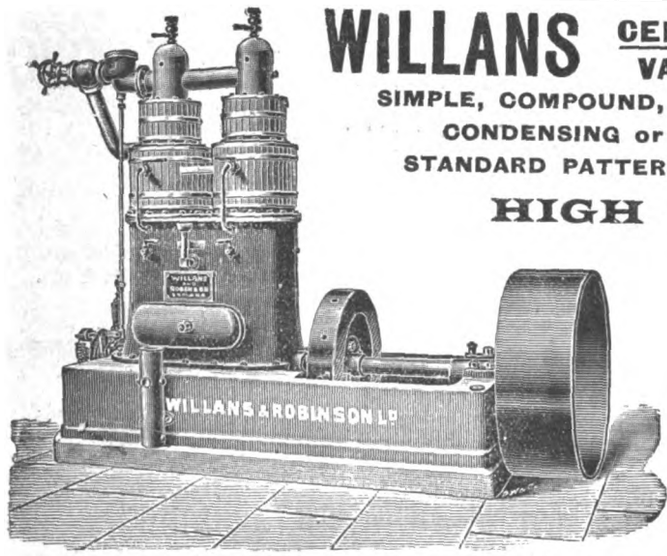


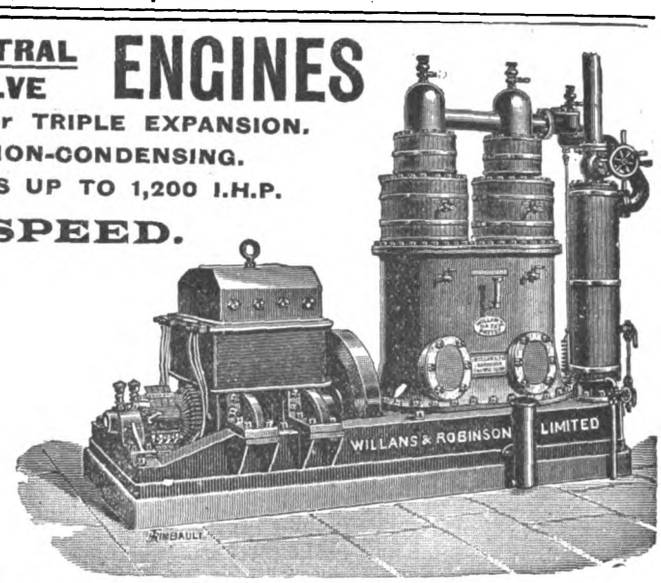


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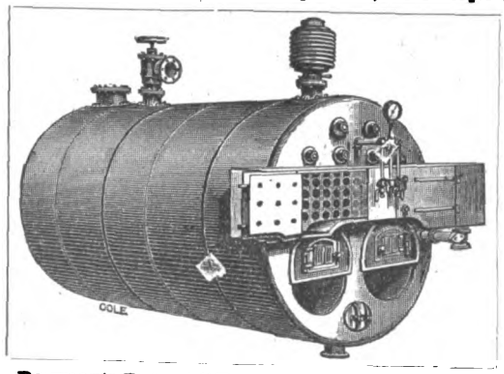


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## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 939. [Vol. No. 3. XXXVII.] FRIDAY, MAY 15, 1896. PRICE SIXPENCE.


## NOTES.

THE Friday evening discourse on "Electric Shadows and Luminescence" delivered at the Royal Institution last week by Prof. SILVANUS THOMPSON was characterised by the prominence given to the vacuum-tube work which led up to the Würzburg professor's great discovery and by the scanty references made to the lecturer's own investigations. It will certainly not be the fault of Prof. THOMPSON if the English public remains opaque to the claims of CROOKES, MÜLLER of Frankfort, LENARD, WIEDEMANN, EBERT and other pre-Röntgenites. The following combination of properties was given as a "test" for X-rays:—(1) They cause phosphorescence; (2) they affect photographic plates; (3) they pass through aluminium; (4) they are *not* deflected by a magnet. This list of idiosyncracies also shows what a very narrow escape X-rays had from being cathode rays, their non-deflectability by a magnet alone differentiating them from the rays which LENARD has investigated so exhaustively.

THE discourse was, it is needless to say, illustrated by a bewildering wealth of experiments. As a good sample we may quote the following:—A sheet of ebonite was electrified, then electrostatically screened, and exposed to X-radiation. On dusting with the usual powdered mixture the discharging action of the rays was shown by the development as a dust-figure of the shadow of an object interposed between the X-ray source and ebonite plate.

WITH regard to Prof. THOMPSON'S own results, he has found that the diamond, although much more transparent than glass, is more opaque than block carbon or graphite. Again, in a Crookes tube he finds that one cannot (unless by a special arrangement just discovered) obtain two shadows of an object by employing two cathodes; whence it follows that *cathode* rays are not mere wave motion. The photographic action of a tube is improved by directing the cathode discharge upon a metal surface or upon an enamel containing lead. Heating the "anti-cathode" is also found to be an advantage. X-rays affect the brush discharge in air of a Wimshurst machine. Perhaps the most scientifically interesting discovery is that the transparency of materials to X-rays is more nearly proportional to their specific heats than to the reciprocal of their atomic weights as announced by Prof. DEWAR. Prof. THOMPSON also lighted upon the fact, unearthed in France by M. HENRY BECQUEREL, and first published by him in the *Comptes Rendus*, that bodies which emit visible rays when shone upon by X-rays emit X-rays when exposed to light.

WHEN, some time since, Prof. AYRTON suggested that if there was a back electromotive force in an electric arc the resistance ought, in certain conditions, to be negative, the not unnatural suggestion met with a good deal of ridicule. In a Paper on "The True Resistance of the Electric Arc," by Messrs. J. FRITH and J. RODGERS, read before the Physical Society last Friday, it was shown that when both the carbons are solid the ratio $d\,V/d\,C$—where V is the impressed voltage, and C the current in the arc—is always negative; while when cored carbons are used it is always positive. The authors of this Paper have called this ratio the true resistance of the arc, and certainly, if this definition is disputed, it is difficult to see what other ratio to settle upon. Obviously, to take the ratio of V to C would beg the whole question of a back electromotive force in the arc, and is quite inadmissible. Nor can we take the V – C curve back to the origin, since an arc is impossible over so wide a range. Nor, again, can we deal with any considerable amount of the possible curve, since every point on it corresponds to a *different* arc. The only resource is to take the rate of change of V with respect to C; and, oddly enough, this never was challenged so long as the result gave a positive value. It is only when the apparently anomalous "negative resistance" is the conclusion forced that any doubt seems to arise.

IT has been argued that a negative resistance is a physical impossibility. To this the authors of the Paper and Prof. AYRTON pertinently reply that so is the electric arc *solus* an impossibility. Mrs. AYRTON has shown that when a fixed potential difference is forced on the carbon ends there is a condition of instability in which a steady arc is impossible. Only when a certain amount of "steadying resistance," sufficient to over-balance the negative resistance of the arc itself, is placed in series with the arc, will the arc continuously and steadily exist. Apparently the corollary to a negative arc resistance is a back electromotive force. For, if the true resistance of the arc is wholly and really negative, the $C^2 R$ loss in overcoming it must also be negative. In other words the true resistance must *absorb* heat, by some obscure endothermic action. But there is a large amount of heat actually and positively generated in the arc, and since this is not generated in overcoming resistance, the only conceivable other way in which it can be developed is by a back electromotive force.

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THERE is something very refreshing in the breeziness of the discussion on Mr. BARNETT's Paper on "The Evolution of the Storage Battery," of which we publish an abridged report this week. As far as possible the phraseology of the original has been retained, and condensation has been effected by omitting unnecessary repetitions and amplifications. After the more or less set debates to which we are accustomed at the Institution of Electrical Engineers, and the guarded tone usually adopted by the speakers, it is a distinctly novel sensation to see men thus fearlessly plunging into the troubled electrolytic waters of the lead cell. There is one point in the Paper which arrests attention at once, and that is, there are no curves. This is a distinct innovation, and one to be rather commended in this connection, for of curves we have had no end, but very little explanation as to the inward and chemical changes of which the physical phenomena are but the outward and visible sign. It is somewhat startling to be told that lead sulphate is an electrolyte, for it has always been considered an axiom in this country that an electrolyte must be a fluid, and further it is difficult to see how the current could pass from one cell to the other without electrolysing the acid, and we must believe in this impossibility if we are to accept LEIBENOW's hypothesis as propounded by Mr. REED. Lead sulphate is only sparingly soluble in sulphuric acid, and though in time the sulphate formed on the plates during discharge might be dissolved in the acid, this would result in the electrolysis of the lead sulphate solution, and not in the conversion of the sulphate on the plates into peroxide of lead and spongy lead respectively, and it is these latter reactions which occur in practice.

WITH regard to the discussion as to the electromotive force as determined from the heat-equivalents of the chemical reactions occurring in the cell, one of the objections to the sulphate theory has always been that on this hypothesis the calculated electromotive force works out a little below that observed in practice, and considerably below that of a briskly charged cell; but when one considers the difficulties involved in the determination of the heat of formation, it is unreasonable to expect an exact agreement between the calculated and observed electromotive forces. On the assumption that the sulphating of the plates which takes place during discharge is due to the abstraction of $SO_4$ from acid of the strength contained in the cell, the calculated electromotive force is usually given as about 1·98 volt, but if we assume that the $SO_4$ is taken from concentrated sulphuric acid, then we get an electromotive force considerably too high. The fact that the acid cools during discharge has considerable influence on the question, and appears to show that the formation of lead sulphate takes place, not at the expense of acid of the concentration next the material undergoing change, but at the expense of free molecules of $H_2SO_4$ present in the acid liquid, the withdrawal of which conditions the appearance of a fresh supply. Chemical energy, which appears as sensible heat, cannot also produce electrical energy, but this is a point which is often overlooked in discussing the chemistry of accumulators.

SOME doubt has also been cast, from time to time, on the identity of the electrolytic lead peroxide with that produced by active chemical process. Mr. DESMOND FITZGERALD has always urged that the former is some hydrated peroxide; and there are experiments on record which show that the electromotive force yielded by a couple formed between lead and ordinary peroxide is not so high as that yielded with electrolytic peroxide. But this may be due to the effect of the support in the former case, for it is well known that the effect of the latter must be eliminated by having a dense and adherent coating of lead peroxide. It is noteworthy in this connection that in electrolytic methods for the determination of lead as lead peroxide it has been found necessary to dry the peroxide at about 150° C., or else the results obtained are inaccurate, and this inaccuracy is supposed to arise from the product being a hydrated peroxide.

PRIOR to 1891 the action of the battery was ascribed solely to the formation of sulphate on both plates during discharge, which sulphate was during charge converted into peroxide of lead on the positive plate, and spongy lead on the negative plate; and no account whatever was taken of any other effects of electrolysis on the acid in the cell. But in this year Mr. ROBERTSON advanced the persulphuric theory which has found such a warm advocate in Mr. BARNETT. This theory was based on the fact that persulphuric acid and its decomposition product, hydrogen peroxide, were found present in the acid of every cell examined, but in those cells which contained sodium sulphate in the acid the characteristic peculiarities of the lead cell were less marked, and at the same time, the amount of the oxidised bodies in the acid was reduced. Cells containing this solution also suffered less on rest. In the following year Messrs. GLADSTONE and HIBBERT brought forward what may be styled the hydrate theory, by which the variations in electromotive force observed on breaking the charging or discharging circuit, the high initial electromotive force, and the sudden fall at the end of discharge with the corresponding rapid recovery, were all accounted for by the variations in the density of the acid *next* the plates which take place during the working of the cell. At the end of charge the acid next to and in the positive plate is very concentrated, and the electromotive force is correspondingly high, while at the end of discharge the rapid weakening of the acid which takes place at both plates produces a rapid lowering, and the diffusion of the acid when the current is stopped accounts for the recovery of the cell. Thus the electromotive force of the cell depends upon the hydrate of sulphuric acid which is next the electrodes at any given moment, and the electromotive force developed is, therefore, a function of the concentration of the acid.

FEW persons nowadays believe in the sulphate theory in its original simple form, so that for practical purposes we may say that there are now only two theories in vogue respecting the working of lead batteries; according to the one, the working of the cell depends on the products of electrolysis formed in the acid, and those products vary somewhat with its concentration. According to the other, the electromotive force of the cell is due to the strength of the acid or the hydrate which is next the plates at any given moment. These rival theories will be found fully set forth in Messrs. GLADSTONE

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and HIBBERT'S Paper "On the Causes of the Changes of Electromotive Force in Secondary Batteries," and the reply thereto by Dr. H. E. ARMSTRONG and Mr. G. H. ROBERTSON, read before the Institution of Electrical Engineers in May, 1892. Whichever theory be right, there can be no longer any doubt that persulphuric acid *is* formed very frequently, if not always, in the working of secondary batteries, and this is a point about which considerable scepticism was felt when Mr. ROBERTSON published his work. At that time a small anode and high current density were considered necessary for its production, probably because MCLEOD had observed these conditions in his experiments carried out on the electrolysis of sulphuric acid solutions of different strengths in 1886. As our columns show, the formation of persulphuric acid has been noted not only in the case of secondary batteries, but in that of industrial operations involving the electrolysis of sulphuric acid; and though its mere presence does not prove that it is necessary to the working of the process in which it is formed, still it is an endothermic compound which must therefore occasion loss of energy in its formation, and its decomposition product, hydrogen peroxide, cannot fail to be deleterious. It seems highly desirable, therefore, that the conditions which determine the production of persulphuric acid during electrolysis should be carefully studied with a view to its elimination or diminution.

**Sir John Pender.**—Tuesday's *London Gazette* contains a notification that Sir John Pender, G.C.M.G., M.P. for the Wick Burghs, has accepted the Chiltern Hundreds.

**City and Guilds of London Institute.**—Particulars will be found in another column of the sessional course of instruction in engineering and chemistry, &c., for session 1896-97.

**The P.Q. Atlantic Cable System.**—The "Seine" has completed the first repair in this system and proceeded to the locality of the deep water break on the other side of the ocean.

**Dynamo and Transformer Construction.**—A course of lectures to the senior students of the Electrical Standardizing Institution will be given by Mr. James Swinburne, on "Dynamo and Transformer Construction," commencing June 2nd.

**The Pacific Cable Conference.**—Mr. H. W. Mercer, one of the private secretaries to Mr. J. Chamberlain, has been appointed secretary to the conference to be held at the Colonial Office to discuss the scheme for laying a cable *viâ* Canada to Australia.

**The Hopkinson Three-Wire Patent.**—The Judicial Committee of the Privy Council have fixed July 15th as the date for hearing the application for the prolongation of the Hopkinson three-wire patent, No. 3,756 of 1882, now owned by the Westinghouse Company.

**The Toronto Meeting of the British Association.**—The Council of the British Association have, says *Nature*, resolved to nominate Sir John Evans, K.C.B., treasurer of the Royal Society, for the presidency at the meeting which will be held next year in Toronto.

**Hungarian Honours.**—Among the recipients of honours from the Budapest University, on the occasion of the celebration of the Hungarian millenium, were Lord Kelvin, Sir Joseph Lister, Herbert Spencer, M. Berthelot, Prof. Virchow, Prof. H. Sidgwick, and Prof. Max Müller.

**A Double-Distilled Doctor.**—The Vienna correspondent of a daily paper solemnly asserts that among the scientists to receive honorary doctorates from the Budapest University, on the occasion of the Hungarian millenium, were "Lord Kelvin (London), and Sir William Thomson (Glasgow)"

**Obituary.**—We regret to record the death last week of Mr. J. A. Kingdon, whose name will be known to many readers of *The Electrician* in connection with an "inductor" alternator. Mr. Kingdon was a frequent contributor to the technical press, and recently written a work on "Applied Magnetism."

**Cable Interruptions and Repair:—**

| | Date of Interruption | Date of Repair. |
|---|---|---|
| Shanghai—Nagasaki ..... | May 5, 1896 ... | May 7, 1896 |
| Puerto Plata—Martinique..... | Dec. 19, 1895 ... | — |
| Ceara- Maranham ..... | April 28, 1896 ... | — |
| San Thomé—Loanda ..... | May 2, 1896 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | —• |

**New York-Haiti Cable.**—The manufacture of the New York-Haiti cable has been commenced at the works of the Société Industrielle des Téléphones at Calais. This cable will place Brazil, Dutch Guiana, French Guiana and the French West Indies generally in communication with France, by what is virtually, if not in effect, an all French line.

**Tramway Bills.**—In the House of Lords on Monday last Lord Tweedmouth moved:—"That Standing Order 133A, relating to tramway Bills, be suspended for the remainder of the Session." He explained that the Standing Order was one which prohibited or impeded the consideration of clauses in that House empowering corporations to work their own tramways.

**Royal Institution.**—The Duke of Northumberland, President of the Royal Institution, has appointed the following Vice-Presidents for 1896-97:—Sir Frederick Abel, Lord Kelvin, Mr. George Matthey, F.R.S., Mr. Ludwig Mond, F.R.S., Earl Percy, Mr. Basil Woodd Smith, Sir James Crichton-Brown (treasurer), and Sir Frederick Bramwell (hon. secretary).

**Analyses of British and Foreign Coals.**—In the March number of *Electrical Engineering*, of Chicago, there is an extensive table giving analyses and calorific values of a large number of American and European coals. This table covers some 21 pages, and should form a useful work of reference for engineers interested in the use of coal. We should add that 17 pages of the table are exclusively devoted to United States coals.

**Appointments Vacant.**—The Committee of the City and Guilds of London Institute invite applications for the Professorship of Mechanical Engineering and Applied Mathematics at the Technical College, Finsbury, E.C. Salary £600 per annum. Applications must reach the Hon. Secretary, City and Guilds of London Institute, Gresham College, E.C., by June 8th.——The Governors of the Northern Polytechnic Institute, Holloway, invite applications for the position of Head of the Physics and Electrical Engineering Department. Commencing salary £250 per annum. Further particulars appear in our advertisement columns.

**Progress of Electric Traction in America.**—Commenting on the statistics of European electric traction systems, which were published recently in *l'Industrie Electrique*, our contemporary, the *Electrical Engineer* of New York, remarks that, notwithstanding "the marvellous rapidity with which electric traction was adopted in the United States . . . it has taken practically ten years to convince Europe that the horse could no longer compete for dividends with the trolley." Our contemporary adds the following table of statistics of traction systems in the United States:—

| | Miles. |
|---|---|
| Length of electric track ..... ..... ... | 10.363 |
| Length of horse track ..... ..... ..... | 1,914 |
| Length of cable track ..... | 632 |
| Length of miscellaneous track ..... | 679 |
| Number of electric cars ..... | 24.745 |
| Number of electric roads..... | 976 |

**A Novel Method of Utilising Water Power.**—Particulars of a new method of utilising the power of falling water are given, as follows, in the *Mining and Scientific Press*:—

The essential principal involved is the compression of air by the force of the falling water, and the compressed air used to drive motors at the falls or be transmitted to a distance for the same purpose. From a tank or a standpipe, in which the water stands at the same level as above the dam, the water is permitted to pour down a pipe, around whose base are a number of holes, admitting air from tubes running up to the surface of the water. The air is sucked in and compressed by the water, and the two are automatically separated by gravitation, the air passing into a storage or supply chamber. The incredible statement is made that from 70 to 80 per cent. of the latent energy in the falling water can be rendered available in this manner. This is no more than a turbine yields, but the latter cannot

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transmit its energy to a distance without the interpolation of dynamos and motors, in which some loss of power occurs. It is said a plant operating on this principal is to be installed at the Dominion Cotton Mills in Magog, near Montreal.

**Royal Society Selected Candidates.**—Amongst the 15 candidates selected for admission into the Royal Society this year we note the name of Prof. Andrew Gray. He was born at Lochgelly, Fifeshire, in 1847, and received his higher education at the University of Glasgow. Prof. Gray was for some time private secretary and experimental assistant to Lord Kelvin. While serving in this capacity Prof. Gray had for a short time as a fellow student Prof. J. Perry, and assisted in the carrying out of the greater part of Lord Kelvin's researches on "The Effects of Stress on Magnetisation." In 1880 Prof. Gray became official assistant to Lord Kelvin, and in 1884, on the foundation of the University College of North Wales at Bangor, he was appointed professor of physics, a post which he still holds. The following are some of the contributions of Prof. Gray to contemporary science:—A well-known book on "Absolute Measurements in Electricity and Magnetism," a Paper communicated in 1883 to the *Philosophical Magazine* on "The Determination in Absolute Units of the Intensity of Powerful Magnetic Fields"; communications on "The Dynamical Theory of Electro-Magnetic Action" and "On the Calculation of the Induction Coefficients of Coils," also made to the same magazine. Prof. Gray is a Fellow of the Society of Edinburgh, and a member of the Physical Society. He is Examiner in Mathematics and Natural Philosophy for Degrees in Arts in the University of Glasgow and in Physics for Degrees in Medicine for the same University.

**Applied Electro-Chemistry.**—Before dealing with the main subject of his third Cantor lecture, Mr. Swinburne referred to the electrolytic recovery of tin from scrap. His own experience had been that it was easy enough to do this in a solution of hot caustic, but *the* difficulty was to find the scrap from which to skin the tin; no one seemed to have any for sale. Coming then to the electrolysis of fused salts Mr. Swinburne remarked that the importance of the process was generally overlooked, it was forgotten how immensely greater the conductivity of fused electrolytes was as compared with that of ordinary ones. The primary batteries, with fused electrolytes as generally described, would not work. Turning to the electrolysis of fused common salt the lecturer pointed out the great complexity of the Leblanc process, in which there were six or eight oxidising and reducing steps to procure the final result Na and Cl. The real difficulty in the electrolysis of NaCl was not the anode or the cathode, most kinds of carbon did fairly well as anodes and any material nearly did as cathode; *the* problem was how to collect the products of electrolysis. Another puzzle was the small amount of sodium obtained. Some suspected a sub-chloride was formed. Examining salt left on the electrode under the microscope it was seen to contain a number of black specks, and on placing it in water gas was given off; this looked as if the sodium were not deposited right on the electrode but in its vicinity, and a lot consequently got carried away. A caustic soda process proposed by Vautin was then described. The principle of this ingenious process is to use fused lead as a cathode to the fused salt, the sodium forming an alloy with the lead which, in the presence of water, yields up the sodium, forming caustic. The lecturer pointed out that in dealing with chlorine by the *wet* electrolytic process, using carbon electrodes, a certain quantity of $CO_2$ was formed and passed off with the chlorine gas into the lime, forming chalk instead of bleach. Allusion was then made to the commercial possibilities of the electrolysis of fused lead chloride, of "fractional" electrolysis of mixtures of fused salts, and to the Hoho process of electrically heating metals under water.

**Third Congress of Chambers of Commerce of the Empire.**—The Council of the London Chamber of Commerce decided, early in 1895, to summon a Third Congress of Chambers of Commerce of the Empire for 1896. Since that time arrangements for the meeting have been continuously in progress, under the charge of the Organising Committee. In its Honorary President the Congress has the influential support of the Secretary of State for the Colonies, who has, by his despatch to the Colonial Governors, and by becoming Honorary President of the Congress, manifested a sincere desire to do everything in his power to promote the success of the gathering. The Council, after conference with Mr. Chamberlain, have selected the week commencing June 8th for the meetings of the Congress. Through the courtesy of the Master Wardens and Court of Assistants of the Worshipful Company of Grocers, the Hall of that Company (Princes'-street, Bank) has been placed at the disposal of the Chamber for the week June 8th-13th, and the business proceedings will open there on Tuesday, June 9th. As far as accommodation permits, members will be afforded an opportunity of being present during the debates. An appeal is made by the Council and the Organising Committee for financial support. Without such support they will be unable to receive and entertain the delegates to, and the distinguished personages who have associated themselves with, the Congress, in a manner either fitting to the character of their guests or creditable to the City of London. The following arrangements have already been made:—Monday, June 8th.—Visit to the East London Trades, Industries and Arts Exhibition (People's Palace). Tuesday, June 9th.—Official Welcome of the Delegates, at 10 a.m., by the Secretary of State for the Colonies in the Hall of the Grocers' Company; Evening Reception by the Right Honourable the Lord Mayor at the Mansion House. Wednesday, June 10th.—Second Meeting of the Congress, 10 a.m. to 4 p.m.; Banquet to Delegates in the King's Hall, Holborn Restaurant, the Right Hon. Joseph Chamberlain, M.P., to preside. Thursday, June 11th.—Third Meeting of the Congress. Friday, June 12th.—Fourth Meeting of the Congress. Saturday, June 13th.—Garden Party by the Right Honourable the Earl of Jersey, G.C.M.G. (late Governor of New South Wales) at Osterley Park, Isleworth. Official Reception, in the evening, at the Imperial Institute, by the Right Hon. Joseph Chamberlain, M.P., and Mrs. Chamberlain, to have the honour of meeting His Royal Highness the Prince of Wales.

**Contemporary Electrical Science.**—An important question connected with the forbidding subject of electric execution is discussed by G. Darin in *L'Eclairage Electrique*. It is as to whether life can be pronounced extinct when no organic lesions are discovered which under ordinary circumstances would be sufficient to cause death. According to the late M. Brown-Séquard and M. d'Arsonval, the administration of alternate currents of high frequency causes stoppage of respiration and syncope. But death may be only apparent, and the victim may be restored by artificial respiration. Only in two cases out of 26 executions do the official reports state that intercranial effusions of blood were found which would ensure death. But, nevertheless, the physicians always declared death to be absolute. The author believes that the only satisfactory test for death is an unsuccessful attempt at restoration. In the same number A. Righi writes further on the globular discharge which he has succeeded in imitating by means of a large condenser discharging through a very high resistance. In a rarefied gas discharges may be obtained lasting several seconds. The globes start from the positive electrode, increase in size, and move slowly towards the cathode, but never reach it. They can be easily followed with the eye or photographed.——M. Ascoli, in the *Nuovo Cimento* describes some interesting magnetic experiments giving quantitatively the amount of disturbance caused by a magnetic substance when placed in a uniform magnetic field. He finds that there is perfect continuity in the components of the external and internal fields, and that the outermost skin of the magnetic substance exerts no superficial protective action upon the inner layers.——A Paper on X-luminescence, by which name the fluorescence produced by Röntgen rays is known in Germany, is contributed to the *Zeitschrift für Electrochemie* by W. Arnold. He finds that Lenard rays and X-rays may have very different effects. Salts of manganese, lithium, cadmium and strontium, which are so very sensitive to Lenard rays, are quite indifferent to X-rays. So is $CaSO_4$, with an admixture of $MnSO_4$, Lenard's chief fluorescent substance. The best substance for X-luminescence is scheelite, a tungstate of calcium. This may be obtained artificially by making a "solid solution" of copper tungstate in calcium tungstate.

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## THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 10.*)

*The Weston Circuit Tester.*—This is an instrument designed to indicate the condition of the mains of a two-wire network on the principle just described. It is actually a voltmeter of about 30,000 ohms resistance, giving readings to both sides of the scale; the scale is equally divided throughout its range. The positive and negative mains are connected to the two binding-screws marked + and − (Fig. 1), and there is a binding screw not seen on the drawing to connect to earth. This

FIG. 1.

latter is one terminal of the voltmeter. On depressing the left-hand key the other voltmeter terminal is connected to the + main; on depressing the right-hand key this terminal is connected to the − main. The connections are shown diagrammatically in Fig. 2. There is, of course, a contrivance to prevent both keys from being depressed at the same time.

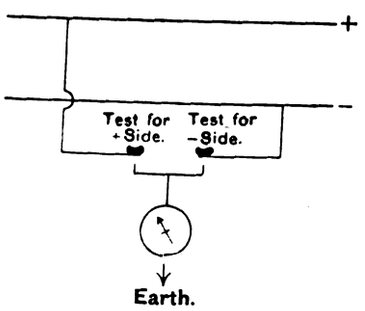


FIG. 2.

The two readings are relatively proportional to the fault resistances of the two mains. The actual value of the fault resistances can be calculated by the formula (10) already given, viz.:

$$f_1 = \frac{g\{V-(d_1-d_2)\}}{-d_2},$$

$$f_2 = \frac{g\{V-(d_1-d_2)\}}{d_1}.$$

$d_1$ and $d_2$ being always to opposite sides of the scale, the two deflections must be added to give $d_1 - d_2$.

Owing to the high resistance of the instrument this calculation of the fault resistances will not be accurate except for networks of high insulation resistance—of a thousand ohms or so. In networks of lower insulation resistance the expression $d_1 - d_2$ will be nearly equal to V, so that $V-(d_1-d_2)$ will only be obtained to a small degree of accuracy. The two readings are, however, relatively proportional to the fault resistances of the two mains, whatever the resistance of the voltmeter. The instrument is on the d'Arsonval principle, similar to other instruments of the Weston manufacture. The resistance of the moving coil itself is only a few ohms, the high resistance being simply a dead resistance placed in series with it. If this resistance were replaced by two lower resistances, one in series with, and the other shunting the moving coil, so as to make the resistance between the terminals more nearly equal to the resistance to be measured, the instrument would be more useful. It could then be used with advantage on networks of moderately high insulation resistance—say of 50 or 100 ohms and upwards—and on three-wire as well as on two-wire networks. The equally-divided scale is a very good feature.

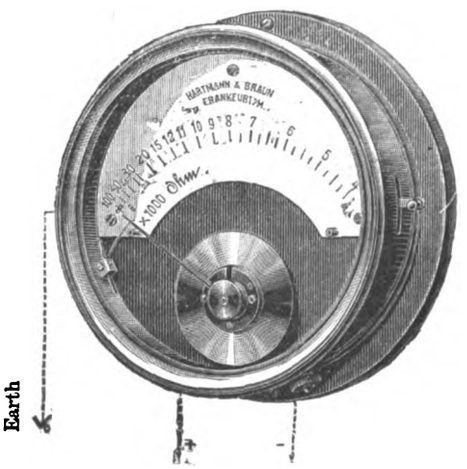


FIG. 3.—Hartmann and Braun's Leakage Indicator. One-fourth full size.

*Hartmann and Braun's Leakage Indicator.*—This is also intended for use on a two-wire network of high-insulation resistance. Fig. 3 is a drawing of the instrument and Fig. 4 is a diagram of its connections. The lever switch on the

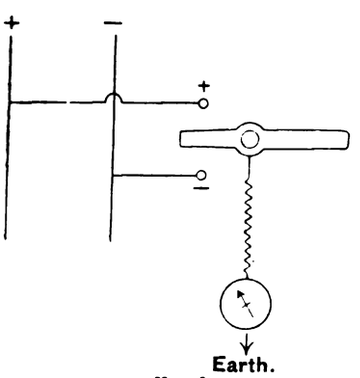


FIG. 4.

instrument is first put in the position + (Fig. 4) and then to −. If a deflection is obtained in one of these positions only, the resistance shown will be the fault-resistance of the opposite main. That is to say, if when the lever key is on + there is a reading 5 on the scale, and when the lever key is at − the needle remains at the mark $\infty$, the fault resistance of the negative main is 5,000 ohms, and that of the negative main is high in comparison. If deflections are obtained in both positions of the switch, the fault resistances of the mains are not equal to the readings, but must be calculated from the following formulæ:—

$$\left.\begin{aligned} f_1 &= d_2 - \frac{d_2+g}{d_1+g}\cdot g \\ f_2 &= d_1 - \frac{d_1+g}{d_2+g}\cdot g \end{aligned}\right\}, \quad \ldots\ldots \quad (15)$$

$d_1$ and $d_2$ being the readings, and $g$ being the resistance of the instrument.

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

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The "leakage indicator" is made for a variety of pressures from 65 volts upwards. The 110-volt instruments have a resistance of about 1,000 ohms, and scale readings from 100,000 to 4,000 ohms.

It is, therefore, only in special cases that the low-pressure type of this instrument can be used.

*Method 2.**—A voltmeter or milliampere-meter is used whose resistance is high compared with the insulation resistance of the mains, and which gives readings to both sides of zero; or any galvanometer of high resistance whose readings are proportional to the currents through it. (The instrument need not be direct-reading.) This is connected between one main of the network and earth (Fig. 5A), and a reading $d_1$ is obtained. Then the instrument is shunted by an adjustable resistance $s$ (Fig. 5B), which is adjusted until the new reading $d_2$ is half of $d_1$. Then *$s$ will be equal to the insulation resistance of the network.*

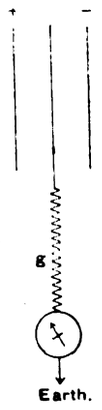


FIG. 5A.

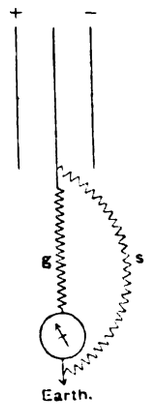


FIG. 5B.

If $s$ cannot conveniently be made small enough, $d_2$ can be made $= \frac{2}{3}\, d_1$; then $F = \frac{s}{2}$.

Or $d_2 = \frac{3}{4}\, d_1$; then $F = \frac{s}{3}$, &c., &c.

The equation connecting $d_1$, $d_2$, $s$, F and $g$ is

$$\frac{1}{F} = \frac{d_2}{(d_1 - d_2)\, s} - \frac{1}{g}. \quad . \quad . \quad . \quad . \quad (16)$$

It is therefore convenient to make $g$ so large that $\frac{1}{g}$ can be neglected, and then simply

$$F = \frac{d_1 - d_2}{d_2}\, s, \quad . \quad . \quad . \quad . \quad . \quad (17)$$

which gives the rule above.

In three or five-wire networks of moderately high insulation resistance—say about 100 ohms—this method is very practical. Then the instrument should be connected between the middle wire and earth, and the resistance $s$, with which it is shunted to obtain the second deflection, can be an ordinary resistance-box if the test be quickly made. A resistance coil must be put in series with the instrument, if necessary, to fulfil the condition that the instrument resistance is great compared with the insulation resistance to be measured.

In the diagram, Fig. 5B, such a resistance has been inserted. The position of the shunt coil in the diagram must be noted. It is not in this case connected to the galvanometer terminals, but shunts the series coil and galvanometer together.

The actual error in the measured insulation resistance, introduced by neglecting the effect of the galvanometer resistance, can be seen by applying equation (16); but it should be remembered that, though the error in the actual calculated insulation resistance may be appreciable, the relative error in comparing the tests of two different days is small.

If the fault resistances of the positive and negative sides of a three-wire network are nearly equal (or in a five-wire network if the equation (14) be nearly satisfied), only a small reading will be obtained when the instrument is connected to the middle wire. The readings can then be obtained from either of the other mains, but in that case special resistance coils designed to stand larger currents must be used for $s$, as the coils of an ordinary resistance box would be damaged by the larger currents. Such coils capable of standing larger currents must also be used when this method is employed on two-wire networks, or on three and five-wire networks of lower insulation resistance.

When the test indicates a drop in the insulation resistance of the network, it is easy to see whether the fault has occurred on the positive, negative or neutral main, if the testing has been done on the middle wire. If the current flowing through the instrument *from* the network *to* earth be considered as giving a + deflection, a fault in the positive wire will diminish the deflection if +, and augment it if −; a fault in the negative wire will have the opposite effect. A fault in the middle wire will only slightly diminish the deflection, though the value of $s$ will be diminished.

FIG. 6A.

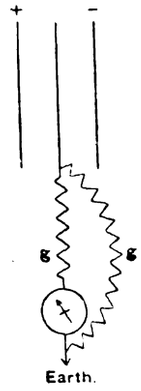


FIG. 6B.

So as to order a milliampere-meter or voltmeter for this test, the value of $d_1$ may be predetermined if the fault resistances of the several mains be known. If a milliampere meter be used the current can be calculated from one of the equations (11) to (13). The $d_2$ in these equations gives the current when the instrument is connected between the middle wire and earth, and is not shunted. If a voltmeter be used, V must be substituted for $\frac{V}{g}$ outside the bracket in these equations. If $g$ is going to be made high, so as to have a practically direct-reading method, $\frac{1}{g}$ can be neglected in the fractions inside the brackets.

*Method 3.*—This is a modification of the preceding method. An ammeter or voltmeter is connected between one of the mains and earth as in Method 2, and the reading $d_1$ is taken (Fig. 6A). Then the instrument is shunted by a resistance exactly equal to its own resistance, and the reading $d_2$ is noted (Fig. 6B). The insulation of the network is calculated from the formula

$$F = \frac{d_1 - d_2}{2d_2 - d_1}\, g \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

This method is suitable for networks with high or low insulation. The formula, though simple, is absolutely correct, and not an approximation, and applies whether a voltmeter or ammeter has been employed, or a galvanometer (which need not be direct-reading, but must give deflections proportional to the current through it).

The instrument to choose for this test should be one of resistance about equal to the insulation resistance of the network, or, if one of lower resistance be employed, a resistance coil should be added in series with it. Then $d_2$ will be about two-thirds of $d_1$.

An ammeter or milliampere-meter will be found most convenient for networks which have not very high insulation resistances. To ascertain the range to order for the instrument the value of $d_1$ may be calculated from one of the equations (11) to (13). The $d_2$ in these equations will give the current if the ammeter is to be connected between the middle

* This method is due to Dr. O. Frohlich, of Berlin. *E. T. Z.*, January 27, 1893, and *The Electrician*, February 10, 1893.

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wire and earth, as in Fig. 6A. If a voltmeter be used instead of an ammeter, V must be substituted for $\frac{V}{g}$ outside the bracket in these equations.

A hot-wire voltmeter will not give accurate results if used for testing by this method or Method 2, for reasons already explained.

If the instrument is connected to the middle wire, on a fault occurring it is possible to see at once on which main it is, as shown in the consideration of Method 2. If the fault has occurred on the middle wire the absolute values of $d_1$ and $d_2$ will not alter so much as when a like fault occurs on one of the other mains.

The tests for this method may be made on any of the mains of the network, though for the sake of convenience the use of the middle wire is preferable when possible.

In cases where the fault resistances of the positive and negative sides of the network nearly balance one another, it is still possible, by a simple expedient, to obtain the readings from the middle wire. A resistance of known value is connected, as an artificial fault, between one of the other mains and earth (Fig. 7), and so destroys the balance.

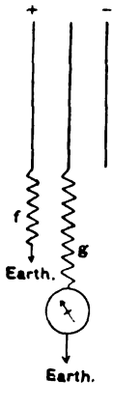

FIG. 7A.

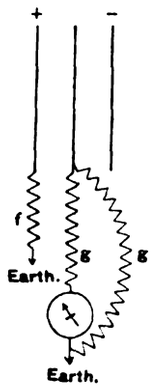

FIG. 7B

Then the insulation resistance F′ is calculated from the formula (18), and the real fault resistance of the network is obtained by the formula

$$\frac{1}{F} = \frac{1}{F'} - \frac{1}{f} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

where $f$ is the resistance of the artificial fault.

*(To be continued.)*

## ELECTRIC TRANSMISSION OF POWER FOR A PAPER MILL AT ROMAGNANO.

An interesting application of electric polyphase transmission to the driving of paper-making machinery has been carried out by the Vonwiller Company to supply power to its large paper mill in Romagnano-Sesia (Italy), the power being derived from a waterfall 5 kilometres distant. The plant, the capacity of which amounts to 810 H.P., was installed by the direction of Messrs. Brown, Boveri and Co., of Baden (Switzerland), and has now been in successful operation for over a year. A general test of its commercial working was executed by Mr. A. Nirrola, who has recently published a complete description of the whole installation giving the results obtained in testing. We quote from his Paper the data of most interest.

The power station is driven by a waterfall on the river Sesia, near Giarola, having a capacity of 8 cubic metres of water per second, and a fall of 10·5 metres. Three vertical Bell turbines of 270 H.P. each have been installed, and drive at 180 revolutions per minute three 195-kilowatt Brown two-phase alternators direct-coupled to the turbines.

The alternators (Fig. 1) consist of a fixed external ring armature and an internal revolving inductor, with radial projecting poles. No winding is visible on the exposed surface of the armature, the active conductors being all embedded in longitudinal holes just near the internal surface. The formation of eddy currents in pole-pieces is thus avoided, and these may be constructed of massive metal. The inductor, of steel casting, is umbrella-shaped, and is wound with 28 poles, half of which are cast with the frame, the other half being secured by bolts; the latter only carry the winding coils, room for which is provided by concavities contrived in the side surfaces of the former ones, such disposition, which constitutes the subject of a patent by Mr. Brown, having the advantage of permitting the employment of cylindrical coils without loss of space. Another peculiarity of the machine is the situation of both bearings supporting the main shaft below to the inductor body, the arrangement adopted being intended to simplify the construction and to facilitate repairs and taking out of the

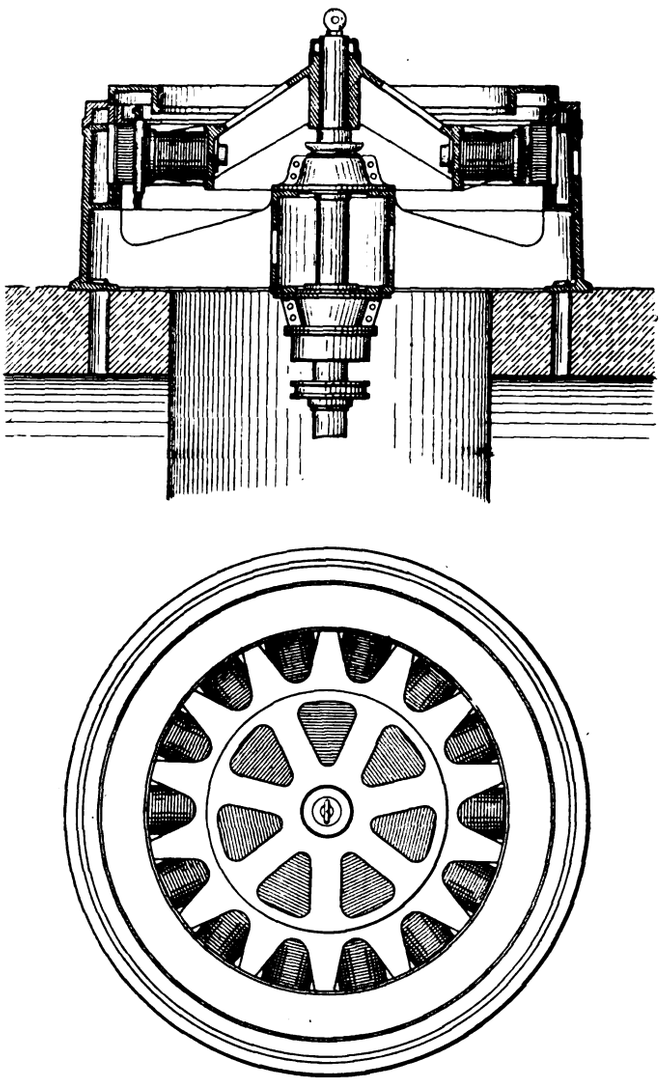

FIG. 1.—Vertical Section and Plan of 195-kilowatt Two-Phase Brown Alternator.

working parts. The exciters of the alternators are two Manchester dynamos, one of which is intended as a reserve; these are fixed in vertical position to the wall, and are driven, at 500 revolutions, by two direct-coupled 25 H.P. turbines.

A *two-phase* system of transmission, with 83 alternations per second, and direct generation at 3,600 volts from the dynamos, has been adopted in this installation. From each generator start four copper conductors, which, crossing the machinery hall underneath the floor, and concealed in the wall, carry the currents to a switchboard of simple construction. The connections of this are shown in the annexed illustration (Fig. 2), and permit the interchange of any generator, and the hand regulation of pressure. No difficulty is experienced in the parallel coupling of the alternators. This operation is accomplished by phase indicating lamps, fed by three 200-watt trans-

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formers, to which the voltmeters also are connected; a fourth transformer, shunted from the main bars, is inserted in series with the lamp circuit, so as to get the synchronism indicated by the *incandescence* instead of, as usual, by the *obscurity* of the filaments, with an obvious advantage.

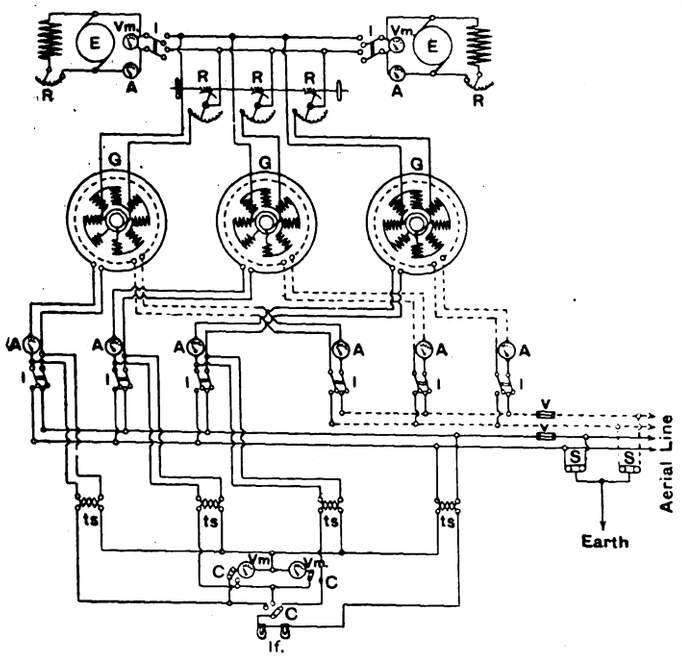


FIG. 2.—Diagram of Primary Station Switchboard Connections.

G, Alternators. E, Exciters. R, Field Rheostats. A, Amperemeters. I, Switches. V *m*, Voltmeters. S, Lightning Arresters. *ts*, Switchboard Transformers. C, Commutators. *l f*, Phase Lamps.

An aerial line, 5 kilometres (3 miles) long, and consisting of four independent wires of 8mm. diameter, transmits the current to the paper works, where it is transformed down to 230 volts, for the supply of motors, by seven 90 kilowatt two-phase transformers; and by two of 15 kilowatt for lighting purposes. The

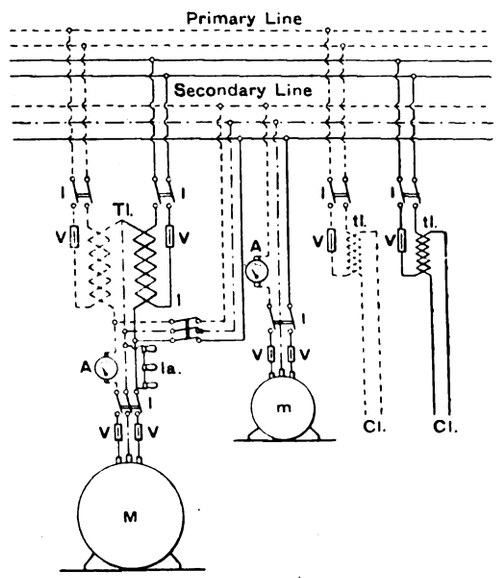


FIG. 3.—Diagram of Receiving Station Connections.

T *l*, Two-Phase 90-kilo-watt Transformer. *t l*, Two-Phase 15-kilowatt Transformers. M, 120-H.P. Motors. *m*, Small Motors. C *l*, Light Circuits. *l a*, Pilot Lamps.

switchboard connections for these are shown in Fig. 3. Six of the 90-kilowatt transformers run each a 120 H.P. motor, driving the paper-making machinery; they are independent of one another, but may be all cross-connected by a collecting network, so as to distribute if necessary the power from the more loaded to the less-loaded ones. The seventh transformer is not connected to any particular motor, but directly to the network, and is intended thus to act as a reserve for substituting for any disabled one. The network extends through the whole premises of the factory, and supplies power, not only to the six main motors, as mentioned, but also to a certain number of small motors, distributed throughout, and ranging from 3 H.P. to 15 H.P. each. It consists of only three wires of 8mm. diameter, the two circuits having a common return conductor, which, for the sake of simplicity is kept of the same size as the others.

The method adopted to solve the difficulties connected with the construction of the motors is worthy of notice. The conditions to be fulfilled in the working of these were in effect by no means easy:—A start under full load with no more than the normal current, no commutators nor sliding contacts. The inductor part of these motors is external and fixed, the rotating armature internal, as usual; to obtain full torque at starting, while preventing an extraordinary flow of current from the line, a resistance is inserted in the armature circuits, to be switched out when full speed is attained. This resistance is contained in the rotating part of the motor (Fig. 4), and to enable its disconnection while running, a screw-acting device is provided; the friction of the hand pressed on the surface of a small drum mounted on the axle causes the screw to advance and press a gun-metal cone against its rest, thus short-circuiting the armature. Successful results have been secured by this arrangement.

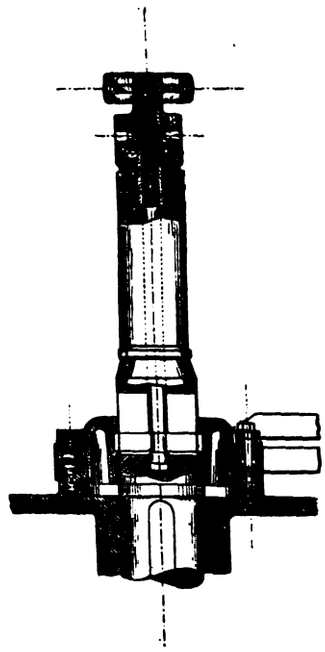

FIG. 4.—Screw-acting Device for Cutting out and Starting the Resistance in the Armature Circuit of Induction Motors.

The 120 H.P. motors experience a variation of 7 per cent. in speed when rising from no load to a 10 per cent. overload, the apparent power absorbed in internal losses being 26 volt-amperes at no load, 88 at 100 H.P. load, at 120 volt-amperes at 136 H.P. load. The tests of the plant show the efficiency of the whole electrical transmission equal to 80 per cent., so that of 810 H.P. available on the turbines at the power house 648 are delivered to the motors at Romagnano.

## EARTHING DEVICE FOR THE PROTECTION OF TELEPHONE CIRCUITS FROM ELECTRIC TRAMWAYS.

In our issue of April 17, 1896, p. 819, we published some details of safety devices for telephonic circuits devised by the Allgemeine Elektricitäts Gesellschaft in connection with electric tramways, and also details of some experiments made with these devices under various conditions. In the opinion of the German Post Office authorities, however, there are cases where the application of this plan would cause difficulties, and another arrangement

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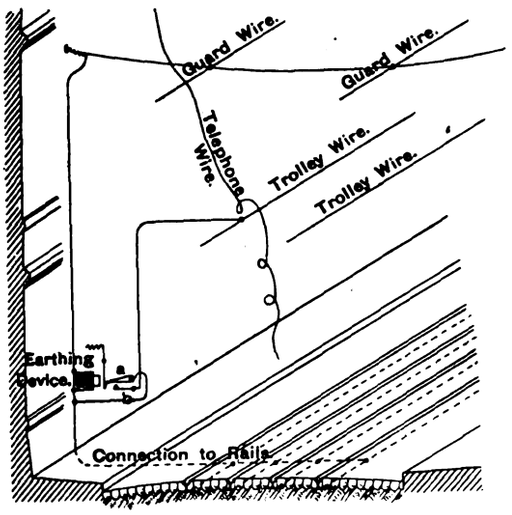
seemed therefore desirable. In Chemnitz, a little while ago, a telephone wire broke, fell on the trolley wire and killed some horses. Herr R. Ulbricht has now made some experiments with an earthing device, which he has invented, and which he describes in the issue of the *Elektrotechnische Zeitschrift* for May 7th. He has repeatedly observed that when the telephone wire falls on an earthed guard wire, and then on the trolley wire, it does not fuse at the latter point of contact, but always at the point of contact with the guard wire. The dead piece of wire then hangs from the trolley wire down into the street, and as the earth detector at the generating station does not any longer show an earth, the automatic cut-out is closed again to the danger of traffic.

This observation induced Herr Ulbricht to design a new arrangement, which has, as tests have proved, given satisfactory results. The arrangement is based on the idea of creating a permanent earth, by means of a momentary one, which can only be removed by an authorised official. The arrangement is shown in the accompanying figure. The shortest contact between telephone wire, trolley wire and guard wire causes a permanent contact at *a b*. The automatic cut-out will then act with certainty, and the short-circuit indicator will show a permanent disturbance until the earthing device near the point of disturbance is reset. As we are dealing here with a great public danger a short stoppage of the working of the line cannot be considered a serious disadvantage.

On February 8th last some experiments were made with this new arrangement on the electric tramway at Zwickau, Saxony. The earthing device, although it was only put roughly together, acted properly. At each fall of the wire the needle of a voltmeter




connected between trolley wire and earth fell at once back to zero. The protection afforded was complete, and even an 8-ohm fuse intended for a maximum current of $\frac{1}{3}$ ampere, when put in circuit with the falling wire, remained intact. At the final experiment the guard wire, which had been weakened considerably by the different contacts burned through, but the short time of contact was enough to cause the earthing apparatus to act.

This device has the advantage of enabling thinner guard wires to be employed, as they have only to take a momentary current; a greater distance between guard wire and the trolley wire is also permissible. Again, an earth produced in this way will cause the automatic cut-out to act with certainty. The device can be easily examined and tested daily, but of course care must be taken to prevent contact at *a* and *b*.

The electric tramway at Zwickau has now been fitted with this apparatus, and on an artificial break of the telephone wire being made the arrangement acted with certainty.

## ITALIAN RÖNTGENIANA.

The Röntgen fever has invaded Italy, and our Italian colleagues are working as hard as any to unravel the mysteries of the new light. There are Papers in the *Nuovo Cimento*, in full or in abstract, by Battelli, Garbasso, Vicentini, Roiti, Righi, Salvioni, Faé, and Villari, some of which are of the greatest importance. Battelli tries to find the point of origin of the X-rays by the method of the inverse square of the distance, and also by a method which may be described as that of triangulation: letting the rays pass through two holes and impinge on a sensitive plate at some distance, and constructing the paths of the rays by joining the holes with their "traces." He finds that the rays behave as if they started from the surface impinged upon by the cathode rays. Also that Crookes tubes emit X-rays for some time after discharge has ceased. The same author, in conjunction with Garbasso, claims priority for Winkelmann and Straubel's method of shortening the necessary exposure for radiography by placing a fluorescent screen behind the plate. The same object may be achieved by placing strongly fluorescent substances inside the Crookes tube. Vicentini and Pacher, who were among the first to introduce the rays into Italy, claim to have reflected them by means of a large parabolic brass mirror, but irregularly. Prof. Righi describes a way of obtaining images independent of photography. The Crookes tube is placed above a metallic plate. The cathode and the plate are both connected with one pole of a charged condenser. Above the metal plate is mounted a discharged ebonite plate, and between this and the tube is placed a sheet of black cardboard coated with aluminium foil connected to the anode and to earth. The object to be radiographed is placed on the cardboard, and after "exposure" the ebonite is sprinkled with a mixture of sulphur and red lead, or talc and manganese dioxide. The picture comes out clearly owing to the different electrifications of the powders and the exposed and unexposed ebonite. Prof. Salvioni describes some radiographs obtained by him, in which the cartilages of the hand were more opaque than the more spongy portions of the bones, and also a radiagraph of a frog showing the lungs, the heart, and the spleen. The conditions under which the radiographs were obtained are not, however, specified. Prof. Salvioni's much talked of "cryptoscope" consists of a small fluorescent screen mounted at one end of a tube, viewed through a lens at the other end. Both he and Faé succeeded in narrowing the area of origin of the rays by deflecting the cathode rays into a constricted portion of the tube by means of a magnet, or by touching the wall with a metallic point connected to the cathode and to earth. E. Villari claims to have reflected the rays by means of a plate of zinc, in accordance with the ordinary laws of reflection. No other substance showed this phenomenon.

## RÖNTGEN RAYS NOT PRESENT IN SUNLIGHT.*

BY M. CAREY LEA.

If Prof. Röntgen's views as to the nature of the X-rays are correct, it would seem that they ought to be found amongst the many forms of radiant energy received from the sun, and various observers have thought that they so found them. Some experiments, the most important of which will be here briefly stated, do not seem to support this opinion.

1. A very sensitive dry plate (S. 27) was placed between the leaves of a book, so that 100 leaves and the red paper cover should be between the sensitive film and the sunlight. The book was then packed in a box frame to exclude all light from the sides. A large and thick lead star was then fastened on the outside of the book, and the arrangement was exposed to exceptionally bright sunshine from 11 a.m. to sunset, March 7th. The plate when put into a developing bath behaved as if unexposed. A prolonged development did not bring out a trace of an image of the lead star. It will be remembered that Prof. Röntgen found that the X-rays penetrated easily through a book of 1,000 printed pages. Indeed, G. Moreau has recently stated that in his hands the X-rays had penetrated through "several metres" of cardboard. So that the above experiment seems to be very significant.

2. A piece of sheet aluminium 1·2mm. thick was accurately fitted into a frame. A very sensitive plate was placed behind it, and a lead star in front. With three hours' exposure not a trace of an image could be obtained. This experiment was varied by substituting thin aluminium foil for the plate, also by using bromide paper as the sensitive surface. No images in any case were obtained.

3. The sun's rays or some portion of its radiation passes readily through wood if the latter is not too thick. Thus, through a piece of white pine $\frac{3}{16}$ths of an inch thick, images that could readily be developed were obtained by three minutes exposure to afternoon sunlight. With half an hour's exposure the images were brilliant. A panel about 12in. square was removed from an inside shutter and replaced with a piece of white pine $\frac{1}{4}$in. thick. When the room was thoroughly darkened, reddish light could be seen to pass through the board. So that wood of this thickness is plainly translucent to the sight.

The sun's light may be examined for X-rays also by fluorescence.

4. The panel just described was replaced by one of stout book board. With the sun shining on this book board directly and not through glass, paper marked with a saturated solution of barium platino-cyanide exhibited no indications of fluorescence when placed behind the board.

5. Three thicknesses of Bristol board were pasted together, a circle was cut out, to one side of which barium platino-cyanide was applied. The circle was then placed in a pasteboard tube (an arrangement, I believe, proposed by Prof Magie). When the sun

* From the *American Journal of Science*, May, 1896

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was looked at through this tube, the barium salt exhibited fluorescence. But the interposition between the card and the sun of very thin aluminium foil sufficed to cut off the fluorescence.

These concurrent results seem to indicate the absence of X-rays from sunlight.

M. Charles Henry quotes an opinion of H. Poincaré that all bodies whose phosphorescence is sufficiently intense emit, in addition to luminous rays, the X-rays of Röntgen, whatever may be the cause of their fluorescence. Henry quotes confirmatory experiments of his own made with zinc sulphide. It seemed worth while to ascertain if this principle is of general application. A dilute solution of uranin was exposed to sunlight, using a large surface of solution so as to get the best effect. A short distance over the surface was placed a sensitive film protected by aluminium foil $\frac{1}{10}$th of a millimetre in thickness, and with a lead star interposed. Two hours' exposure gave no result. The experiment was repeated with acid solution of quinine, with which five hours' exposure gave no result.

I have also examined the Welsbach light for X-rays. This light is usually burned under a chimney which increases the brightness but interposes glass between the source of light and the sensitive film. Even without a chimney the light is bright. The experiment was therefore made both ways. No X-rays could be detected. Nothing capable passing through aluminium foil $\frac{1}{10}$th of a millimetre in thickness by five hours' exposure to the uncovered flame.

## EXPERIMENTAL TESTS ON THE INFLUENCE OF THE SHAPE OF THE APPLIED POTENTIAL DIFFERENCE WAVE ON THE IRON LOSSES OF TRANSFORMERS.*

BY STANLEY BEETON, C. PERCY TAYLOR AND J. MARK BARR.

*Introductory.*

At the conclusion of some articles on "Wave-Form Synthesis," which were published in June, 1895,† we mentioned that we were then engaged in testing the iron losses in transformers with the aid of the method we had devised for easily altering the shape of the applied potential difference wave. This question of iron losses has naturally been regarded as one of considerable importance by electrical engineers, since the success of every system of alternate-current supply depends to a great extent on the all-day efficiency of transformers. Hence, we have thought that an account of some fairly complete experiments on this subject might be worthy of the consideration of this Institution. These experiments were carried out at the Central Technical College during May, June and July, 1895.

* Paper read before the Institution of Electrical Engineers.

† *The Electrician*, June 21 and 28, 1895, Vol. XXXV., pp. 257 and 286.

*Work of Previous Investigators.*

Up to August, 1895, when our investigations were completed, the most important contributions to the study of the effect of the shape of the alternating wave on the amount of iron loss in a transformer were the experimental tests of Dr. Fleming* and Mr. Steinmetz,† while the theoretical side of the question had been studied by Mr. Evershed ‡ in 1891, and again more recently by Mr. Feldmann. §

Mr. Steinmetz carried out some tests in America in 1891, with a view to finding "whether there was any difference in the "action of transformers" when worked off alternators of the iron-clad and smooth-core types. An average difference of 9 per cent. in favour of the distorted iron-clad wave was observed; but it should be noticed that in these experiments the power lost in hysteresis was alone considered, whereas the total loss in the iron must decide the question as to which of the two machines it would be better to employ. To make Mr. Steinmetz's test, then, of any real practical value it becomes necessary to assume that the power wasted in eddy-currents does not vary with the form of the E.M.F. wave. And although we now think that this assumption is justifiable (as will be shown later), we do not consider that there was sufficient experimental evidence at that time to entitle Mr. Steinmetz to make this assumption. (It is possible that Mr. Steinmetz may have meant total iron loss when he spoke of hysteresis, but we cannot form any definite opinion on the point from the data given in his letter.)

Dr. Fleming, who found "differences of 10 per cent. and 15 per cent. in the iron core losses," observed that "the iron core loss in any transformer was greatest on that alternator the E.M.F. curve of which most closely approximated to a sine curve." For his tests Dr. Fleming employed several different types of alternators, and this necessarily limited the number of types of E.M.F. waves at his disposal. We think it was this limitation that led Dr. Fleming to the result stated above, for our tests certainly point to a conclusion which differs very materially from this. ||

In a series of articles on transformers in *The Electrician* in 1891, Mr. Evershed dealt pretty fully with the question of the applied P.D. waves and the corresponding iron losses in transformers, chiefly, though, from a theoretical standpoint. He sums up this part of his subject by saying; "The broad lesson to be learnt from the diagrams is, that in studying iron losses in the cores of the transformers we may neglect the slight differences due to widely differing E.M.F. waves." Mr. Evershed has given, in vindication of this statement, three waves (viz., the sine, the rectangular, and the zigzag), which, though they differ considerably

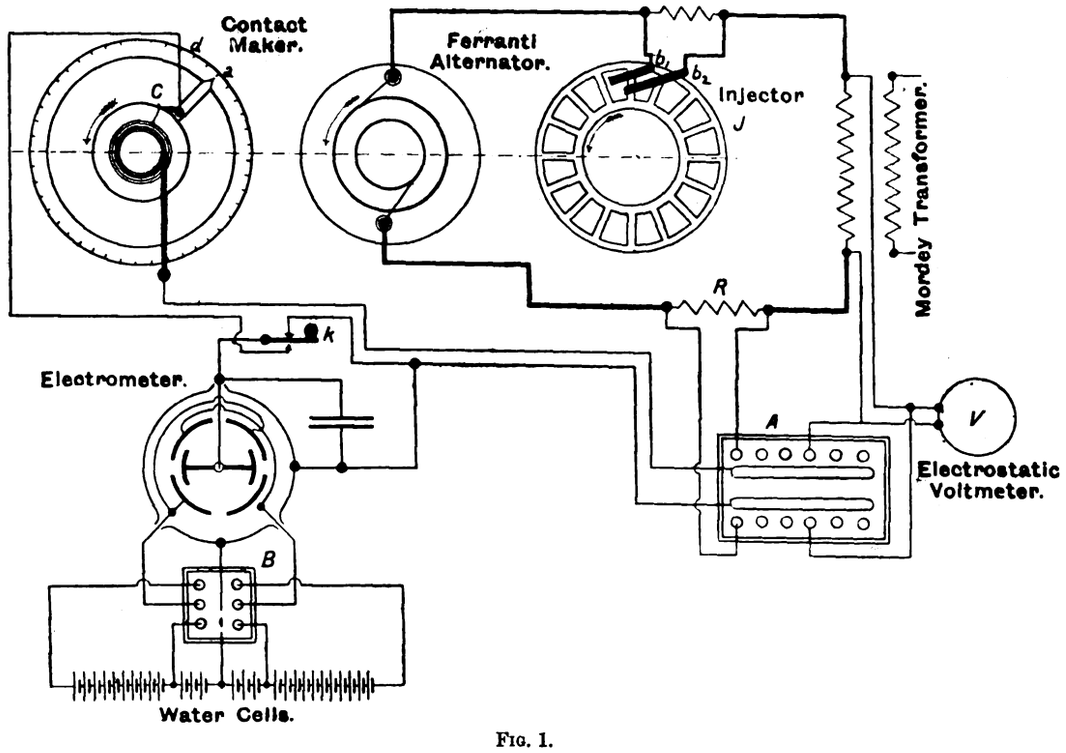


FIG. 1.

* *The Electrician*, June 28, 1895, Vol. XXXV., p. 304.

† *The Electrician*, August 24, 1894, Vol. XXXIII., p. 498

‡ *The Electrician*, March 27, 1891, Vol. XXVI, p. 635.

§ *The Electrician*, October 18. 1895, Vol. XXXV., p. 809.

|| Since writing this we gather, from an article which appeared in *The Electrician* for January 10th that Dr. Fleming has altered his opinion considerably.

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in *shape*, do not, for the same effective value, vary much in *area*. This, as we shall show later, is an essential point. It is not, therefore, very surprising that Mr. Evershed did not discover a large variation in the iron loss when considering these wave shapes.

We come now to one of the most recent contributions to this question, namely, that of Mr. C. P. Feldmann. This consists of an entirely theoretical treatment of the subject of this Paper. One or two serious errors have been pointed out by Mr. Hay,* and by one of the authors† of the present communication, in Mr. Feldmann's reasoning. But quite apart from these mistakes we do not think that the principle and methods of this Paper, in which unnecessary complications are introduced, could ever be made of great practical value.‡

## Description of Apparatus.

The method employed in our transformer tests was that of obtaining the complete curves of P.D. and current by means of an electrometer and Joubert contact-maker. This method, while being simple and accurate, is absolutely complete; any results required can be calculated from the two curves taken. The P.D. was kept constant by means of an Ayrton and Mather electrostatic voltmeter; thus we used only electrostatic instruments which required no sort of correction such as is necessary when wattmeters and dynamometers are employed. The method we employed for varying the shape of the P.D. wave impressed on the transformer was, as already stated, the one described in *The Electrician* for June 28, 1895. It consisted in throwing into the circuit, during similar parts of each half-wave, a resistance or capacity by means of an apparatus which we have called the "injector." It is indicated in the accompanying diagram (Fig. 1), which also shows the details of the remainder of the apparatus used by us in testing the iron losses in the transformer.

*The "Injector."*—The arrangement which we have previously called the "injector," is shown diagrammatically at J. It consisted of two brushes, $b_1$, $b_2$, bearing on a commutator keyed to the shaft of the alternator. To these brushes was connected a resistance or capacity, as the case might be. We used a Ferranti alternator giving eight complete periods per revolution, and, in order that we could throw into the circuit any desired resistance or capacity during certain similar parts of *each half-wave*, the commutator was made with 16 segments. These segments—completely insulated from the machine and from one another—had no connections brought to them whatever; they were merely used to periodically short-circuit the two brushes $b_1$, $b_2$. The position of the brush $b_2$ determined the *epoch*, or the instant at which the resistance or capacity was thrown into the circuit, while the distance between $b_1$ and $b_2$ determined the *interval*, or the duration of the effect for any given speed of the alternator. To the other end of the alternator shaft was fixed the usual form of Joubert rotating contact-maker. The movable brush C, and fixed graduated scale, used for taking the wave-forms, were also employed by us to fix the positions of the "injector" brushes in the following manner:—

*Method of Setting the Injector Brushes.*—The normal P.D. wave was first obtained in the ordinary manner, and by this means we really calibrated the fixed scale of the contact-maker; that is to say, we found positions of the brush C corresponding with certain points in the wave of P.D., thus imparting a definite meaning to each point in the scale. Having decided over which part of the normal P.D. wave the injection was to take place, we found the points corresponding with this interval on the fixed scale of the contact-maker. Let these points be $a$ and $d$. The brush C was fixed with the pointer at $a$, and the alternator shaft turned until the metal web of the contact disc came under the brush (this is the position indicated in Fig. 1), and the trailing injector brush $b_2$ was then adjusted till it was about to leave one of the segments. We next moved on the brush C to the point $d$, and turned the shaft of the dynamo until contact between the brush and the metal web was again restored. With the armature in this position the brush $b_1$ was set so that it was just coming on to the next segment behind the one which $b_2$ had been adjusted to leave. It is evident, therefore, that during the interval in which the armature moves from the position $a$ to the position $d$, the resistance or capacity inserted between $b_1$ and $b_2$ would be in the circuit, and that during the remainder of the half-wave it would be short-circuited.

*Transformer Details.*—Our tests were carried out on a Mordey transformer designed for an output of 3 kilowatts. The transformer was wound with three coils, two consisting each of 12 turns, and intended to be used with a pressure of 50 volts, while the third, or fine-wire, coil was wound for a pressure of 2,000 volts. This latter and one of the former were left on open circuit throughout these experiments, and the other coil was used by us as the magnetising coil, taking about 3 amperes at a frequency of 100 ∿. Hence, as the resistance of this coil was only 0·016 ohm, the drop in pressure due to it was negligible.

*Electrometer Connections.*—The instrument used for taking our waves was an Ayrton and Mather quarter-cylinder reflecting electrometer, connected up in series with the Joubert contact-maker as shown in Fig. 1. In parallel with the electrometer we had a small condenser, which was short-circuited by the key K after every reading. A number of water cells (connected with the instrument as shown in Fig. 1) were used to maintain a permanent P.D. between the opposite pairs of quarter-cylinders, and the P.D. to be measured was set up between the needle and the case. This method, as explained in our above-mentioned article, has the advantage of making the deflection directly proportional to the P.D. to be measured, even when the auxiliary P.D. required in the heterostatic use of an electrometer is quite small. The only readings used in working out the tests were those taken with the electrometer; for this instrument was also employed to measure the P.D. between the ends of a non-inductive resistance R, placed in series with the transformer, and so to indirectly measure the current flowing through the latter. The electrometer was calibrated before—and, in almost all cases, after—every test with a set of 70 standard Clark cells. In order to facilitate taking the instantaneous values of both P.D. and current in quick succession, two change-over switches were used at A and B. A consisted of a solid block of paraffin wax, in which were cut two long slots and two rows of small holes, all of which were filled with mercury. The electrometer and

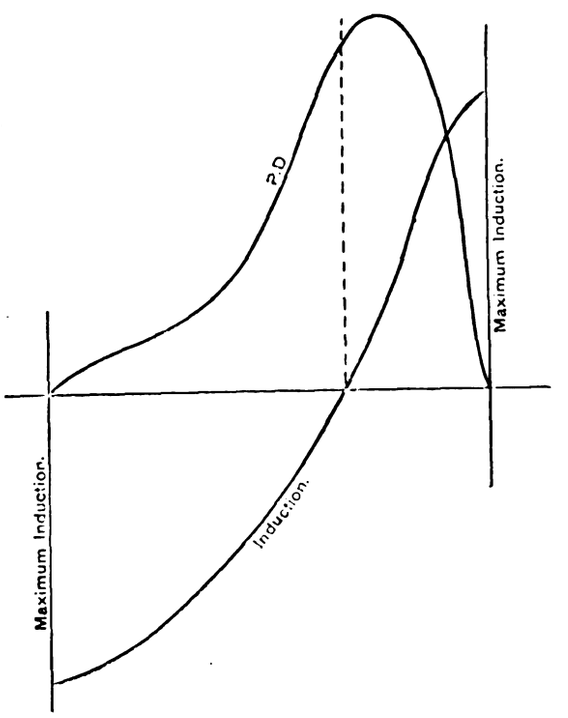


Fig. 2

contact-maker were directly connected with the two slots, while to the small holes were led wires from the terminals of the transformer and the non-inductive resistance R, or from any points in the circuit between which we wished to find the instantaneous value of P.D. As a matter of fact, the terminals of the "injector" were also connected with a pair of holes in the change-over switch A; but these wires are not shown in the diagram, as the graph obtainable at these points was not always taken, and it did not form an essential part of the transformer test.

The value of the non-inductive resistance was 4·15 ohms, so that the maximum reading for obtaining the current-wave was about 16 volts, whereas the maximum ordinate of some of our P.D. curves was as high as 100 volts. In order, therefore, to use the full range of the electrometer in each case, it was necessary to change the potential to which the quarter-cylinders were charged; hence for the P.D. wave we used six cells between the opposite pairs of quarter-cylinders, and for the current-wave 30 cells, the middle of either set being connected with the case, as indicated in Fig. 1. This alteration was effected by means of the change-over switch B. An Ayrton and Mather electrostatic voltmeter, V, was used to keep the R.M.S. volts at the terminals of the transformer constant during each test.

*Speed of the Alternator.*—The speed of the alternator, which could be adjusted by means of coned pulleys, was kept constant at 750 revolutions per minute, thus giving a frequency of 100 ∿. No electrometer reading was taken unless the speed, as shown by a

* *The Electrician*, October 25, 1895. Vol. XXXV., p. 857.
† *The Electrician*, November 8, 1895, Vol. XXXVI., p. 61.
‡ The only complete account of an investigation on the subject of this Paper—published, however, since August, 1895, when our investigations were completed—is that by Dr. Roessler. This is dealt with at the end of the communication.



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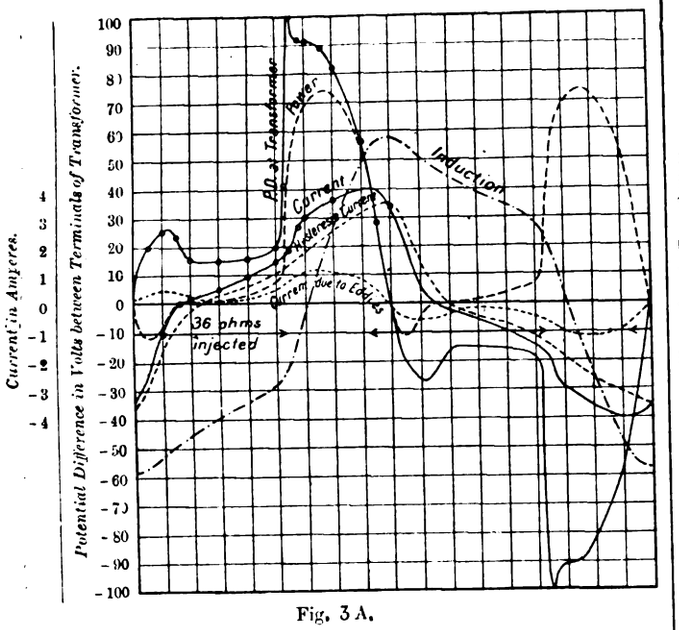


Fig. 3 A.

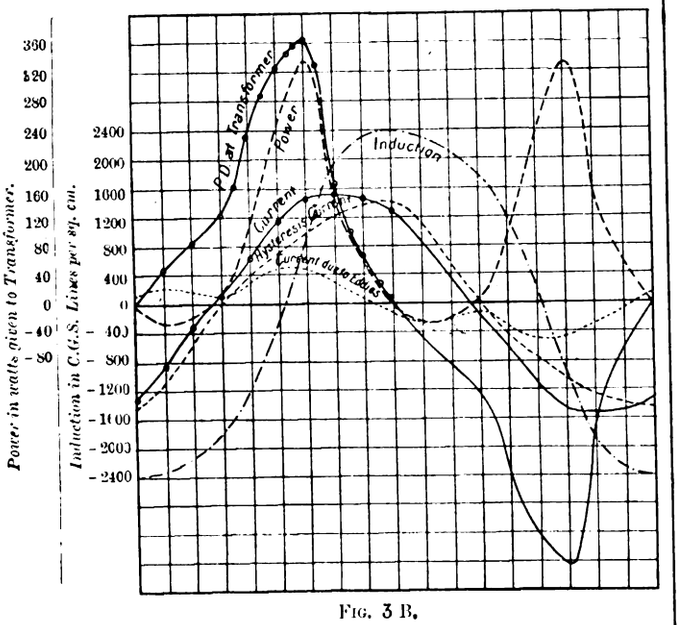


Fig. 3 B.

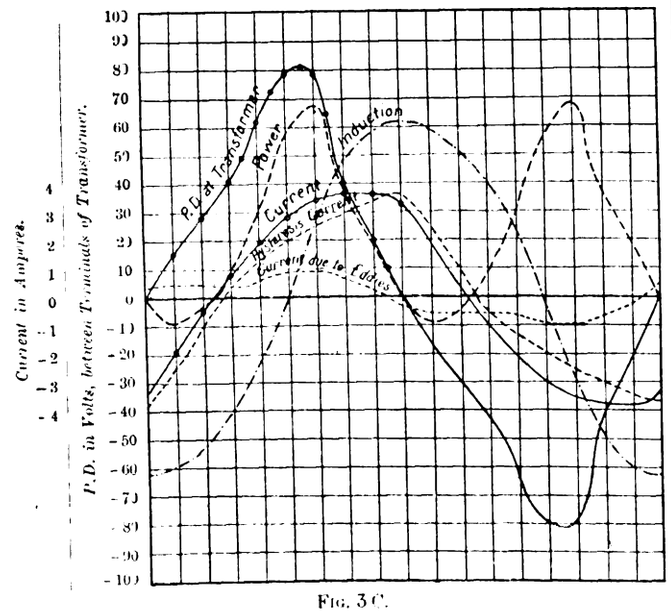


Fig. 3 C.

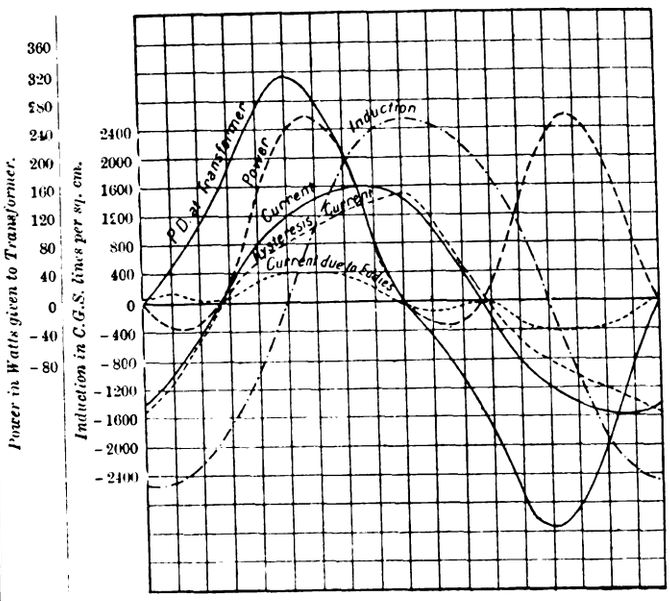


Fig. 3 D.

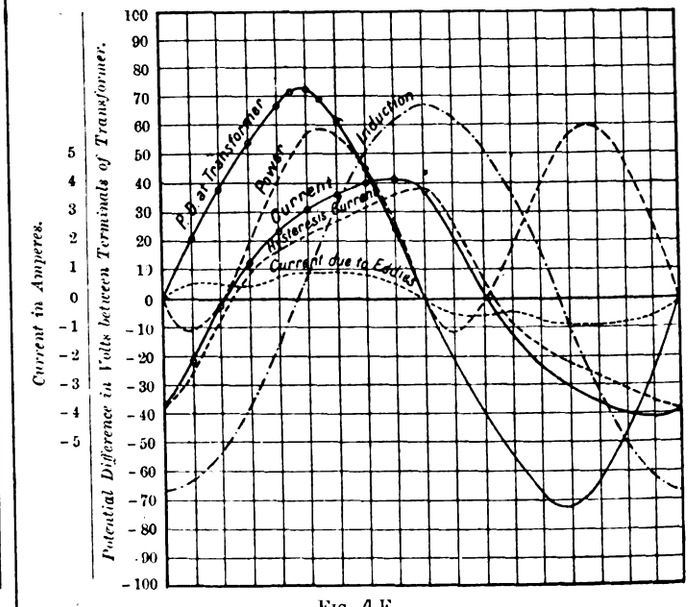


Fig. 4 E.

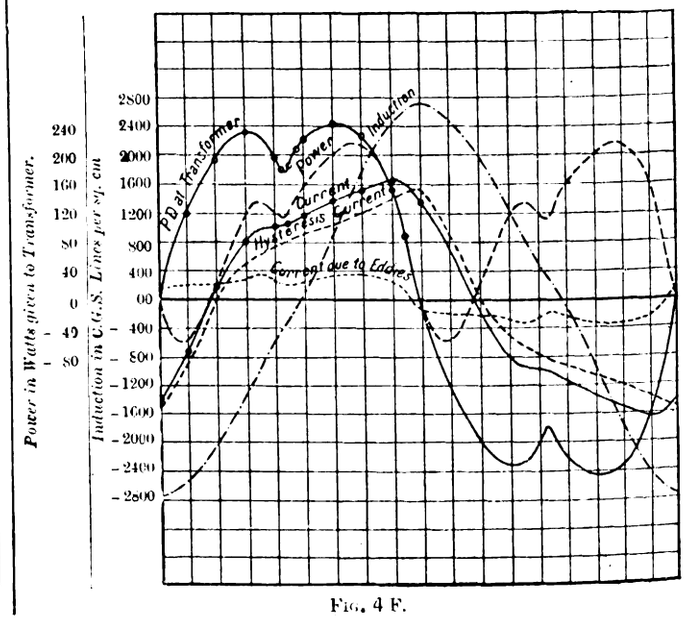


Fig. 4 F.

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Rungs pneumatic speed indicator, was exactly right. The indicator was checked several times by a revolution counter, and found perfectly accurate.

*Advantages of Open Secondary Tests.*—Since it is now generally admitted that, with the exception of a slight drop due to leakage at high loads, the total iron losses in a transformer are constant at all loads for the same frequency, we made all our tests with open secondary circuit. This method of attacking the subject offers great advantages, because errors caused by the variations of temperature in the iron core and the non-inductive resistance R, due

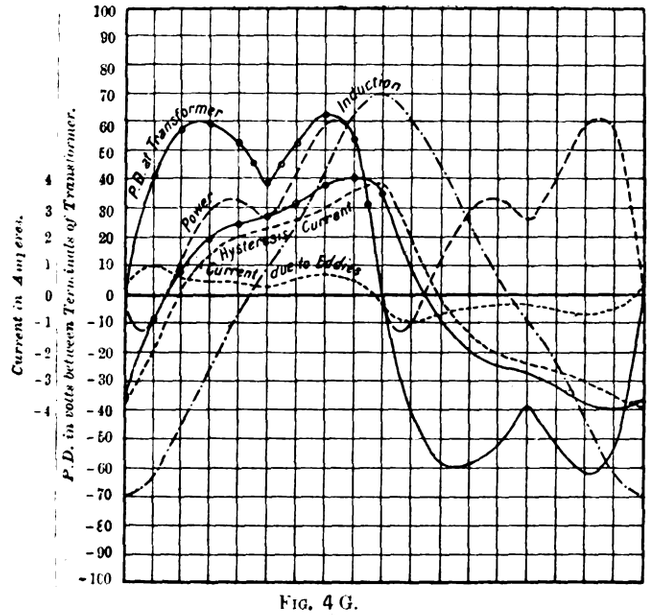


FIG. 4 G.

to the use of different currents, are not introduced into our experiments. In addition to this it will be seen that the working out of our results is somewhat simplified, especially with respect to the determination of the maximum induction. It is in the determination of the iron loss, however, that the method possesses its chief advantages, for we can measure this loss directly, and not as the difference of two much larger quantities. By this means we have been able to find the iron loss accurately to within ½ per cent., which would have been quite impossible with a load on the secondary.

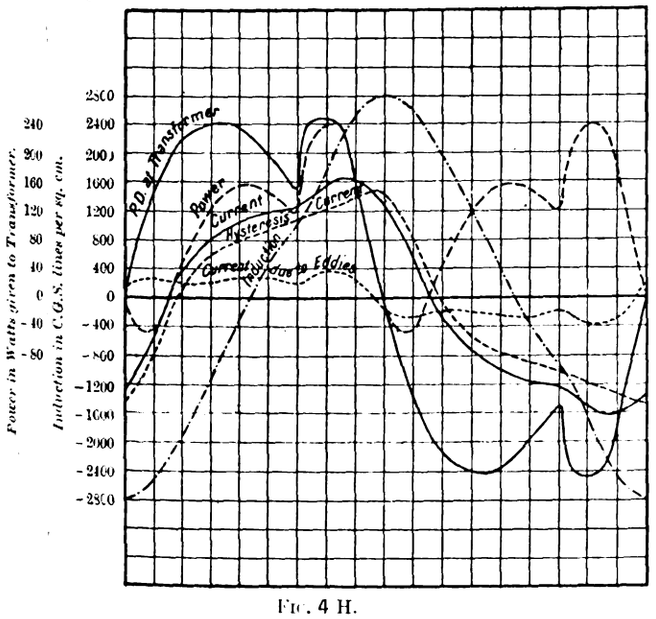


FIG. 4 H.

### DISCUSSION OF CURVES.

All the curves of P.D. and current given in the figures have been obtained by taking the means of the homologous readings on each half-wave. The mean wave thus determined was never found to differ appreciably in any way from the positive or negative half-wave. Each wave was drawn as the observations were made, so that, when the exact contour of the wave appeared doubtful, more readings at points intermediate between those already observed could be *at once* taken and plotted; hence a large number of observations were made on every wave, sometimes as many as 48 points being taken. The normal P.D. wave of the Ferranti alternator (Fig. 4 E), is seen to be very nearly a sine curve, while the current-wave possesses the characteristic deformation always observed when a transformer is working light.

*Induction Waves.*—The induction wave must be found by integrating the curve of back E.M.F. Now in our case the latter is practically identical with the applied P.D. wave, since the drop in pressure due to the resistance of the magnetising coil is neligible. It is interesting to note how smooth the outlines of the induction curves are, even when derived from very distorted waves of potential difference. This point has been fully dealt with by Mr. Evershed in the articles referred to above. We have, therefore, to integrate the P.D. wave; but to do this, we require some starting point, and this must first be found. When the ordinate which divides the half-wave of P.D. into two parts of equal area is known, this presents no difficulty, as the induction must be zero at the point where this ordinate cuts the axis of time. When, however, as is more often the case, we do not know this ordinate, then the above relation will not help us; but there is another relation which is true in every case, viz.: *that the induction must be a maximum when the P.D. is zero.*

It is evident, on reference to Fig. 2, that, according to this relation, the induction must pass from a negative to a positive maximum, or *vice versâ*, during the half-period of the P.D. wave. Since the induction wave is the integral of the P.D. curve, it will also be evident from Fig. 2 that *the area of the semi-wave of P.D.*, multiplied by the required constant, will give twice the maximum induction. (This constant must contain the number of turns in the magnetising coil and the cross section of the iron core.) Thus in every case we can get a starting point for the induction curve by setting up the maximum induction at the point where the P.D. is zero. The wave is then drawn by integrating the P.D. curve in steps from this point, and subtracting the inductions thus obtained from the maximum value. This direct relation between the maximum induction and the area of the P.D. wave is of the greatest importance, for it is evident then that the *amount of hysteresis loss* for different shapes of applied P.D. waves will depend only on the *areas of these waves.*

*Power Curve.*—The actual mean power supplied to the transformer was determined by finding the products of corresponding instantaneous values of the applied P.D. and current. The products thus found were plotted as curves (Figs. 3 and 4), which were then integrated with a planimeter, and the mean ordinate determined. This then gave us the input, and, since the copper loss was negligible—being less than one-fifth of a watt—it represented with sufficient accuracy for our purpose the total watts lost in the iron core of the transformer.

(*To be continued.*)

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, May 15th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*5 p.m.* Students' visit to the Robertson Incandescent Lamp Factory, Brook Green, Hammersmith.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Cable Laying on the Amazon River," by Alexander Siemens.

**MONDAY, May 18th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture IV.: "Applied Electro-Chemistry," by James Swinburne.

**TUESDAY, May 19th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture (III.): "Ripples in Air and Water," by C. Vernon Boys, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. The following Papers to be submitted for discussion: (1) "The Magnetic Testing of Iron and Steel," by Prof. J. A. Ewing, F.R.S.; (2) "Magnetic Data of Iron and Steel," by H. F. Parshall.

**FRIDAY, May 22nd.**

PHYSICAL SOCIETY.

*5 p.m.* Meeting at Burlington House. Adjourned discussion on Messrs. Frith and Rodgers' Paper: "On the True Resistance of the Electric Arc." The following Papers will be read: (1) "On Dielectrics," by R. Appleyard; (2) "The Field of an Elliptical Current," by J. Viriamu Jones; (3) "An Instrument to measure Frequency," by A. Campbell.

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Students' Meeting at 25, Great George-street, S.W. Paper to be read: "The X-Ray Photography," by H. S. Tyson-Wolff.

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## THE JAMES FORREST LECTURE.

The title of Prof. KENNEDY's lecture was not altogether in keeping with the substance. When a man is asked to tell a story, and he replies that he cannot tell a story, but he will sing a song, we let him sing his song, and we give him our best thanks. Prof. KENNEDY has sung his song, and a very good song it is, a song that is getting more and more popular every day, and there is just the chance that it may get too popular, and be sung about the streets with bad voices and bad accompaniment. But we cannot hear the song too often from men like Prof. KENNEDY, and it cannot be too often sung in the lecture-room of the Institution of Civil Engineers. The lecture was not upon "Physical Experiment in Relation to Engineering," but upon "Measurement in Engineering." Electrical engineers need no telling that in their profession it is necessary to know that two and three make five and not six or four; but many engineers do need to have statements of this kind repeated to them. Prof. KENNEDY expressly states that he wishes to regard "mechanics" as a part of physics, and he evidently includes chemistry and all other parts of natural science which in any way relate to engineering. He made a careful and proper distinction between the measurement work of the physicist and the mere metering work of the engineer: "Purely physical experiment is necessary to supply us with most of our important constants, whether connected with the thermal properties of steam, the electromotive force of a Clark cell, the density of water, the elasticity of steel, the coefficient for a *vena contracta*"; and he points out that "the first work of the physicist dealing with his problem is, in fact, to find out a way of so isolating his question that its solution may give

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him exactly the one quantity he wishes to know, and no other," and he declares that the problem of the scientific engineer is a very much more complex one.

We have ourselves often pointed out that an engineer's problems involve physical quantities in a rather complicated fashion, as something known to everybody but not sufficiently reflected on. For example, there is almost no practical mechanical problem which can be exactly solved by calculation. The mathematical physicist takes a problem involving twenty variables, rejects all but two or three, and gives a result which to some extent can bear to be illustrated by experiment. This hypothetical result is called *theory*. The young engineer is apt to forget that the problem has been simplified, so that what we mean by saying that he is gaining experience is really that he is finding out the proper method of using his hypothetical results in actual work. He calls it exercising his common sense. The man who when he finds that his hypothetical result does not represent an actual problem, rejects the mathematics altogether, is just as unfortunate as the man who never makes the discovery, and indeed each of them is a bad example to the other. When will our teachers give lessons in the use of theory? To reject all but a few of the more important variables, and know what your result really means, or know how to find out by experiment what it means, and so find whether such a method of calculation may be employed in future; and, after rejecting terms before applying his mathematics, to have the wisdom to reject insignificant terms in the progress of the reasoning. To know that pages of mathematical calculation may be saved by using approximately correct simple terms instead of complicated expressions. What is all this but the result of experience—the exercise of common sense?

We do not think that the measurements of the engineer are necessarily difficult ones to make, nor ought his methods to be essentially different from those of the laboratory physicist. He also has, in solving a problem, to isolate it as much as possible from its surroundings, and his object is to give him as exactly as possible the quantity he wishes to know. He also has to try to evaluate unavoidable errors.

It seems to us that the great difference between the engineer's problem and that of the physicist lies in this, that the physicist obtains results which may be repeated over and over again with the same results, by himself or others, whereas the engineer recognises the fact that it is almost impossible to exactly reproduce all his conditions again. And this is why it is so stupid to give results to six significant figures. Prof. KENNEDY in laughing at this stupidity says that although four figures may be useful in mere arithmetical checking three figures are sufficient for results. We must congratulate him if he finds that he can conscientiously give his results of steam engine measurement in three figures, and we are not surprised that he finds the calibration of indicator springs a weariness to the flesh. Less experienced men will probably be satisfied to give only two figures in their answer, and their lot is a happy one if they feel quite certain about the second of those two.

An engineer takes a machine as a whole and makes measurments of certain physical quantities. He can hardly be said to experiment with it. In dealing with his results he uses arithmetic to five or to only three significant figures. In taking temperature he may use a thermometer graduated to the one-hundredth of a degree or only to a degree; he will, both in his arithmetic and his thermometry exercise common sense and waste no effort in an absurd pretence of greater accuracy than the whole problem admits of, but he will also have to get what accuracy is necessary. Experience shows that he obtains results which are of real value in improving his machine or the ways in which it is to be used. Furthermore, the important lesson is learnt that however complicated a machine may be in its construction, in however complicated a way the principles of physics enter into the detailed explanation of its working, there are certain quite simple results or laws obtainable from the engineer's experiments. For example, in a complicated machine where the mechanism may be of elastic and inelastic solid and fluid materials, where friction occurs at millions of places, where the motions are of millions of kinds, where lubrication is as varied as possible, we can rely upon there being a simple relation between energy given to the machine and energy given out by it. Just as good an illustration is afforded by the Willans' rule connecting the weight of steam per hour and the indicated horse-power of a steam engine. The complexity of behaviour in an individual, and the simplicity of law in the behaviour of a society; the complexity of political and social movement in a decade, and the simplicity of the movement when 500 years are studied, these are social phenomena which can be traced to the same causes.

In minor points we differ from the lecturer. An engineering student ought never to think that he is engaged on rough exercises, and, however rough his apparatus, he ought to be taught that he is to obtain notions of its behaviour which are as exact as possible, and notions of the limits of this exactness. There is the old sneer at the interfering physicist and the old cry of the practical man to be let alone as he knows his own business best. Happily he is not to be let alone, and whatever of truth there is in the criticism of outsiders will gradually get to be recognised as such by practical men. But, on the whole, the lecture was worthy of the series and worthy of the lecturer's reputation, and much greater praise cannot be given.

## PHYSICAL EXPERIMENT IN RELATION TO ENGINEERING.*

BY PROF. A. B. W. KENNEDY, F.R.S., M.INST.C.E.

It has been the expressed wish of the gentleman in whose honour the "James Forrest" lectures have been instituted, that they should deal with the relation of various sciences to our own profession. To those of us (and they are many) who have long enjoyed his friendship, and who are to some extent familiar with the extent to which our profession is in his debt in matters innumerable, it is practically a duty to meet his wishes in such a matter. But it must be acknowledged that the duty—as regards the lecturer—must grow every year more difficult, as the field becomes limited by his predecessors; and even at present it was with no little nervousness as to the selection of a subject that I accepted last year the invitation to give this lecture in 1896.

There is perhaps no science, except those in the biological group, of which it might not be argued, with some degree of plausibility and reasonability, that the profession to which we all belong was a direct application. The sciences of mathematics and of physics, of chemistry and of geology, concern themselves with the exact statement of the nature and relations of facts and phenomena with which we as engineers have continually to concern ourselves. But the points of view of the purely scientific investigator and of the engineer, in regard to these facts and phenomena, are no doubt very different. In rare and exceptional cases, one man can play both *rôles*, but this happens so very seldom that for all practical purposes they may be regarded as distinct from each other. And no one who is not terribly narrow—on one side or the other—would deny that either might form a worthy life-work for any man, however high his aims or ambition.

* "James Forrest" Lecture, delivered before the Institution of Civil Engineers, May 7th.

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I excepted just now the biological sciences from those with which engineers were directly in touch. But, in spite of this, I confess that I have had a great wish for years past to devote some time to the working out of a theory of evolution in relation to engineering progress. I cannot help thinking that there is something in relation to things inorganic which closely resembles the position of natural selection in the organic world. The struggle for existence, which too obviously exists among engineers themselves regarded as organic beings, seems also to exist in effect among engineering productions. There is also among them a survival of the fittest, and the laws which determine what is the fittest at any time, and how the standard of fitness alters as time goes on, are probably capable of fairly exact statement—in correlation with the laws of general human progress; at any rate, they are very well worthy of examination. This biologico-engineering investigation would be no doubt rendered more difficult by the fact that artificial selection continually comes in to help and accelerate, or it may be to hamper and impede, but in any case to modify, the inorganic equivalent of natural selection. I have found this whole subject a most tempting one, full of fascination, and to some extent also of surprises. But finally I felt constrained to leave it, at least as far as this lecture is concerned, to someone—some fortunate person—whose mind was not so overcrowded with the innumerable details of everyday work as my own, or who was able, in spite of these details, to obtain at the same time a broad and comprehensive view of the whole subject from a point higher and more commanding than any that I seemed able to attain to. I hope that in some future year I may have the pleasure of listening to a "James Forrest" lecture in which "Evolution in Engineering" may be adequately dealt with. For myself, I have found it necessary to be content with a much more limited subject, although one perhaps on which my own work gives me more right to speak, "Physical Experiment in Relation to Engineering."

We are all at this present time so familiar with the idea of physical laboratories—places in which physical experiment is carried out systematically and continuously, both for purposes of scientific investigation and of education—that it is hard to realise how very modern an institution the physical laboratory is. Until quite lately the most distinguished investigators worked in laboratories which they had made for themselves and which were essentially their own private studies. The Royal Institution laboratories—originally, I think, rather chemical than physical in conception—nevertheless became to a great extent physical, and in this way were early and notable extensions of the purely private laboratory, and happily exist still to furnish admirable physical work. But it is practically only within the last 30 years that physical laboratories, as we know them to-day, have come into existence. Thanks very much to this growth of experimental and physical teaching, we have now an army of trained physical investigators distributed all over the country, whose principal occupation (besides teaching) is the making of researches in experimental physics, and in this way contributing to our knowledge of the phenomena of the world around us—the phenomena which it is our business to turn to the "use and convenience of man." Not only this, but within the last 20 years there have come into existence numerous well-equipped engineering laboratories in connection with our technical colleges and schools. These engineering laboratories are, of course, simply physical laboratories modified in a certain special direction for our special purposes, and the investigations carried on in them are of the nature of physical experiment as fully and completely as those which are carried out in physical laboratories proper. The aim and scope of the two classes of experiment, however, differ considerably, as do their relations to our own work, and it will be my object this evening to put before you what, according to my own view, are the relations between these classes of experiments, and especially between each class and our own work. I need hardly say that I am bound to look at the whole matter throughout from the point of view of the engineer. I do not for a moment pretend that I am capable and taking up the position of the physicist, and of course I keep in mind also that I have to speak to an audience consisting essentially of engineers, and not of physicists.

Physical experiment, so far as it has relation to our own profession, may fairly be considered to serve three distinct purposes. In the first place, from the purely academic or educational point of view, it is most important and helpful in the training of engineering students. (And it is well to remember that although a great many of us never were engineering students, nor had any opportunity of obtaining such training, yet the most conservative must now recognise that in the future our sons and successors must look on the student stage as being as essential as the pupilage or the apprenticeship.) Then, secondly, what may be called purely physical experiment is necessary to supply us with most of our important constants, whether connected with the thermal properties of steam, the electromotive force of a Clark cell, the density of water, the elasticity of steel, the coefficient for a *vena contracta*, or a thousand other matters of a similar nature. Lastly, technical experiments, which are essentially physical experiments, but of a much more complex nature than those of the physical laboratory (although not on that account more difficult to carry out) are necessary for determining many matters—such, for example, as the efficiency of a dynamo, the steam consumption of an engine, the flow of a river, the resistance of a ship, or even the deflection of a girder under a moving load.

Let us consider, in the first place, the purely educative or academic type of experiment. Here the first requirement is the very simple one—which indeed may be served by an endless variety of experiments extending far beyond the limit of physics—that the student should learn first to see and to measure, and then to write down what he has seen and measured. (Anyone who has had to do with laboratory work knows very well how necessary it is to differentiate in this fashion). The experiments require to be, as far as possible, quantitative rather than merely qualitative; but, otherwise, the simpler they are the better. It is unnecessary here to go into any details about them, but with a view to emphasising their importance it is worth while just to look for a moment at the sort of thing by which, in actual engineering work, these simple experiments may be said to be represented. Perhaps those whose work lies greatly in experimentation, like my own, know best how very hard it is to find assistants, unless they have been trained in a laboratory, who can be trusted at first even to take quarter-hourly readings of a steam gauge or a counter, or any such duty, ridiculously simple and easy as it appears. To ask an untrained man to count the revolutions of an engine which has no continuous counter attached, or to read the dials of an ampere-hour meter, at exactly regular intervals of time, is merely to court disaster! The story is familiar of how Robert Houdin had so trained his faculty of general observation that one look at a shop window would impress its contents on his mind more vividly and accurately than 10 minutes of hard looking would do in the case of an ordinary man. It is really just the same with the simplest of our observations. The ordinary mind does not naturally and at once see, and see accurately, the simplest thing that is before the eyes. One has to look to exercise conscious mental effort, as well as merely to see, and we all of us require to be taught how to look, even in these most simple matters. And when the enforced looking has to be done at exactly a particular time and no other, the average mind is apt to find the whole process an intolerable burden, all the more because it is inclined to despise the work as being too childishly easy for consideration at the very time when it is failing to carry it out!

So far as concerns the training of the faculties of observation at the stage of which I am speaking, probably chemical experiments would serve as well as physical. In certain respects possibly they might even be better, but with this we need not now concern ourselves. An important point is, perhaps, that in their earlier stages the student should not be allowed in any way to get the notion that his experiments are more than mere rough exercises. Any standard of accuracy which he can possibly attain is comparatively a very low one, and by the nature of the case the experiments he can do must be simplified down enormously before they can be put into his

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hands, so that at best he is only making a rough determination of one element in an artificially simplified operation, the full conditions of which he is not even in any position to understand. The actual figures which are obtained by him can under no circumstances be regarded as having any intrinsic value; and one of the difficulties of the case is, no doubt, to persuade the student to exercise his highest degree of care in obtaining results, which at the same time he is told, or knows, are of no use whatever. The engineering student, I am sorry to say, is generally a terrible utilitarian. The unhappy professor has to enter into all kinds of subterfuges to get him to take an interest in, or do any careful work at, matters which the omniscience of youth has once pronounced to be "useless." Later on, of course, he is wiser and a trifle less narrow-minded; but I suppose the stage of first-yearness is one through which all of us have to pass in one fashion or another, to the grief of our pastors and masters, and to our own later regret.

More interesting to most of us, perhaps, than this purely academic matter is the consideration of physical experiment under the last two headings which I have mentioned.

First among these comes experiment which really belongs to pure physics, but in which we engineers may claim to be as much, or even more, concerned than the physicists, although both the difficulty and the honour of the experiment must fall to them. I suggest that we are even more concerned than the workers in pure science for two reasons, of which the first is that the whole of our interest is practically concentrated on what constitutes only a small part of the boundless region open to the physicist. He can spread his affections over glass and sealing-wax, and let them roam from ice to iron. We have only one love, or at any rate never stray very far from a limited number of matters which concern what I have heard contemptuously called "technical materials." He interests himself legitimately and equally in argon and carbon, in steam and in ethyl-alcohol; he loves to extend his thermal conditions so as to get liquid air or gaseous carbon. We, on the other hand, are compelled to deal with a very small number of materials, and with these materials only in states in which we can readily obtain them. In fact, as every one knows, nineteen-twentieths of our liquid and gas problems affect only liquid and gaseous (or vaporous) water, and only the remaining small percentage is left to be distributed between coal-gas and producer-gas, liquid carbonic acid and anhydrous ammonia, and so forth. So far as the more or less "permanent" gases are considered, our interest is throughout perhaps rather chemical than physical.

Then, again, we may claim to have a first interest in certain physical results, because of the extraordinary frequency with which we have somehow or other actually to make use of them—I mean a real live use, and not merely a use in an examination question, or in a text-book or a lecture. Not only would our whole work become mere guess work without the knowledge of these results, but, having this knowledge, we are compelled by the very nature of our work to make such continual use of it that probably we are much more familiar both with the figures concerned and with the phenomena which they represent, than even the men to whose magnificent accuracy and unlimited diligence we owe their original investigation and determination. I mean, of course, such results as refer to the thermal relations of water and steam, to the calorimetry of fuels generally, to many hydrodynamic problems, to most problems in elasticity and what is clumsily called the strength of materials, to frictional questions, to innumerable problems relating to electrical matters, and certainly to an enormous number of matters bearing on mechanics, which, of course, is to be considered as a branch of physics.

I feel so strongly this sense of our paramount interest in certain physical problems that I have not hesitated sometimes to resent the way in which physical writers and speakers are occasionally inclined to instruct us how to express our ideas, for example, as to mass and weight, and sundry vital matters of that kind. I really think that people who have to deal with these matters as much, as often, and as thoroughly as we have, and who are on the whole reasonably competent beings, may be assumed to know how best to manage our own affairs in these respects. Mechanics are to us the breath of our nostrils, and not a mere vehicle for examination papers; and it should be remembered that the requirements of the latter case may be very different from those of what I may venture to call "real life." I feel some satisfaction in remembering that the only fatal case of a misused "$g$" that I can call to mind was on the part of a physicist, whom we all admire none the less for the way in which he scolds us, but who, in the very act of showing us the way we ought to use that symbol, proved conclusively that all submarine cables would break by their own tension while lying on the sea-bottom! It would, perhaps, be hardly proper, or even safe, that I should here say anything, as I am much tempted to do, as to the vexed question of units, which from time to time seems to agitate many minds. Let me only suggest that, on the whole, it does not seem to me that the people who would be most affected by the change are at present those who are most anxious for it. In fact, admitting certainly a few notable and very distinguished exceptions, it really seems as if engineers in general were content to go on in their own way, unconscious of the terrible pitfalls and difficulties by which it is understood that they are surrounded on all hands. I quite admit, of course, that it by no means follows that the pitfalls do not exist, although I confess to being somewhat sceptical about their reality.

But having spoken so strongly of engineers as being the users of certain physical results, I must look at the other side of the matter. We engineers may have, as I urge, more interest in these matters than anyone else, but it is certainly true that we have not ourselves to thank for the determination of the results which we require and which we make so much use of. For practically the whole of these results—results without which, as I have said, our profession would hardly exist, would at best be a mere trade instead of (as we are proud to consider it) a scientific profession—we are indebted to workers in physical science pure and simple, men without the least taint or suspicion of technical or utilitarian intent.* It would therefore ill become us engineers if we were to say or do anything which should, even in a most indirect fashion, tend to belittle the work of pure physicists, on which every day shows us more how much we are dependent. Our gratitude is so real and so deeply seated that we need not, and do not, even resent the expression of regret which has sometimes been heard from a discoverer, that what he has done should be of any use whatever!

A physical experiment such as is necessary for the determination of any one of the physical constants which we have in continual use differs very essentially from such physical experiments as we engineers have to carry out in the course of our own work. It is at once much simpler and much more difficult. It is simpler, because its object is the solution of one certain problem, which has been by much care and pains isolated from all its surroundings, from all related and, so to speak, adjacent problems. The first work of the physicist, dealing with his problem, is, in fact, to find out a way of so isolating his question that its solution may give him exactly the one quantity he wishes to know and no other. Of problems of this kind I confess I speak as an outsider; but as an outsider it has been to me often a matter of the greatest interest, and even wonderment, to see what enormous pains a physicist takes, and must necessarily take, to make sure that he is measuring exactly the thing he wishes to measure—that thing, that whole thing, and nothing but that thing; to see also what innumerable precautions he has to take to ensure the absence of minute errors, or to find out where any such errors might occur, and whether they have occurred, and to evaluate them if they are unavoidable. I have found, too, that in such cases suggestions derived from my own experience in engineering experiment have been often received with a coldness which I am afraid was no more than they may have deserved! For, as I shall endeavour to show, the conditions under which

* I think probably the only notable exception to be made in this matter is in regard to scientific experiments relating to strength and elasticity, some of which have been made by engineers and with a more or less definitely technical intention. But probably such men as Bauschinger, Martens and Tetmajer are to be considered essentially as in the position of physical workers.

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experiments of this kind have to be made are absolutely different, both as to aim and method, from those of the experiments—more technical if not less physical—which we have to carry out for ourselves in our own work.

In a physical experiment of the second category, such as those of which I have been speaking, the primary points may be said to be, first, that the object of the experiment should be single, definite, isolated, separable and separated from all surroundings; secondly, that it should be general in its nature, and should not relate merely to one special case; next, that as a problem it should be capable of exact determination; and lastly, that the final result should be as nearly absolutely accurate as it is possible for any physical determination to be. Take as examples such matters as the determination of the density of steam, of the variation of the specific heat of water with change of temperature, of the calorific value of pure carbon, or of the mechanical equivalent of heat. Such problems properly stated admit each of one exact solution, one answer which is absolutely right, even in the mathematical sense of that phrase. It is the highest object of the physicist, in dealing with such a problem, to obtain the right solution. He spares no pains to obtain it, he determines each minute correction with the patience and care of a man who knows that the value of his whole work may be vitiated by a single overlooked source of error, even of the smallest magnitude. We engineers are possibly in some danger of forgetting occasionally, in view of the familiarity and matter-of-courseness of certain figures with which we have frequently to deal, that just these everyday and familiar numbers, on account of their very importance, were those which required and obtained for their determination the most careful, exhaustive, and accurate experimentation in the hands of the most experienced physicists.

After speaking in this fashion of the nature of experiments in pure physics, it may sound at first absurd, but it is nevertheless true, to say that physical experiments in the third category—the technical experiments which we engineers have so often actually to carry out—do not fall under a single one of the conditions which I have just given as characteristic of experiments in pure physics. We cannot, even under the most favourable circumstances, put before ourselves exact and isolated problems; we have much more often to deal with special than with general cases; we cannot choose problems which are capable of finally exact solution; and, therefore, lastly, we should treat the matter entirely wrongly if we attempted to obtain more than a certain limited degree of accuracy in our solution—an accuracy very limited indeed when compared with the all but mathematical accuracy with which problems in pure physics can be solved.

The conditions under which engineers have to carry out physical experiments, of course, vary very greatly. In certain simple cases they are essentially physical investigations, be it in connection with friction, with elasticity, or what not, which at first sight do not greatly differ from the experiments which I have just discussed. There is probably, however, more difference than appears at first sight, although the spirit in which both sets of experiments have to be made is the same. Take as an example the determination of the elastic modulus (or the specific extension) of a piece of steel. Probably, with very perfect instruments and with extreme care in manipulation, a value of the modulus could be obtained which should be accurate, say within 1 in 2,000, for that particular piece of steel. But a figure so obtained would not be accurate even for other pieces of steel made at the same time, and out of the same ingot as the one experimented on; while, of course, there is no one absolute value for the modulus of elasticity of the widely-differing material of which all sorts go by the name of steel. Under such conditions—and I have chosen a particularly favourable example—it would be mere affectation, and, in addition, would be actually misleading, to claim anything like physical accuracy for our results. Indeed, I must go further and say that the truly scientific way of treating an experiment in engineering physics is to recognise from the outset its limitations as to accuracy, and to be careful not to state a final result in a form which should lead to the supposition of any greater degree of accuracy than that which the conditions of the work can actually allow.

The difference between physical and technical experiments may easily be illustrated by another example from the region of elasticity. The determination of the deflection of a beam, transversely loaded, as a physical experiment would resolve itself into the test of the behaviour of a piece of homogeneous material, preferably of the simplest possible cross-section, probably rectangular. It would be a matter of importance to ensure that the material was exactly of a certain chemical nature, and that it was mechanically free even from the slightest defects; it would also have to be machined to certain exact dimensions. Even with every care, the almost unavoidable imperfections in the material, minute variations in uniformity of structure, and so on, would be very difficult to deal with and to allow for. As a technical experiment, on the other hand, the beam might consist of plate and angle irons secured together by rivets, the whole forming a structure with absolutely no pretence to homogeneity, nor to absolute exactness of dimension. Its rough surface would be carefully left intact, and not in any way machined, its riveted parts would be brought together as well as was reasonably possible with the appliances at the command of the engineer, but without any attempt to make a special fit between surfaces. In fact, the whole thing would be constructed in imitation of the way in which a riveted beam, such as is used as a girder, is usually made. The result obtained would obviously not be a general one applicable to steel as a material, or to beams as geometrical forms, because the data of the problem, even the dimensions of the beam itself, could not be determined with minute accuracy, nor would the actual final result be comparable in accuracy with the determination of the similar problem treated from the purely physical point of view. Hence, as the experienter cannot for a moment pretend, and should not for a moment delude himself into supposing, that his results could be more accurate than his data, it is his first duty in this line of work to find out within what limits of accuracy his experiment can be carried out, and, when he has obtained his results, to state it only within these limits. Under these conditions the statement of a result in round figures is often much more accurate that its statement down to the last decimal place which appears in the arithmetic. I have heard it said by some of the students of the greatest of our physicists, Lord Kelvin, that this was a point upon which, even in a great deal of purely physical work, their master always insisted most strongly. But I am afraid that it must be admitted, as a weakness of much of our engineering experimentation, that its results are given in figures which are absolutely ludicrous as indicating the value of the quantities actually measured. In these matters, perhaps, our friends in America are even worse than we are, and those of us who have anything to do with steam vessels or with steamship trials, are perhaps the worst sinners. I suppose no physical problem could very well be much more complicated than that (I ought rather to say those) involved in the carrying out of a marine-engine trial at sea, especially when power and speed are both concerned. When it is considered that the final result depends on the accuracy of our knowledge of the dimensions of the steam engine itself, and of the steam engine indicators, on the uniformity of elasticity and proper scale of the indicator springs, the accuracy with which the revolutions are observed, the accuracy of timing on the mile and of observing the distance at the same time, to say nothing of the assumption that the indicators themselves and their gear, unlike every other thing in the universe, are entirely devoid of hysteresis, it will be seen how entirely out of the question it is that the figures obtained, even for a single run in one direction, should admit of statement in, say, more than three figures. When to this is added the uncertainty of the method of averaging speed as between a number of runs under different conditions as to tide and wind, the matter becomes still more striking. Or, when coal and water are also to be measured, and the weighing or measuring of both, and the calibration of all the heavy apparatus used for the purpose, as well as the personal errors due to making observations of large quantities under awkward physical conditions, in a minimum of time and in the worst of atmospheres, are considered, the uselessness and indeed the absolute inaccuracy of extremely minute figures

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become absolutely glaring It is sometimes useful, no doubt, under these conditions, to work out results to four significant figures for the sake of mere arithmetical checking; but no one who has had anything to do with the matter would suppose for a moment that more than three figures were of the least importance and the statement of results of observations in five or six figures merely causes the enemy to scoff. Let me again say here that I am not suggesting, and I do not think, that an experiment of a technical nature is unscientific because its result is only capable of expression within 1 or 2 per cent. instead of within one or two hundredths per cent. I wish only to urge very strongly that in a really scientific spirit such an experiment must be undertaken only with a distinct recognition of its limitations, and of the limitations of accuracy of result such as I have roughly indicated.

But I must claim for technical experiment that it is truly scientific work if only it be conducted with full recognition of its conditions and limitations, and not as if it were a laboratory experiment badly done—a mistake which I fear is too often made. Let it be recognised first of all that our object is generally the determination of certain facts, or quantities, or ratios, which are to be found under certain very complex conditions. As I have elsewhere said, the duty of the engineer is to recognise these conditions and deliberately to include certain of them in his experiment. The physicist has to spend much thought and trouble on the modification of conditions, which are disturbing elements in his work. All conditions which might justify his main result, or which might make it difficult for another experimenter to obtain precisely the same value for the quantity looked for, have to be either eliminated or evaluated. The conditions are his enemies, in fact. Otherwise with us, the conditions in general form part of our problem, and for many purposes the reduction of the experiment to its lowest terms, which is the object of the physicist, would not only be impossible, but would, if it could be done, make the result quite useless to us.

The determination of the efficiency of a steam engine is, of course, a very common piece of work, and may serve as an illustration of the two different ways of approaching such a matter in connection with this question of conditions. From the physical point of view, I imagine it would be best to endeavour to reproduce the working of the much-abused Carnot cycle.* If this were absolutely successful it would merely gave us a result which would agree with those which we can already calculate from the physical data which are in our possession, and this result would add nothing to our present knowledge, nor would it give any additional help to the designer of steam engines.† But it would, if it could be carried out, be an experiment strictly physical, and following in the lines of, for instance, Joule's classical experiment on the mechanical equivalent of heat. The engineer, on the other hand, who has to work at the same problem, has to deal with it in the fashion in which it is now handled in so many engineering laboratories. He has to make for himself an actual engine, in which the normal conditions of engine working—as to loss of heat by conduction, condensation, radiation, and so on—are, or can be, reproduced, and he has to make his experiments on this machine, and as nearly as possible under conditions resembling those under which engines normally do work. Then one by one certain of the conditions may be altered, so that some estimation may be made of the effect of each. So may be obtained figures as the result of *bonâ fide* technico-physical experiment, which are also in a form more or less directly applicable to engineering work.

I have just mentioned the variation of conditions one by one. This is hardly a matter which I need insist on. It is of great importance even in a physical experiment, where all the conditions are simplified to the last extent; but in a technical experiment, where the conditions themselves are very complex and often not easy to grasp, it is obviously vital. It is no doubt one of the great difficulties of all technical experiment to find out exactly what the conditions are, and it may in many cases need more experience and more care to determine and define the actual conditions than it does to carry out the measurements involved in the experiment. This is a matter which will be recognised by everyone who has had to do with work of this kind, but about which probably it is unnecessary to say more here. Bearing on it, however, is a matter which may fairly be mentioned, namely, the combining of the results of several technical experiments. This is often very tempting, but is always very difficult. A simple case is, for instance, the determination of the efficiency and of the economy of a steam-engine. A certain experiment may show a certain maximum efficiency; another experiment, on a more or less similar machine, but carried out at another time, may show a maximum economy. Naturally there is a strong temptation to state both maxima as belonging to the machine tested. It is, no doubt, possible that they may do so; but, on the other hand, without the most minute knowledge of the circumstances of the case, it is quite unsafe to assume that they do, and in this respect the difference between the general character of purely physical work and the special character of technical experiment comes into clear relief.

In fact it is much more difficult to handle rightly the results of engineering experiment when they have been determined than those of pure physics. It is by no means always, or obviously, easy to apply these last, at least one has known very ludicrous mistakes to occur through their misapplication. For instance, I have seen elaborate calculations based on the determination of the weight of steam used by an engine from the pressures shown by an indicator card and the measured dimensions of the engine; and quite recently I was confronted with certain supposed phenomena, which rested entirely on the assumption that a vessel of certain dimensions actually received from a steam pipe suddenly opened to it only the weight of steam corresponding to its volume and the pressure shown by a gauge! In both cases the troublesome phenomena of condensation were entirely left out of account, and the result of a purely physical determination was applied to a technical problem with very disastrous results. But it is infinitely more difficult often to interpret and to apply the results of our own experiments. For instance, let it be found that one boiler, engine and dynamo together require the consumption of so many pounds of coal per electrical unit, how much coal per unit will another boiler, engine and dynamo require? Put baldly in this form the question sounds ridiculous. But after all, is it any more absurd than our constant endeavour—that is, before the days of the present development of engineering experiment—to arrive at similar comparative conclusions from the doubtless unimpeachable figures of an engineering pocket-book? I am sure there must be many of us who can still recollect how painfully we endeavoured to make the statements of Molesworth furnish us with an answer to our own problems, and how entirely we failed to get things to fit in. I do not suggest that the fault lay with the pocket-book; the fault lay in the endeavour to correlate figures and results which in no way belonged to each other, which represented the result of experiments made under conditions quite unknown to us, but certainly varying from each other, and no less from the conditions (possibly also unknown to us) of the problem we actually were trying to work out. I dare say that many of us, who have been hungry and thirsty for facts and figures during most of our lives, remember very well the joy with which, at a certain stage, we put down in our note-books any kind of experimental results of which we could hear, or of which we could obtain possession by any means, whether they related to steam engine trials, or to girder tests, or to the discharge over weirs; I do not say to dynamo trials, because there were no dynamos in those days. And I am sure that all of us must have suffered pain and disappointment later on, when we found how extremely difficult it was to make any use of the much-

* I need hardly say that I do not for a moment suggest that any physicist would wish to obtain experimentally a result for which he has already given us all the constants, and which we can therefore completely obtain by calculation based on physical results already before us.

† I do not wish here to be understood in the least as sharing that great objection to the Carnot cycle which I know fills the breasts of some of my friends. It appears to me that it would be just as reasonable to object to the asymptote of a hyperbola or to the line at infinity! We require these limiting cases, and should get on very badly without them, and I am not inclined to say that they are useless—indeed, I think they are extremely useful—although I am perfectly conscious that they represent a state of affairs which is technically, and even physically, unattainable.



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valued figures that filled our pages—they would never, somehow or other, seem to tell us just what we wanted; there was always something about them which eluded us, one particular matter of vital importance in the data, or in the result, of which we had no memorandum. The fact is that it is always extremely difficult to apply accurately the results of experiments made by others, however carefully made and however accurately described. To realise this, even in reference to purely physical work, one need only see how many pages in the *Philosophical Transactions* are sometimes necessary to describe the methods and precautions involved in a determination which has not one-tenth the complexity of such matters as we are compelled constantly to try to measure.

To anyone who wishes to realise to the full the difficulty of dealing with, or applying, the very simplest kind of experimental result, I recommend the maddening task, so often lightly spoken of by those who have not tried it, of calibrating indicator springs, and then trying to apply the results to the correction of the corresponding indicator diagrams.

The fact is that no one can usefully apply physical results who has not himself studied the methods by which these results are obtained, either by the royal road of work in a physical or technical laboratory, or by the hard and up-hill method of self education in the making of technical experiment without the advantage of the preliminary training which I have mentioned earlier; and hence the importance of the knowledge of how to make accurate observations, which I have insisted upon as a thing quite apart from the knowledge of the actual figures to be obtained by such observations. It would, perhaps, be cruel to say that no one can usefully apply physical results who has not studied the methods by which they are obtained, were it not that nowadays the possibility of such study is open to everybody. One may, therefore, state the truth in this matter without the fear of making anyone unhappy. I do not know whether I should be far wrong in suggesting that a certain amount, perhaps a great deal, of the very rapid improvement which has taken place in late years in engineering practice in respect to efficiency in the working of machinery, economy in the production of energy, and economy also in the use of material, has been due directly or indirectly, or both, to the growth of the habit and knowledge of experiment among the present generation of engineers. No one who is familiar with the progress in such matters as I have this evening dealt with, during the last 20 years, and has noted the extraordinary development which has taken place, can fail to be struck with it. No doubt a considerable part of this development has been due to the better education generally of engineers, and particularly to the great extension of engineering literature in which undoubtedly the engineering newspapers have played a most honourable and important part. But these general causes in themselves would not, I believe, have been sufficient if it had not been for the contemporaneous development of what I may venture to call experimental training, accompanied by a demand on all hands from inventors, manufacturers, and even from the public, for reasonably exact numerical statements in relation to everything which can be measured, instead of the vague generalities which used to pass muster as critical examination of the advantages and disadvantages of any new proposals.

I hope I need not say here that I quite recognise that an engineer's life is not made of experimentation, and that the work of *doing* is even higher than that of *measuring*, at least from our point of view. But in dealing with my subject of to-night, I am, of course, bound to take up and emphasise this aspect of engineering work. I hope that it may be considered that I have been able to justify my choice of a subject which at first might appear so limited, but which in reality I believe so important, as that to which I have addressed myself this evening—the relation of physical experiment to engineering.

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**Annual Dinner of the Old Students of King's College.**—This dinner will be held at the Holborn Restaurant on Monday, June 29th. Sir Benjamin Baker has kindly consented to preside.

## ON RAILWAY TELEGRAPHS, WITH SPECIAL REFERENCE TO RECENT IMPROVEMENTS.*

BY W. LANGDON.

*(Concluded from page 57.)*

### Gutta-Percha and Covered-Wire Work.

It is believed there is very little to record in the matter of gutta-percha-covered wire. In making it a practice to use ozokerite taped wire in all instances for underground work or for wooden casing, it is probable the author is merely following the practice of others. The taping adds very little to its cost and very largely to its life. The number of wires which are now required for signalling purposes—the fact that, as a rule, the "leading-in" pole is placed in the rear of the signal box, while the instruments are invariably arranged over the signal lever frame in the front of the box—leads to a large consumption of gutta-percha-covered wire, and renders it all the more necessary that every precaution should be adopted to preserve the life of the insulation. To this end all G.P. wires should be boxed in; and the boxing (which should be grooved from the solid), when carried underneath the floor of the signal box, should be inverted, so that any moisture from the washing of the floor of the signal box may not penetrate the boxing and impair the percha.

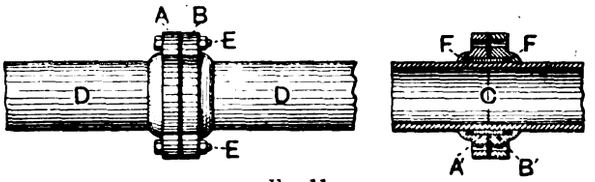


Fig. 11.

The author has for some years employed wire covered with india-rubber, plaited cotton, and compound, for signal posts. It withstands heat much better than G.P., the conducting wire is less liable to become decentralised, and he has good reason to believe that it will prove very durable.

Although instances have arisen where armoured cables composed of from three to ten conducting wires have been employed for telegraph and signal purposes, it cannot be said such are in general use. In station yards, where the wires are generally laid underground, and in other equally crowded places, armoured cables for odd lengths will probably be found not only useful, but in order to avoid disturbing the body of through wires, a necessity. Such cables are extremely useful for crossing the line of railway for repeater, or similar purposes, where, unless the wires are carried underground, a large alteration is necessary in the poles in order to carry them overhead.

In laying down some underground work at Leicester and Nottingham, a simple form of cast-iron piping, which, having an india-rubber joint, is very quickly placed in position, has been used.

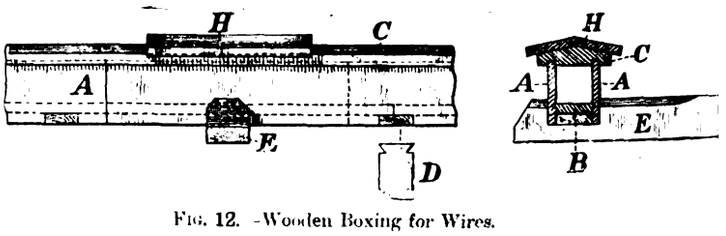


Fig. 12.—Wooden Boxing for Wires.

It is inexpensive and readily handled. An illustration of the joint will be found in Fig. 11. A B are clamps, which slide over the pipe D, which is merely a straight tube. A, B are recessed at A', B', so as to receive the small piece of tubing C, together with an india-rubber washer, $F_1$, at either end. The pipes D are laid out so as to meet at C. A and B, as well as C, are then slipped on, the tube C is brought into its proper position, and A and B are then closed up and tightened by the bolts E. The india-rubber washers afford a firm grip, so that the pipes D are not readily drawn apart. The arrangement is better suited for level ground than for heavy slopes.

Fig. 12 represents a form of wooden boxing for tunnels and wall work. It is the production of my inspector carpenter, Hobday, and is set together and maintained in position without the aid of a nail or screw. It is formed of four pieces of wood. The side pieces, A, A, are grooved to accept the bottom board, B; the top, C, is grooved to accept the side pieces: the two sides are held together by tie-pieces, D, inserted at intervals of 3ft. Instead of iron

* Paper read before the Institution of Electrical Engineers, April 30th.

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supports wood blocks, cut from flawed or otherwise unsatisfactory oak arms, are shaped as shown by E to receive the boxing. These supports are fixed in the masonry by wood wedges or cement 6ft. apart. A piece of wire passed around the support and the boxing holds the entire structure safely in position. No two pieces of wood from which the boxing is composed terminate at the same point, with the exception of the lid. At the junction of these pieces a wooden capping, H, is employed to cover the seam.

### Instruments.

In telegraph message instruments the vertical handle "single needle" remains that generally used in Great Britain. For some years it has been the practice on the Midland to employ at the transmitting or terminal station of all busy single-needle circuits a "Bright's Bell" in place of the single needle—an arrangement which will be found to aid despatch and lighten the labour of the clerk. The "Bright's Bell" is also largely used by the Great Northern between telegraph offices. The Lancashire and Yorkshire and the Great Eastern employ it on single-needle circuits in a similar manner to the Midland.

Although the "sounder" is very generally employed for railway message work in Ireland, it cannot be said to have taken root on English railways. For direct and long circuits it is occasionally used, but, it is believed, not to any great extent. For "quadruplex" working the demand does not appear to have been very urgent. It is employed by Mr. Hollins on the Great Eastern, between London and Harwich. "Duplex" working is employed on the Great Eastern, Caledonian, London and South-Western, and London and Brighton, and on the Midland. On the Midland a duplex circuit between Derby and London also provides for a phonopore communication. The phonopore is employed to a very limited extent on the Midland, Great Western, Great Eastern, Brighton, and North British lines. Telephones, as was to be anticipated, are now very generally employed for *viva voce* communications between signal boxes, and at busy centres between the administrative offices. That their employment largely aids the disposal of traffic there can be no question. At many points, and under exceptional conditions of weather, they are invaluable.

On the Continent, as well as at home, serious rumours have, from time to time, arisen with respect to the dissemination of disease by means of these instruments. It has been contended that a person suffering from throat or other internal affection, on speaking into a transmitter, may leave in the interstices of the instrument germs of the disease, which may be inhaled by others using the same instrument.

Fig. 13 represents a transmitter which has been designed with a view to obviate any such evil effect. The ordinary mouthpiece is removed, and in its place the entire face of the instrument is covered by a diaphragm, A, made of wood or metal—the former by preference—which encloses an air space, B, between it and the ordinary, or electrical, diaphragm C. On speaking in the neighbourhood of the outer diaphragm its vibrations are transmitted by the pressure of the enclosed air to the electrical diaphragm. Speech is marvellously clear, and only when used for long-distance telephony, as between London and Glasgow, is any diminution in the sound noticed, and then only in a very slight degree.

### Block-Signalling Instruments.

The practice of arranging the block-signalling instruments apart from the signal frame has with most companies been abandoned. As a rule, all block apparatus is now fixed on a shelf immediately over the signal frame, so that they may be readily manipulated by the signalman, and their indications remain present to his view.

With the exception of the introduction of Tyler's tablet block, and Messrs. Webb and Thompson's electric staff for working single lines, there is little of novelty in block instruments to record.

Interlocking the electric with the mechanical signals has made but little progress. The mileage of railway lines in Great Britain* worked under the absolute block is 26,398. A very small fraction of this has the electric signals interlocked with the mechanical signals.

It appears almost marvellous that the enormous traffic which now passes over our railways should be conducted with so few casualties under an arrangement which entails a perfectly independent action for both the electric and the mechanical signals. The former are provided for the regulation of the traffic between signal post and signal post; but where they are not interlocked with the mechanical signals, which are those which actually guide the engine-driver, they merely indicate to the signalman how he is to work his signals; they in no way control them! That so few casualties arise testifies in the highest degree to the care and watchfulness exercised

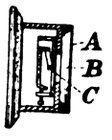


Fig. 13.—Telephone, with Wood Diaphragm.

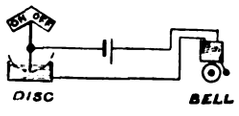


Fig. 14.—Repeater Disc.

by the signalmen to whom falls the duty of working the traffic under such conditions. The subject is one which may well lay claim to further consideration at the hands of some member of this Institution. In the meanwhile, it may be desirable to point out that the interlocking which has so far been employed is still wanting in finality. As now used, it is the first vehicle which releases the lock. Needless to say, it should be the last.

Electric "signal repeaters" and "light indicators" have become indispensable adjuncts. On the Midland there are no less than 3,000 of the former and some 800 of the latter in use, and with many other companies the number is no doubt as large.

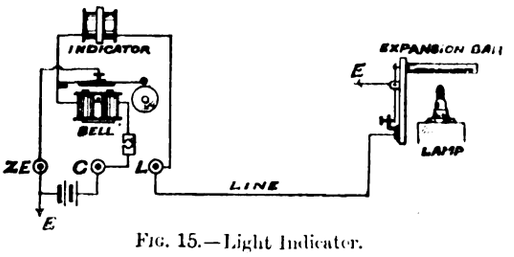


Fig. 15.—Light Indicator.

Another useful adjunct is that termed the "repeater disc," employed to indicate the movement of the lever of "slotted" signals. It differs from the signal repeater in that the indicator, when passing from the ON to the OFF indication, directs the signalman's attention to the alteration by ringing a bell (Fig. 14).

"Light indicators" should be so constructed that they may indicate any failure in the light by a continuous ringing of the bell. This entails the maintenance of the *Light In* signal by permanent current. Two No. 1 Leclanché cells work the instrument perfectly well. Fig. 15 is a diagram of the connections.

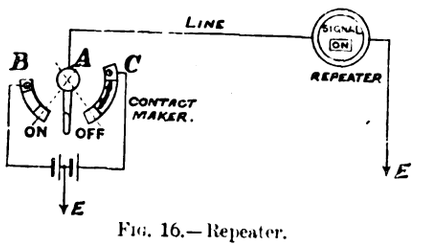


Fig. 16.—Repeater.

Fig. 16 it a diagram of the signal repeater arrangement, the batteries being placed at the signal post. The ON contact B is fixed, and the contact which the tongue-piece A makes with it is only sufficient to admit of a movement of 2deg. The contact C is adjustable. Samples are on the table.

### Batteries.

To the bichromate and Leclanché battery the author ascribes the palm of merit for a good and useful battery for railway purposes. For hard and constant work the former is unsurpassed. For occasional purposes, and for constant action, under certain limitations, the Leclanché commands attention. The old form of Daniell (sulphate of copper) battery, it is assumed, no longer finds a profitable field in railway telegraph work.

* *Extract from Board of Trade Returns, Year ended December 31, 1894.*

| | Total length of railway open for passenger traffic. | | Distance worked by absolute block. | | | |
|---|---|---|---|---|---|---|
| | | | Double line. | Distance of single line. | | |
| | Double. | Single. | | Worked by train staff system in addition. | Worked without the train staff system. | Worked on electrical train staff or tablet system. |
| | m. ch. | m. ch. | m. ch. | m. ch. | m. ch. | m. ch. |
| England and Wales | 9,281.49 | 4,376.55 | 9,266.69 | 2,263.18 | 42.39 | 1,680.66 |
| Scotland | 1,289.09 | 1,761.00 | 1,287.19 | 222.04 | 119.43 | 961.61 |
| Total for Gt. Britain | 10,570.58 | 6,137.55 | 10,554.08 | 2,485.22 | 162.02 | 2,642.47 |
| Ireland | 613.00 | 2,414.52 | 613.00 | 451.09 | 0.70 | 1,555.51 |
| Total | 11,183.58 | 8,552.27 | 11,167.08 | 2,936.31 | 162.72 | 4,198.18 |



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The Leclanché-Barbier cell is the latest development of the liquid Leclanché type of battery. It differs from the preceding types in the form of the positive element, together with other mechanical details. The positive element consists of a hollow cylindrical agglomerate of carbon and peroxide of manganese, around the upper part of which is cast a metal ring, caused to fit the neck of the jar, between which and the metal ring an india-rubber washer is inserted. The centre of the cylinder is covered by a wooden block, which serves to support the zinc and to close the jar. There is thus little possibility of evaporation; the cell is practically hermetically closed, and is in every way satisfactory.

The most recent innovation in batteries is the so-called "dry cell," but of them the author cannot profess to any lengthened experience. In their early days they were frequently disappointing and unreliable. Much of that has now been remedied; yet, it is doubtful if their employment in railways would be economical, for it would still be necessary to retain linemen and battery men, or assistant linemen, to attend to failures of instruments, &c., when such arose. General freedom from such failures would in no way modify this demand for the presence of the linemen. Failure at some time would be certain to arise. Whenever it did the lineman must be there promptly to attend to it, or the traffic would necessarily suffer.

I feel that, in submitting to your consideration so lengthy a Paper, I have largely encroached upon your time and patience. It has, however, been impossible for me to deal with the subject in less space, and equally impossible to divide it into two parts. I believe that you will, under these circumstances, generously accord me your kind indulgence. As it is I fear I may still have omitted some points of interest, and that possibly a want of knowledge of that which has been, or is being, done by others may even now render my treatment of the subject incomplete. Where such is the case I must trust to my *confrères* to supply any such deficiency in the discussion which the Paper may elicit.

*Post Office Tables for Stresses to be observed in erecting Iron Wires at various Temperatures.*

| Temperature in degrees Fahr. | Stresses in pounds for various spans in yards. 200lb. per mile (121mils. diameter, No. 10½ S.W.G.). | | | | | 400lb. per mile (171mils. diameter, No. 7½ S.W.G. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 50yd. | 50yd. | 70yd. | 80yd. | 90yd. | 50yd. | 60yd. | 70yd. | 80yd. | 90yd. |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| 22 | 135 | 135 | 135 | 135 | 135 | 270 | 270 | 270 | 270 | 270 |
| 25 | 120 | 124 | 127 | 128 | 130 | 239 | 247 | 253 | 256 | 259 |
| 30 | 103 | 110 | 115 | 119 | 122 | 205 | 219 | 230 | 238 | 243 |
| 35 | 91 | 100 | 107 | 112 | 115 | 182 | 199 | 213 | 223 | 230 |
| 40 | 83 | 92 | 99 | 105 | 110 | 165 | 184 | 198 | 210 | 219 |
| 45 | 77 | 86 | 94 | 99 | 105 | 153 | 172 | 187 | 199 | 210 |
| 50 | 72 | 81 | 89 | 95 | 101 | 143 | 161 | 177 | 190 | 201 |
| 55 | 67 | 77 | 85 | 91 | 97 | 134 | 153 | 169 | 182 | 194 |
| 60 | 64 | 73 | 81 | 88 | 94 | 127 | 146 | 162 | 175 | 187 |
| 65 | 61 | 70 | 78 | 85 | 91 | 121 | 139 | 155 | 169 | 181 |
| 70 | 58 | 67 | 75 | 82 | 88 | 116 | 134 | 149 | 163 | 175 |
| 75 | 56 | 64 | 72 | 79 | 85 | 111 | 129 | 144 | 158 | 170 |
| 80 | 54 | 62 | 70 | 77 | 83 | 107 | 124 | 140 | 153 | 165 |
| 85 | 52 | 60 | 68 | 75 | 81 | 103 | 120 | 135 | 149 | 161 |
| 90 | 50 | 58 | 66 | 73 | 79 | 100 | 117 | 132 | 145 | 155 |
| 95 | 48 | 56 | 64 | 71 | 77 | 97 | 113 | 128 | 142 | 157 |
| 100 | 47 | 55 | 63 | 69 | 75 | 94 | 110 | 125 | 138 | 150 |
| Poles per mile ... | 35 | 29 | 25 | 22 | 19½ | 35 | 29 | 25 | 22 | 19½ |

Factor of safety of 4 at 22 F. for all wires.

The stress varies with both the gauge and the material.

The stress for 100lb. (No. 14) copper wire is half that for 200lb., and the stress for 800lb. (No. 4½) copper wire is double that for 400lb.

*Post Office Tables for Copper Tape Binders.*

| Line. | Weight of wire per mile. Approximate Gauge. | Binder. | Length of Binder. | Copper Tape. Length. | Width. |
|---|---|---|---|---|---|
| Lb. | | Lb. | Inches. | Inches. | Inch. |
| 800 | 4½ | 400 | 19 | 24 | ¼ |
| 600 | 6 | 400 | 19 | 24 | ¼ |
| 400 | 8 | 200 | 19 | 23 | 7/32 |
| 200 | 11½ | 150 | 17 | 22 | 5/32 |
| 150 | 12½ | 150 | 17 | 22 | 5/32 |
| 100 | 14 | 100 | 17 | 22 | 5/32 |

## DISCUSSION.

Speakers who have returned their proofs revised are denoted by an asterisk.

*Mr. LANGDON read letters from Mr. Graves, of the North-Eastern Railway, and Mr. W. H. Preece. The former said that the first copper wire he erected was in July, 1871, between the Newcastle station yard and the Gateshead yard, and he employed copper wire in a number of other places before the line at York, put up at York in 1877, and alluded to in the Paper as the first. Mr. Preece thought the author was wrong in saying that Mr. Graves was the first to put up copper wire. All the wires erected between Paddington and Slough, the first ever put up, were of copper. The great start in copper was when he (Mr. Preece) induced Mr. Patey to run a copper wire from London to Newcastle, which proved that it not only reduced resistance, but increased capacity, eliminated electromagnetic inertia, and also increased the speed of working. They also introduced copper for the Post Office telephone circuits with the same objects in view.

*Mr. WYLES said he was not prepared to discuss Mr. Langdon's Paper with regard to telegraphic arrangements, because they generally accepted what was done on the Midland Railway as the best that could be done; that was well-known amongst railway telegraph engineers. But the question of interlocking had not been dealt with very far, and Mr. Langdon almost invited another Paper to be read on that subject. He might say that all the congested traffic out of London, at any rate on the southern side, was controlled electrically. On the South-Western Railway, from Waterloo as far as Esher and Twickenham, everything was interlocked, and they were extending that very largely. From Cannon-street to London Bridge on the South Eastern and a considerable way down everything was interlocked; and the same thing was true of the Brighton line and the Great Eastern. On the South-Western especially they were largely called upon to assist the mechanical department by doing a lot of work electrically which could not be done mechanically. Electrical fouling bars were coming very much into use, and were put down by the telegraphic department, but were

APPENDIX.—*Post Office Tables for Stresses to be observed in erecting Copper Wires at Various Temperatures.*

| Temperature in degrees Fahr. | Stresses in lb. for various spans in yards. 150lb. per mile (97 mils. diameter, No. 12½ S.W.G.) | | | | | 200lb. per mile (112 mils. diameter, No. 11½ S.W.G.) | | | | | 400lb. per mile (158 mils. diameter, No. 8 S.W.G.) | | | | | 600lb. per mile (193 mils. diameter, No. 6 S.W.G.) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 yd. | 60 yd. | 70 yd. | 80 yd. | 90 yd. | 50 yd. | 60 yd. | 70 yd. | 80 yd. | 90 yd. | 50 yd. | 60 yd. | 70 yd. | 80 yd. | 90 yd. | 50 yd. | 60 yd. | 70 yd. | 80 yd. | 90 yd. |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| 22 | 120 | 120 | 120 | 120 | 120 | 160 | 160 | 160 | 160 | 160 | 320 | 320 | 320 | 320 | 320 | 480 | 480 | 480 | 480 | 480 |
| 25 | 96 | 102 | 106 | 109 | 111 | 129 | 176 | 142 | 145 | 148 | 258 | 272 | 284 | 290 | 296 | 386 | 409 | 425 | 436 | 444 |
| 30 | 76 | 84 | 91 | 96 | 99 | 102 | 113 | 121 | 128 | 133 | 204 | 226 | 242 | 256 | 265 | 306 | 338 | 364 | 383 | 399 |
| 35 | 65 | 74 | 81 | 86 | 91 | 87 | 98 | 108 | 115 | 122 | 174 | 196 | 216 | 230 | 244 | 262 | 295 | 323 | 345 | 365 |
| 40 | 58 | 66 | 73 | 79 | 84 | 77 | 88 | 96 | 106 | 113 | 154 | 176 | 192 | 212 | 225 | 232 | 265 | 294 | 318 | 338 |
| 45 | 52 | 61 | 68 | 74 | 79 | 70 | 81 | 90 | 98 | 105 | 140 | 162 | 180 | 196 | 210 | 211 | 243 | 271 | 296 | 317 |
| 50 | 48 | 56 | 63 | 69 | 75 | 65 | 74 | 84 | 92 | 100 | 130 | 148 | 168 | 184 | 200 | 194 | 223 | 253 | 277 | 299 |
| 55 | 45 | 53 | 59 | 65 | 71 | 60 | 70 | 79 | 87 | 94 | 120 | 140 | 158 | 174 | 183 | 182 | 211 | 238 | 262 | 284 |
| 60 | 42 | 50 | 56 | 62 | 67 | 57 | 66 | 75 | 83 | 90 | 114 | 132 | 150 | 166 | 180 | 171 | 200 | 226 | 250 | 270 |
| 65 | 40 | 47 | 53 | 59 | 65 | 54 | 63 | 71 | 79 | 86 | 108 | 126 | 142 | 158 | 172 | 162 | 189 | 214 | 238 | 260 |
| 70 | 38 | 45 | 51 | 57 | 62 | 51 | 60 | 68 | 76 | 83 | 102 | 120 | 136 | 152 | 166 | 153 | 181 | 205 | 229 | 249 |
| 75 | 37 | 43 | 49 | 55 | 60 | 49 | 58 | 66 | 73 | 80 | 98 | 116 | 132 | 146 | 160 | 147 | 175 | 197 | 220 | 240 |
| 80 | 35 | 41 | 47 | 53 | 58 | 47 | 55 | 63 | 71 | 77 | 94 | 110 | 126 | 142 | 154 | 141 | 166 | 190 | 212 | 232 |
| 85 | 34 | 40 | 46 | 51 | 56 | 45 | 53 | 63 | 68 | 75 | 90 | 106 | 122 | 136 | 150 | 136 | 160 | 183 | 205 | 225 |
| 90 | 33 | 39 | 44 | 49 | 54 | 44 | 52 | 59 | 66 | 73 | 88 | 104 | 118 | 132 | 146 | 131 | 155 | 177 | 199 | 218 |
| 95 | 32 | 37 | 43 | 48 | 53 | 42 | 50 | 57 | 64 | 71 | 84 | 100 | 114 | 128 | 142 | 127 | 150 | 172 | 191 | 212 |
| 100 | 31 | 36 | 42 | 47 | 52 | 41 | 48 | 56 | 62 | 69 | 82 | 96 | 112 | 124 | 138 | 123 | 146 | 167 | 188 | 207 |
| Poles per mile. | 35 | 29 | 25 | 22 | 19½ | 35 | 29 | 25 | 22 | 19½ | 35 | 29 | 25 | 22 | 19½ | 35 | 29 | 25 | 22 | 19½ |

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always asked for by the mechanical department to assist them in working and to help the traffic and secure greater safety. They had a good many cases where signals were thrown to danger electrically. With regard to single lines, they had an arrangement on the South-Western which was devised by Mr. Sykes – and he (the speaker) had a good deal to say in the matter—by which the starting signals were controlled so that they could not lower the starting signal unless the tablet was drawn.

*Mr. GOLDSTONE thought there was a printer's error in the Paper where there was an allusion to duplex working on the London and South-Western Railway. He thought that was meant to be the London and North-Western, for they had nothing of the kind on the South-Western service. He must also say that he was somewhat surprised to find that so little was being done generally throughout the Kingdom in connection with interlocking. On the South-Western they had at the present moment in use something like 150 miles of electrical interlocking. They had large orders in hand, and he apprehended that by the end of the year quite a third of the line would be interlocked, and certainly all the busy portion of it. As Mr. Wyles remarked, they were also called upon to enable the trains to throw up signals electrically as they passed them; in fact, at no period in his experience had they been making greater progress than at this moment, principally in connection with interlocking.

*Mr. C. E. SPAGNOLETTI said the Paper wanted carefully digesting before it could be discussed properly, but they must compliment Mr. Langdon for giving them so much information, a good deal of which, he had no doubt, was new to the younger members of the Institution. There were one or two points in the Paper that needed a little discussion; and for one thing he rather took exception to the system of poles described by Mr. Langdon in Figs. 1 and 2. The H-pole system, as they called it, had been used for a considerable time, and he thought he could suggest an improvement on Mr. Langdon's method. If they looked at the diagrams they would notice that the cross pieces of the poles were bolted through. If one of these poles were to sink the cross pieces at the bottom of the poles caused a hinge, as it were, on the other pole. It was true the iron cross-piece in the middle of the poles would, to a certain extent, stop sinking, and also the cross-arms; but it would put a very heavy strain on the upper portion of the pole. On his line they generally, instead of having them on one side of the pole, put one at the bottom, and so had a bottom bearing, which gave a much more substantial position to the pole, and then they generally put two cross-pieces of wood bolted through between the two poles, which made a stronger structure of it. In the pole shown in Fig. 2 there were no cross pieces at all. If either pole were to sink, all the strain was put on the cross-arms. He thought, perhaps, if Mr. Langdon looked at that system closely he would find that an alteration for the better might be made in that respect. With regard to staying poles, that was a most important matter, and one that he took up very strongly, because they had had such great difficulty in staying the poles properly, and he introduced a method of screw stay-rods to get out of the difficulty. It helped them to a great extent, but he found after some years' work that the heads of the bolts pulled through the blocks of work, although creosoted, through decay. He substituted then a stay plate, an iron plate, where the rod went through a hole with a flange each side to support it and to prevent it from turning. They never found any of them draw at all, and being made of cast iron they lasted very well underground. The iron arms he had not done very much with, but they did not always earth-wire the arms, as was done now. In connection with this staying question, Mr. Langdon also spoke of the snow falling on the wires. The stays were, of course, of very great assistance in the case of snowstorms. They had had lines for 30 or 40 miles broken down, and the poles dragged down in a shocking state. Snow attached itself to the wires and soon became covered with ice, presenting a considerable surface to the wind, which would break the wires and the poles would go down by the strain on the other side. The difficulty thus caused had been got over to some extent by staying the poles with the wires as well as laterally. If they stayed a pole first on the right side, and then another four or five poles away on the left side, that would limit the breaking down, for four or five poles, at any rate. With regard to insulation, Mr. Langdon stated that he had adopted on the Midland a system having one gauge of iron wire, No. 8, and one class of insulator. That was a good thing to do, and he thought most lines used one class of insulator now; but he did not see why, in open country, iron wire should not be used. Mr. Langdon seemed tohave a great preference for copper wire. There was no doubt that for lightness and conductivity it was an excellent wire to use, but on country branch lines, where they had a pure atmosphere, they did not know the end of iron wires. He (the speaker) knew of some which had been up for 35 years, and were still very good wires. It was much cheaper, as Mr. Langdon showed in the prices he had given. Copper wire, too, was very difficult to handle, and required great care on the part of the men who put it up. If they saw the elaborate instructions issued for the handling of copper wire they would be frightened to use it. With regard to the terminal insulator, that was a very good insulator indeed. The only fault of that as against the old shackle was that although it was a better insulator it was considerably more liable to pull over because of the strain at the top and the fixture at the bottom. With the shackle there was an equal strain at the top and bottom. This insulator made a very good system where they had to join wires together, as Mr. Langdon had shown, but he did not think it had any advantage over the shackle in sustaining the wire in case the earthenware or porcelain got broken. The leading-in cups shown in Fig. 6 were very excellent things, but they could not be considered a new introduction. Mr. Latimer Clark introduced them a good many years ago. Then with regard to the shortness of life of the iron wire, that depended entirely on the position where it was fixed. In South Wales, in the copper smoke, it lasted three years; in Birmingham, four or five years; and in London, six to seven years. The covering of the wire, West's compound, was a very excellent one indeed. They had found that if they warmed their wire and put it into boiling tar, and then sanded it with fine sand from the ironstone, it was coated with an enamel that was better than any other compound they had ever seen. There was some wire of that description put up between Wolverhampton and Worcester, and the iron beneath the enamel was as bright now as when it was put up 35 years ago, and was in excellent condition. It made a splendid preservative against atmospheric effects on the wire. But the worst of copper wire was that it was so liable to be damaged when being put by the draw-vice; it very often had to be painted over again and tarred over in order to cover those places up: otherwise the strongest link in the chain would become the weakest. The interlocking system had been adopted entirely on the Metropolitan Railway from one end to the other. They had a system also for shunting and protecting trains when on the wrong line or crossing from one line to the other. If a train on the up line had to cross to the down line, the up line was blocked; whilst it was crossing both lines were blocked; and when it was on the down line the up line was free and the down line was blocked. They used to have the iron tubing represented in Fig. 11, but they found that very often workmen with their pickaxes would break the tubes and damage the wires, and they found it better to put a thick oak or elm sheathing over them, so that the workmen would learn of their presence before doing any harm. The phonopore telephone was being used on a great many railways: this gave them the opportunity of speaking over the telegraphic wires whilst they were at work, and of holding a running conversation without any difficulty whatever. They could divide a long wire up into several short circuits by taking the connections from the telegraph wires into the administrative or other offices and making circuits as they wished, thereby telegraphing and telephoning at the same moment.

*Mr. CHARLES BRIGHT asked whether it was the custom to use gutta-percha for the underground wires instead of india-rubber, and why in using gutta-percha pains seemed to be taken to avoid moisture. He thought moisture was rather a good thing than otherwise. Was it the ozokerited tape that was damaged by the moisture or the gutta-percha?

*Mr. VON FISCHER TREUENFELD said telegraph engineers ought to be very much obliged to Mr. Langdon for bringing this subject forward. He was very pleased to see that at least one branch in telegraphy was not regarded as having reached finality, that of interlocking. He thought they would agree with him that not merely one, but a good many branches in telegraphy were still wanting in finality, and the general opinion which in recent years had prevailed was wrong, that the limit of the sphere of action of telegraphy had been reached, and that there was no further field for energy and intelligence to develop. They could suggest to the younger members of the electrical fraternity a splendid field for energy and development. With regard to the Paper, there were one or two points he would like to mention. The author referred to Mr. Alexander Siemens in connection with iron poles, and as Mr. Siemens was not present, he (the speaker) might, perhaps, be allowed to answer the questions in his stead. Iron telegraph poles had been very much and very successfully employed, especially in the Colonies, in consequence of their greater stability and greater ease of transport over long distances. But there was a strange fact, which iron manufacturers could probably better explain than telegraph engineers, and that was that iron telegraph poles of certain dimensions would not stand the breaking strain nowadays that they would 25 years ago. This fact had led to the necessity of devising new methods of construction which would give the poles greater stability, and Mr. Siemens had succeeded in doing this, and had taken out a patent for a pole of very simple arrangement. The lower part was of cast-iron tubing, and the upper portion of wrought-iron tubing. At first the top part was cemented to the upper 6in. or 9in. of the lower tube; but it was found that these poles broke at the joints, and Mr. Siemens had constructed a pole in which the upper tube was not fastened to the top 6in. or 9in. of the lower tube, but went right down inside to the bottom of the conical shaped bare tube. This gave a very solid pole, much stronger than the older form. If he might be allowed he would like to say a word or two against the employment of copper wire. He was fully aware of all the advantages of copper over iron wire. The electrical capacity and the consequent increase of speed in working, which amounted to something like 30 per cent., was enough to give the preference to copper over iron. He had in mind the very poor breaking strain of copper wire. The electrical resistance, as compared with that of iron, rose very nearly inversely as its price per ton, so that if they had to replace iron at 12½ ohms per mile by copper wire, they had to choose a No. 14 or No. 16 wire of 0·069 diameter. The breaking strain of the 7½ iron wire was about 1,300lb., but that of the 14 copper was only 290lb. If they adopted the rule that the tension of the span of the wire should not exceed a quarter of the actual breaking strain of that wire, there would be left a reserve breaking strain of 867lb. for the iron wire, and only 193lb. for the copper wire to oppose any extra tension or load such as would be caused by the accumulation of snow or the pressure of wind. It came to this, that telegraph lines erected of copper wire during a snowfall combined with wind were much more likely to succumb than those constructed of iron wire. He would ask the experience of Mr. Langdon with regard to the breaking down of copper wires in snowstorms.

*The PRESIDENT said it had long been an opprobrium to the Institution that they had no Papers from railway telegraph engineers, but Mr. Langdon had certainly removed that opprobrium, and he believed at great inconvenience to himself.

*Mr. LANGDON, replying to the points raised in the discussion, said no doubt interlocking had progressed during the last three or four years to a considerable extent on the lines mentioned, but particularly on the South-Western and Great Eastern. There was no doubt this interlocking was a most desirable thing; but it was to be regretted that in undertaking this matter the companies should not have dealt with it in a more final manner. As he stated in the Paper, it was the first vehicle which gave relief to the block section. A train entering a section put on the starting signal automatically, and the block signals were put on

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by hand; those block signals controlled the mechanical signals, and they remained locked until the train passed out of the section. If a train happened to be divided, the second portion remained in the section, and if one vehicle passed over the redress point that enabled the signalman to clear the train and another train might then come in and cause a serious accident. Therefore the present system had no finality about it, and it would be well for the railways companies to consider the matter further. Complete safety was only to be attained by attaching to the last vehicle of the train something which should give the signal "train out of section." If the train divided that vehicle would remain on the line and the signal would not be cleared. Mr. Wyles had mentioned that electricity was rendering considerable aid in what he termed the mechanical departments, that is to say, that it had taken the place of mechanical appliances; Mr. Treuenfeld also indicated that there was a larger field. That was undoubtedly so, and it was only necessary for railway engineers to associate themselves with other branches of the service to find out those places where it could be applied and make use of it. Mr. Goldstone had corrected him with reference to duplex working on the South-Western Railway. He was not aware that he had made the mistake, but if he found it was the case, he would correct it. Mr. Spagnoletti took exception to the "H" pole system; he had probably forgotten the diagonal piece at the bottom, the object of which was to prevent that scissors motion which Mr. Spagnoletti thought would arise. There was nothing, of course, to prevent one pole sinking more than another. That was why in planting the second pole he allowed it to stand for a time before trying to consolidate the structure by putting on the cross arms. The proof of the pudding was in the eating, and the point was that they had erected some hundred miles of those poles and had not found one sink more than the other. He did not think he was entitled to any credit in the matter, because he believed it had been done by other engineers before, although perhaps not to any great extent. Then Mr. Spagnoletti pointed out that the stay rods sometimes pulled out. He never knew them do so unless the blocks were rotten. In all stay rods there was a plate at the bottom of the block, and the head of the rod banked upon that plate; that ought to prevent it from going through unless it was very rotten.—[Mr. SPAGNOLETTI: I referred to rotten ones].—If they were creosoted they ought not to rot. With reference to lateral staying, he had not mentioned it, but it was a practice pursued by him for many years. It had been the case that they had had a serious breakdown, and the wires ran back. The way to prevent that was to have lateral stays at every tenth pole where the poles exceeded 20. Mr. Spagnoletti also mentioned his experience that iron wire lasted 35 years. He could only congratulate Mr. Spagnoletti on having such a locality; he wished he had such. Either the districts where his Company's lines ran were more smoky or their wire was very inferior. It had been said that there was a difficulty in the handling of copper wire. He had not experienced it; the men under his direction found no difficulty. They had to be careful not to pull it up too tight, but they had their tension tables, which showed them the amount of strain to put on the wire in putting it up; they complied with that, and there was no difficulty whatever. There was no question that the shackle had a much more direct influence upon a wire than a terminal insulator. There was not the leverage about it, the strain came direct in the loop, but at the same time it was an inferior insulator. Mr. Spagnoletti might also be quite right with reference to leading-in cups, although he (the speaker) did not remember their being in use at the time mentioned. As to wire being steeped in boiling tar, it occurred to him the value of tar as a protective resided mainly in the oil it possessed, and when that oil evaporated under the influence of the sun there was nothing but the sediment left, which would be a very poor protection for the wire. That was his experience. At the same time he must admit he had not heated wire and steeped it in boiling tar. With respect to the phonopore, his Company had enjoyed its use to a limited extent, and if those who had the phonopore in their hands could only arrange it in such a manner that it would dispense with the induction they got from it it would be an excellent instrument. The induction interfered with their telephones, and they get nothing but complaints. Mr. Charles Bright asked why gutta-percha was used for underground work rather than india rubber. Gutta-percha had been used for a good many years. India-rubber, he had no doubt, was equally good. It became more plastic when exposed to the air. If they could keep gutta-percha always in the water undoubtedly that would be the best thing to do, but that was an impossibility, and if they had it sometimes dry and sometimes wet it soon became porous. Mr. Treuenfeld called attention to iron poles. Iron poles had been tried, to a certain extent, on railways, but they were not large enough or strong enough for their purposes unless they went to great expense—such an expense as would be wasteful in comparison with creosoted poles. Then Mr. Treuenfold objected to copper wire, as compared with iron wire, and he had strengthened his argument somewhat by reference to the accumulation of snow on wires. It was very strange, but he found very little difference between the amount of snow gathered by the iron wire and that gathered by the copper wire, although one might be much larger than the other. At all events, the experience they had was that copper wire stood just as well as the iron.

## BOOKS RECEIVED.

"Les Applications Mécaniques de L'Energie Electrique." By J. Laffargue. (Paris: J. Fritsch.)

"An Elementary Treatise on the Calculus for Engineering Students." By John Graham. (London: E. and F. N. Spon.)

"University Physics." Part II. By H. S. Carhart. (Boston: Allyn and Bacon. Price $1.50.)

## THE EVOLUTION OF THE STORAGE BATTERY.*

BY MAURICE BARNETT.

The history of the advances which have been made in producing electricity by chemical means is traced from the time of Gauterot in 1801, to 1859, when Planté made a systematic examination of polarisation effects with the view to their utilisation, and brought out his well-known form of battery, zinc, iron, and even copper, which on account of the energy they develop during chemical action, would be even more efficient than lead for the purpose of battery construction, but are objectionable on account of the solubility of their salts. Lead furnishes salts which are practically insoluble in the electrolyte. The influence which this insolubility exerts in diminishing local action is apparent on consideration. The peroxide and the metallic lead of the positive and negative plates, respectively, are both converted into sulphate during discharge. The same reaction takes place as the result of local action. Now as this sulphate forms, it gradually encloses the remaining active-material, and protects it from further loss. Again, the fundamental principle of the storage battery is the possibility of reversing the physical and chemical changes which take place during each discharge. With soluble electrodes, the difficulty that lies in the way of the redeposition of the metal in an efficient form seems almost insuperable. Up to the present day, effort after effort has been made to accomplish this, but without anything like a satisfactory result. The consequence is that recourse has been had to electrodes which are either insoluble, or which, like lead, form salts insoluble in the electrolyte. At the present time lead is the only metal used to any extent in the manufacture of storage batteries. Zinc and copper have been used with lead in what are known as the Reynier and the Sutton cells, while zinc has been used with copper in the Thomson-Houston and the Waddell-Entz cells. This departure from the lead type of battery has not been attended with success. Lead seems to be the only metal of which it can be said that it is easy to reproduce both the physical and chemical changes which take place in the electrodes during discharge, and this reversal may be repeated almost indefinitely without the plate showing much deterioration. Two other properties of lead adapt it for use in the construction of storage batteries—first, the conductivity of its peroxide, and, secondly, the high E.M.F. furnished by a lead and lead peroxide couple in dilute sulphuric acid.

Between 1859, when Planté began his experiments, and 1880, when Faure invented the pasted battery, the dynamo-electric machine had been perfected, and offered the means for the cheap production of currents of great density and high E.M.F. This circumstance put the storage battery on a different footing, and held out a promise of its future utility. Faure's invention had for its object the reduction of the time and cost of the Planté process of formation, and consisted in coating the plates with red lead and litharge respectively. Scarcely had the Faure plate been brought out than accumulators were put to a variety of uses, and as far back as 1883 an electric car furnished with a Siemens dynamo used as a motor, and about 4,000lb. of batteries, was run at Kew Bridge.

The storage battery was put upon the market in a crude and undeveloped form before it had been sufficiently studied by the chemist and the physicist, and improved by the manufacturer. In addition to this, it was applied to a variety of purposes for which in its early form it was notoriously unfit. Failure resulted, and the prejudice thus created still exists, although secondary batteries as now manufactured give satisfaction. So great an improvement was the Faure battery supposed to be over that of Planté, that between 1880 and 1890 it was thought that no commercial storage battery could be made that was not of the pasted type. Recently the Planté type has again come into favour, together with an improved form of battery known as the chloride accumulator. These are all lead batteries. Planté batteries are made in diverse forms. In the first place, there are the solid plates with striated surfaces. Then there are the various forms of laminated plates, where the greater part of the body of the plate consists of ribbons of lead. Then again there are other forms where porosity is given to the lead by kneading it hot with some porous material, which may afterwards be dissolved out. The objects aimed at by increasing the surface of the lead per pound of material, are: first, to facilitate the forming process (it is easy to see that the more surface there is, the more lead will be exposed to the electrolyte, and the more quickly will electrolytic action accomplish the requisite formation); second, to increase the capacity of the plates, *i.e.*, the ampere-hour output per pound of the elements; third, to permit changes of volume to take place in the active material without prejudice to the life and efficiency of the cells. The plates are sometimes formed by the Planté method, and sometimes by an electro-chemical treatment which quickens the process. The characteristics of the Planté type of battery are: capability of giving heavy discharges without sustaining

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injury, minimum local action, and general freedom from the irregularities due to local action. In the Faure type of cell, a paste of minium or litharge respectively is applied to the plates, which may be perforated or solid, and their formation is then completed by electrolysis. When these cells go into service local action occurs between the active material and its support, which, amongst other things, leads to the loss of the charge of the battery and to the formation of lead sulphate, which weakens the contact between the paste and the grid. Expansion takes place in every direction in the active material, which is an ordinary mechanical mixture, with the result that it falls away, causing short circuits between adjacent plates and deteriorating the cell. The Tudor positive is a modern form of pasted plate, which requires special mention. The plate is heavy and thick, and provided with grooves or channels to support the active material. A paste of red lead is applied to both sides of the plate, which is then formed electrolytically. This form of battery is specially adapted to central station work, as it is capable of yielding the whole of its discharge in one or two hours, and is employed in 80 per cent. of the central stations in Prussia and Austria. The lead chloride battery takes its name from the fact that its active material is prepared from lead chloride rather than from metallic lead, as in the Planté type. Lead chloride is cast into small pastilles, with bevelled edges. These, spaced in moulds, have antimonial lead cast around them under pressure. The resulting plates, alternating with sheets of zinc, with which they are in dead short-circuit, are then placed in a solution of chloride of zinc, and allowed to remain until the zinc chloride has been dissolved out and the lead brought to a metallic state. The active material of these plates is porous, and of a fine crystalline structure. The positives are formed electrolytically. The claims made for this battery are: (1) Good contact between the active material and support, owing to the bevelled edges of the original chloride tablets, and the lead forced around them under pressure; (2) that the crystalline formation allows of changes of volume without undue strain being set up; (3) that the cohesion of a crystalline mass is always greater than that of a mechanical mixture; (4) that the porous condition of the active material secures large capacity per pound of elements; (5) that the porous condition facilitates formation. These claims appear to be substantiated in practice. Choride batteries are Planté cells, but differ from this type in that the lead which is to furnish the active material is prepared separately from the rest of the plate. Choride negatives are said to be the best which have yet been produced, and are largely used with other forms of positives.

## DISCUSSION.

Mr. C. J. REED stated that there were some points raised in this interesting and instructive Paper on which he was unable to agree with the author. The reduction of lead sulphate was stated by him, as it was generally stated by others, to be affected by the action of nascent hydrogen. In other words, it is held that the electric current first decomposes the solution, liberating hydrogen and oxygen; that the hydrogen reacts on the lead sulphate, producing metallic lead and sulphuric acid, while the oxygen at the positive plate acts upon the lead sulphate and water, producing lead peroxide and sulphuric acid. There is no evidence to substantiate the theory of this double reaction, and we have every reason to believe that the charging of the accumulator results directly in the electrolysis of lead sulphate on both plates, as stated by Leibenow in the *Zeit. f. Electrochem.*, January 5, 1895. If oxygen and hydrogen are produced as the first step by the current, we have no way of knowing it, since the gases are not evolved. Pure, chemically precipitated $PbSO_4$ is easily changed to $PbO_2$ and Pb by the electric current, references to the contrary notwithstanding. If a paste of pure $PbSO_4$ and pure water be placed between lead or platinum electrodes, and a current passed through the mixture, the paste is rapidly converted into $PbO_2$ and Pb. In this case, at least, there can be no decomposition of the $H_2O$ at the beginning, since pure water is not an electrolyte, and no $H_2SO_4$ is present. The formation heat of PbO is 55,350 calories, corresponding to an E.M.F. of 1·19 volts, and that of $H_2O$ is not less than 68,360, corresponding to 1·47 volts. The formation heat of $H_2SO_4$ (assuming $H_2$, $O = 68,360$ and $SO_3$, $H_2O = 21,310$) is 89,680, and that of dilute sulphuric acid 107,530 calories, corresponding respectively to 1·93 and 2·22 volts, whilst that of $PbSO_4$ is only 75,552 calories (not 145,130 as given by Mr. Barnett) corresponding to 1·63 volts. It is known also that $H_2O$ is not an electrolyte and could not be decomposed. The liberation of hydrogen, therefore, will require greater E.M.F. than that of lead, and there is no more reason to suppose that the reduction of lead sulphate is effected by nascent hydrogen than there is to suppose that the latter effects the deposition of copper in electroplating. It is merely a question of whether lead or hydrogen has the greater heat of combination per electro-chemical equivalent. This explains the absence of gassing on the commencement of charge, as the current is all employed in the decomposition of lead sulphate on both plates according to the equation—

Pos. plate. Neg. plate.

$$PbSO_4 + 2H_2O + PbSO_4 = Pb + PbO_2 + 2H_2SO_4.$$

As the lead sulphate is used up during charge the current begins to decompose the solution with the evolution of free oxygen and hydrogen, and this accounts for the higher E.M.F. required towards the end of the charge. The only products of discharge are, as stated by Messrs. Gladstone and Tribe, $H_2SO_4$ and $PbSO_4$, the latter mixed in varying proportions with $PbO_2$ on the one plate and with Pb on the other. The only lead products of the charging process that have ever been found are lead and lead peroxide. Under these circumstances there is formed on the solution some $H_2O_2$, $O_3$ and $H_2S_2O_8$, but no lead persulphate or any other compound of lead except the peroxide. If any lead persulphate were formed incidentally in charging, it would immediately be dissolved in the solution, and could no longer be considered a part of the active material of the electrode. Its gradual spontaneous decomposition would cause a white precipitate of lead sulphate in the bottom of the cell. But to consider such a product as the normal result of charging an accumulator, or as an intermediate step in the formation of lead peroxide is out of the question. If such were the case the positive plate would go into solution the first time it was charged. The only lead persulphate known to exist is so highly soluble that it can be brought into the solid state only by evaporating its solution in vacuo. The second question raised in the Paper with which Mr. Reed cannot agree is the statement that an insoluble active material is necessary or desirable in an accumulator to prevent local action. Any insoluble coating that prevents local action must also interfere with the normal action of charge and discharge.

Mr. BARNETT: The electrolytic decomposition of $PbSO_4$ is more difficult than Mr. Reed supposes, and he will find it hard to prove that it is effected without the agency of hydrogen. Lord Kelvin and Dr. Lodge objected originally to the lead sulphate theory of the action of accumulators because of the impossibility of reducing lead sulphate, and even Gladstone and Tribe showed that it was only partially reduced after days of electrolytic action. There is nothing in the nature of lead persulphate to preclude it being an intermediary in the conversion of $PbSO_4$ into $PbO_2$. Admitting its solubility, it must be remembered that it is an endothermic compound, and is decomposed as soon as formed with the production of $PbO_2$ and regeneration of $H_2SO_4$. It could not, therefore, disperse through the electrolyte. Dr. H. Marshall, in Vol. LIX. of the *Journal* of the Chemical Society, London, describes the action of PbO on ammonium persulphate, which gives rise to the formation of water, lead persulphate, and ammonia according to the following equation:—

$$(NH_4)_2(SO_4)_2 + PbO = Pb(SO_4)_2 + H_2O + 2(NH_3).$$

This lead persulphate in presence of water yields lead peroxide and sulphuric acid as follows:—

$$Pb(SO_4)_2 + 2H_2O = PbO_2 + 2H_2SO_4,$$

which explains why no soluble persulphate of lead is found in the electrolyte, for it has been decomposed. Gore, on p. 40 of his "Electrolytic Separation of Metals," gives the heat of formation of $PbSO_4$ on Thomson's authority as 145,130 c.g. calories, and the chemical equation of the discharge of the lead cell with the corresponding heats of formation of the substances produced shows that there is no ground for doubting the accuracy of the above figures. The electrolytic equation of the action of lead accumulators may be written as follows:—

$(2PbSO_4) + (2H_2O) - 2H_2SO_4 19H_2O)$
290,260 + 136,720 − 277,280 app.
$+[\text{Electrolyte} + 2\,19H_2O + H_2O)] - PbO_2 = 90,970$ c.g. calories.
+3,520 − 62,300

Apply Sir W. Thomson's rule, and we get an E.M.F. of 2 volts, which agrees with the results attained in practice. The E.M.F. required for charging is sufficient to decompose the electrolyte and to break up $PbSO_4$, and when that compound is broken up the $SO_4$ is not transferred to the positive plate, but combines at once with the hydrogen to form hydrogen sulphate. There are endothermic compounds (or those which *absorb* heat when their constituents unite), as well as exothermic compounds, which give out heat when their constituents unite. It makes no difference, therefore, whether the heat of formation of $H_2SO_4$ is greater or less than that of $PbSO_4$. In 1878 Berthelot discovered persulphuric acid, and showed that it was the primary product at the positive electrode when dilute $H_2SO_4$ was electrolised, and yet, according to Mr. Reed, such a compound could not be formed because it absorbs heat. Mr. Reed knows that in charging an accumulator there is consumed nearly 20 per cent. of energy in excess of what is needed to overcome electrical resistance. Does it not occur to him that part of this is used in effecting endothermic combinations? If the E.M.F. of a charging current were capable of decomposing $PbSO_4$ *without decomposing the electrolyte*, then we could have the reaction given by Mr. Reed:—

$$PbSO_4 + 2H_2O + PbSO = PbO_2 + Pb + 2H_2SO_4.$$

But, as a matter of fact, the charging current is always capable of decomposing the electrolyte, therefore the hydrogen formed at the negative plate must combine with the $SO_4$ simultaneously liberated there. If we reject this view, we must consider that when the electro-negative ($SO_4$) of the $PbSO_4$ is attracted to the positive pole, the electro-positive (Pb) is attracted to the negative pole, with the result that under continuous charging the negative plate ought to have deposited on it an amount of lead which is only limited by the existence of the positive plate. This view is absurd, but it is the logical outcome of the hypothesis that the independent electrolysis of $PbSO_4$ is concerned with the charging reactions of the lead cell. Lastly, as regards the necessity or desirability of having insoluble active material as a preventive of local action, it would obviously be preferable to prevent it by other means, but can this be done at present? Soluble electrodes are objected to chiefly on account of the difficulty in reversing the physical and the chemical changes taking place in the cell. Though lead is not a good electrode, especially for the negative plate, we do not find any cells in successful operation where soluble electrodes are employed. Of the numerous modifications of the "Sutton" type of accumulator, consisting of a lead peroxide-copper couple in an electrolyte of copper sulphate; of the "Reynier" type, consisting of a lead peroxide-zinc couple in an electrolyte of zinc sulphate; of the "Thomson-Houston" type, which is a reverse form of the Daniell cell; and lastly, the "Waddell-Entz" type, consisting of porous copper oxide and metallic zinc in an electrolyte of potassium zincate—can Mr. Reed point to any of these in successful operation to-day?

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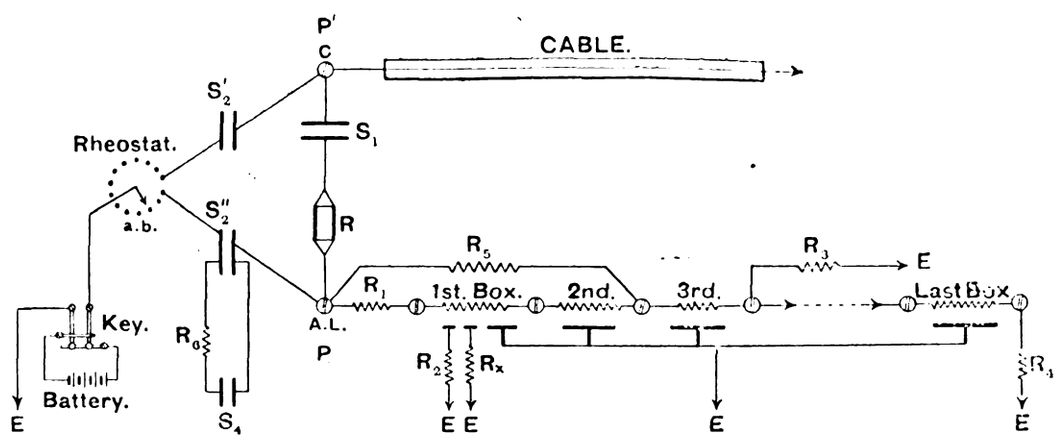
## "DUPLEX" ON SUBMARINE CABLES.

In a pamphlet recently copyrighted and issued privately to the working staffs of several of the leading cable companies, a series of hints are given to operators on "Duplex" from which we extract the following :—

In the accompanying figure, *a*, *b* are the rheostat coils, commonly called the "quarter ohm rheostat," because its resistance can be varied by a quarter of an ohm at a time. Its function is to introduce a variable resistance between the battery and the condenser blocks $S_2'$, $S_2''$, and thus to regulate the rate of charge into the latter with regard to each other. This rheostat is also provided with one fixed coil, marked 10 ohms, and with a shunt commutator, connected. $S_2'$, $S_2''$ are the bridge condensers, which are substituted for resistances when balancing long cables. $S_1$ are the receiving condensers. $S_4$ is a sub-divided condenser, facilitating the introduction of different capacities at $S_2''$. This condenser is subdivided to hundredths of a microfarad. $R_1$ is a resistance provided with a subdivided ohm adjustment for adding to the resistance of the artificial line. This has the effect of raising the potential at P with respect to $P_1$. $R_2$, $R_x$, are resistances inserted between the earth plates of the artificial line and the earth, $R_2$, or $R_x$, according to the amount of variation of temperature of the A.L and the underground wire to the cable which may take place during the 24 hours.

It is important to remember that resistances or condensers inserted in the "cross circuit," that is to say, between C and A L, will not affect the duplex balance—assuming always that their insulation is good—but they *will* affect the received signals. Increasing $S_1$ will augment the range of the signals, but if too great a capacity is employed the signals become straggly and of bad shape, and if, on the other hand, too small a capacity is used, they are rendered small and unsafe. As the ratio of the resistance to the capacity of the "artificial line" is usually somewhat higher than that of the cable, the tendency will be for the potential to rise more quickly on the artificialline side; consequently, it is usually necessary to make the condenser block $S_2''$ on the artificial line side somewhat smaller than that on the cable side. The effect of adjustments at the beginning or "home end" of the artificial line is much more marked than that caused by adjustments nearer the further end. For instance, any small alteration of the quarter ohm rheostat, of $S_1$, of $R_1$ and of $R_2$ and $R_x$ (if the latter be interpolated between a large number of condenser terminals and the earth, or if between a fewer number of terminals and the earth at the beginning of the artificial line) will have a much greater effect on the balance than comparatively large changes




to retard the rate of charge into the plates. This has *practically* the effect of decreasing the capacity of the plates so adjusted. $R_3$ is a "leak" from any line terminal of the A. L. to earth. A resistance of, say, 3,000 to 10,000 ohms is usually employed, but sometimes two leaks are found to be advantageous, one of a high resistance and one of a low, the former generally nearer the home end. These leaks are useful in eliminating the wave in a duplex balance. A resistance, $R_5$, is inserted between the end of the artificial line and earth when required, usually from 1,000 to 5,000 ohms. $R_3$ is a resistance placed as a shunt between any two of the artificial line terminals (line side). A resistance, $R_6$, is inserted in the subdivided condenser ($S_4$) circuit to retard the rate of charge into the condenser. Sometimes this adjustment is found useful in eliminating a "jar" in a duplex balance, but it is not frequently employed.

For cables exceeding 300 miles in length a balance will be found as follows:—Having substituted condensers $S_2'$ and $S_2''$, and a finely-subdivided condenser $S_4$ connected up with the latter for purposes of adjustment in the place of the bridge arms used on shorter cables, commence with the adjustable condenser $S_4$ and the resistance $R_1$ at nil, and send a rather rapid succession of "dots" by means of the key, and turn the knob backwards and forwards until the best balance procurable is obtained. If a satisfactory result is not so obtained, insert 0·05 microfarad in $S_4$, increase or diminish it by 0·01 or 0·02 microfarad at a time, after each alteration obtaining the best balance possible by means of the rheostat. Should the last adjustment not be effectual make the resistance of $R_1$ 5 ohms, and increase or diminish it by 1 ohm at a time, after each alteration obtaining the best balance possible by means of the rheostat, in the same manner as when adjusting the subdivided condenser $S_4$, always proceeding in the direction of improvement. When getting the balance near, alter $R_1$ by smaller amounts, say halves or tenths of ohms, as the case may require. Should there still remain a "jar" of the mirror, or blurred line on the recorder slip while signalling on one key, which is unaffected by any variation of the condenser $S_4$ and the resistance $R_1$, then insert the resistance box $R_2$ between the first capacity or earth terminal of the first box of the A.L. and the earth. From day to day it will be found necessary to alter the rheostat and the subdivided condenser $S_4$, and perhaps the resistances $R_1$, in $R_3$, $R_1$, or $R_5$. A spare recorder is sometimes inserted between the end of the artificial line and earth, in the place of $R_5$, or in conjunction with $R_1$, or in one of the "leak" circuits, where its resistance can be made to form part of the "leak," and in these positions it affords a ready means of recording the sending signals passing to the receiving station.

## ON VISCOUS DIELECTRIC HYSTERESIS.*

BY RICCARDO ARNÒ.

The phenomenon which I discovered of the rotation of a dielectric cylinder in a rotating electric field †, and the results of my experiments on the dissipation of energy in the dielectric placed in such a field ‡, demonstrate the existence of a lag with which the polarisation of the dielectric follows the rotation of the field itself.

Two kinds of lag may produce the dissipation of energy demonstrated: either a lag in the variation of the dielectric constant by which this would have smaller values for a field of increasing than for one of diminishing intensity; or a time retardation between the instant of application of the electric force and the instant at which the dielectric has attained its corresponding polarisation.

To this second species of lag, which may be described as viscous dielectric hysteresis, part at least of the dissipation of energy in dielectrics in an alternating electric field may be due. This follows essentially—

(1) From Northrup's experiments, § which show that the value of the specific inductive capacity of a dielectric under the influence of a cyclically varying electric field, depends upon the rate of variation of the field itself.

* *Rendiconti dei Lincei*, Vol. V., 5A, pp. 262-264.

† *Rendiconti*, Oct. 16, 1892. See *The Electrician*, Vol. XXX., p. 516.

‡ *Rendiconti*, April 30, and Nov. 12, 1893, March 18, June 17, and Nov. 18, 1894. See also *The Electrician*, Vol. XXXI., p. 201; XXXII., p. 222; XXXIII., p. 210; XXXIV., p. 327.

§ *Phil. Mag.*, January, 1895.

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(2) From the experiments of Janet*, and of Porter and Morris,† on condensers subjected to rapid and to slow electric oscillations for a given value of the difference of potential between the armatures. In the first case, the charge is smaller when the difference of potential is increasing than when it is diminishing; in the second case it is constant.

(3) From Eisler's‡ experiments, which bring out the influence of the frequency of a given alternating difference of potential on the loss of energy, and show that this loss increases at first with the frequency, and then reaches a maximum and decreases again.

The experiments of which I give the results here were undertaken in order to test whether the dissipation of energy in a rotating field must also, like that in an alternating field, be partly attributed to viscous dielectric hysteresis. The effect of viscous hysteresis is, for a rotating field, a function of the velocity of rotation of the field. Hence it will suffice if we maintain a field of uniform strength and vary its velocity of rotation.

As before, I used two alternating fields of equal intensity perpendicular to each other, and having a difference of phase of 90 deg., obtained from a single alternating current. The duration of a single rotation is then equal to the period of the alternating current. Hence, in order to vary the speed of rotation, it was only necessary to vary the frequency of the original current, while maintaining the two fields at the same strength.

In the following table are shown the results of the experiments, performed with the apparatus previously described, corresponding to two values (0·083 and 1·818 C.G.S. units) of the electrostatic induction B, using a hollow cylinder of paraffined cardboard weighing 2·011 grammes, and 26mm. high, 30mm. in external diameter, and 1mm. thick. In the second column are given the frequencies $n$ of the current, and in the third the deflection $d$ of the cylinder and mirror as read with the telescope :—

| No. | | $n$. | $d$. |
|---|---|---|---|
| I. B = 0·083 | 1 | 44 | 5·5 |
| | 2 | 22 | 9·5 |
| | 3 | 11 | 13·5 |
| II. B = 1·318 | 4 | 44 | 59 |
| | 5 | 22 | 87 |
| | 2 | 11 | 129 |

The reading $d$, which is proportional to the work in ergs performed performed per cycle by the deflecting electric forces, must be referred to two different degrees of sensitiveness of the apparatus, changed according to the induction B.

These results show that the energy dissipated in each cycle in the dielectric cylinder varies with the rate of rotation of the field. It therefore appears that the dissipation of energy, or part of it, is the effect of viscous hysteresis in the dielectric examined.

## PHYSICAL SOCIETY.

At an ordinary meeting of the Physical Society, held on May 8th, 1896, Capt. Abney (president) in the chair, Messrs. FRITH and RODGERS read a Paper on

### "The True Resistance of the Electric Arc."

It was pointed out by Prof. Ayrton at the British Association meeting at Ipswich that if the "true resistance" of an arc is defined as the ratio of a small increase of the P.D. between the carbons to the corresponding change in the current, then it follows that this "true resistance" must be a negative quantity.

In order to measure the "true resistance" without appreciably altering the form of the carbons, &c., the authors superpose a small alternating current on the main continuous current. The arc lamp employed was adjusted by hand, and the arc length was measured by projecting an image of the arc by means of a lens. The main (continuous) current and P.D. were measured by a Weston ammeter and voltmeter, while the auxiliary alternating current was measured by means of an air transformer and an electrostatic voltmeter.

The authors find that between the limits employed the magnitude of the alternating current did not influence the results obtained for the resistance of the arc. The frequency, so long as it lies between the limits 250–7 complete alternations per second, and the wave form do not influence the resistance, since the same results were obtained with a Pyke and Harris alternator, a Ferranti alternator, a Gramme alternator and a Mordey transformer.

For each make of carbon examined four combinations were used : + cored, – cored ; + cored, – solid ; + solid, – cored ; + solid, – solid. The general characteristic of the curves obtained is that for the + solid – solid combination the "true resistance" is always negative, while for + cored – cored it is always positive, the other curves being between these two extremes, those which have the + carbon solid always being more negative than those which have the + carbon cored. In the case of the curves showing, for solid carbons, the relation between the resistance of the arc and the P.D. between the carbons, the current being constant (10 amperes), a minimum (maximum negative) value for the resistance occurs at about 55 volts. With combinations having a cored positive this minimum becomes more strongly marked and occurs at a lower voltage. The authors find that for cored carbons the position of this minimum is closely connected with the presence or absence of the dark space in the arc. For points on the curve to the right of the minimum point the dark space is absent, while for points to the left of the minimum the dark space is always present.

It was found that the effect of using as the + carbon a Carré carbon in which the core had been bored out, was to obtain a curve closely resembling that obtained when both carbons were solid. On filling this hollow carbon with plaster of Paris or kaolin, the resistance of the arc became positive.

The above experiments were made with the + carbon uppermost ; other experiments made with the arc inverted showed that with solid carbons the resistance is not appreciably altered by inverting the arc. With cored carbons, however, the resistance as well as the physical character of the arc is altered, for on inversion the dark space disappears and the resistance considerably diminishes. If, however, the conditions under which the arc is burning are such that the dark space is absent, then inverting the arc does not alter the resistance.

Attempts were made to measure the "true resistance" of a direct-current hissing arc, but it was found that even with the alternator at rest there was a large deflection of the electrometer, showing that the current through a hissing arc was oscillatory.

In order to elucidate the marked difference between their results for cored carbons and those deduced from Mrs. Ayrton's curves, the authors have made a series of measurements at low frequencies. They find that there is a critical frequency, above which the resistance has a positive value, which is independent of the frequency, and below which it has a negative value, this critical frequency being between 75 and 0. In order to investigate the sign of the resistance at low frequencies the vibrations of the needles of the ammeter and voltmeter were made use of. By an arrangement of mirrors, the needles and scales of both instruments could be observed simultaneously. In this way, it would be seen whether the two needles were, at any instant, vibrating in the same or in opposite directions. If the needles vibrate in the same phase, *i.e.*, if an increase of P.D. is accompanied by an increase of current, then the resistance must be positive ; while if they are vibrating out of phase, *i.e.*, if an increase of P.D. is accompanied by a decrease in current, then the resistance is negative.

An attempt to run the arc off a continuous-current dynamo failed, since even with the alternator at rest the electrometer showed a large deflection, evidently due to the oscillation of the current owing to the commutator of the dynamo having a finite number of segments.

Prof. A. GRAY doubted whether it was right to give the name "true resistance" of the arc to the slope of the curve connecting the potential difference (V) and the current (A). The authors' method of deducing $\frac{\delta V}{\delta A}$ was only true if the curve was a straight line, while in the case of the arc E and $\alpha$ may both vary with the current.

Mrs. AYRTON said that with reference to the question of the existence of a back E.M.F. the evidence tended to show that it did not exist. By using an exploring carbon no constant back E.M.F. would be found.

Prof. AYRTON said that considering the arc as consisting of a back E.M.F. and a resistance, it was necessary to separate these two. Simply obtaining one value of the P.D. and the current was of no assistance in solving this question, but a series of values had to be taken. By taking the change in P.D. and current sufficiently small the curve over the range considered was practically straight. It was curious to note that as long as observers obtained a positive value for the resistance of the arc no fault was found with the method, but that now a negative value was found the accuracy of this method was questioned. If a back E.M.F. does really exist, then it follows that the arc must have a negative resistance. Mr. Frith has shown why some people have got positive and some negative values for the resistance of the arc and also that with an alternating current you may get either one or the other.

Mr. CARTER asked if the fact that the arc had a negative resistance did not imply a back E.M.F., in order that the arc might be stable ? If so, was a negative resistance such an absurdity ?

Mr. CAMPBELL said he was very pleased to see that the authors had applied a method which he (Mr. Campbell) had suggested for measuring pulsating currents. If a pulsating current such as could be obtained by means of a make and break is passed through a thermopile you would get a back E.M.F., while if an alternating current were employed you would not.

* *Comptes Rendus*, February 20, 1895.
† *Proc. Roy. Soc.*, Vol. 57 ; see also *The Electrician*, Vol. XXXIV., p. 735.
‡ *Zeitschr. f. Electrotechnik*, June 15, 1895.

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Mr. FRITH, in his reply, said that he had defined the "true resistance" as $\frac{\delta V}{\delta A}$. Mrs. Ayrton has shown that an arc will not run unless a certain resistance is placed in series with it, this resistance must be numerically equal to the negative resistance of the arc itself.

Prof. AYRTON said Mr. Frith's remarks as to the cause of the want of stability of an arc without outside resistance were most suggestive.

The CHAIRMAN (Capt. Abney) said he did not like the expression potential difference. He suggested the employment of photography to facilitate the accurate registration of the instrument readings.

**The further discussion on the Paper was adjourned to the next meeting on May 22nd.**

## LONDON COUNTY COUNCIL.

At the weekly meeting of the London County Council held on Tuesday, the Finance Committee reported upon the application of the Vestry of St. Pancras for a loan of £75,000 for electric lighting purposes and a refuse destructor at the King's-road station. In July, 1896, the Council agreed to lend £30,000 for electric lighting purposes, and £26,100 for the dust destructor, and the Committee now recommended that the application for a further loan of £18,900 towards defraying the cost of carrying out an electric lighting installation be granted to the extent of £15,300, and further that the Vestry be notified that, as they had elected to spread the whole of the initial cost of the electric lighting installation over 42 years, the Council would decline to give its sanction to the raising of any loan to replace plant and machinery which might be necessary during the currency of the loan, and would expect all renewals to be provided from a sinking fund or from maintenance account.—The recommendation was agreed to.

The Bridges Committee submitted a scheme for a new foot tunnel under the Thames to connect Greenwich and Millwall. The proposed tunnel would be lighted by electricity. It was also proposed to lay pipes in the concrete below the footway for telephone wires, &c. With regard to maintenance, the Committee proposed that electricity for lighting should be used, and it would also be used for working the ventilating and pumping machinery. The cost of the installation and upkeep of an independent plant would be very expensive, and they had received a proposal from the London Electric Supply Corporation to lay a cable from the nearest point of the Company's mains to the south end of the subway for about £1,000, which would in the first instance be paid for by the Council, and to supply the current at the rate of 4d. per unit. The Committee had reason to believe that the Electric Supply Corporation would be willing to enter into an agreement to return the £1,000 within five years, or in a shorter time if it were found that private consumers in any number took current from the main. The Committee considered the proposal to be satisfactory, and to show a great economy over the results which would be obtained by putting down a special installation.—As the recommendation involved an expenditure of over £5,000 the report stood postponed till the next sitting.

The Fire Brigade Committee reported that in connection with the establishment of the Kingsland and Shoreditch Fire Stations estimates had been obtained from the Post Office (*a*) For Kingsland, 10 Stuart's fire alarms (four to have telephones attached), 2 portable telephones, and a 6-hole switch, £125, less £54. 5s. in respect of fire alarms now connected with other stations; (*b*) for Shoreditch, 11 Stuart's fire alarms (three to have telephones attached), 2 portable telephones, and a 6-hole switch, £124. 15s., less £63 in respect of fire alarms connected with other stations; (*c*) for Hackney, 5 Saunders and Brown's fire alarms (3 to have telephones affixed), and a 4-hole switch, £57. 15s., less £19. 10s. in respect of alarms connected with other stations; (*d*) for Bishopsgate, 1 Saunders and Brown's fire alarm, £6. 15s.—It was recommended that these arrangements be sanctioned, and this was agreed to.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May 1, 1896.*

**The Electrical Exhibition.**—At the present time all interest is centred in the Electrical Exhibition which opens in this city next week, and will continue during the month of May. It is evident that the show will greatly surpass the most sanguine expectations of its projectors, and it will be in many respects the most unique and extensive electrical exhibition ever held, not excepting even the World's Fair display. Besides the industrial features of the Exhibition, it will be notable for the exhibits of historical and experimental apparatus used in research in every department of electrical science. Among the historical and special exhibits may be noted that of the Patent Office of the United States Government, which will be of unusual size and interest. No fewer than 361 models of electrical devices, apparatus, machinery and appliances will be shown, many of them embodying the fundamental and elementary idea upon which the modern electrical arts have been founded. Cornell University will exhibit a Gramme dynamo built by Prof. W. A. Anthony in 1876, and exhibited at the Centennial Exhibition of that year. It is probably the first dynamo of practical form constructed on those lines in this country. The University will also show many other things of interest. The Western Union Telegraph Company has placed at the disposal of the Exhibition authorities two of its wires, over which a portion of the current developed at the Niagara Falls power plant will be brought to the Exhibition Hall for the purpose of operating the model of the plant itself; and it is also proposed to charge storage batteries by the same power at the Falls themselves, ship them to New York and use their energy in operating the model during the daytime when the wires are in constant use by the telegraph company. The wires will be used in the manner above mentioned at night only, when the regular telegraph business is slack. The object of using storage battery current for the operation of the model during the day is, of course, an extension of the idea of operating the model at all times by the power generated by the Falls. This exhibit will be remarkably interesting as illustrating the flexibility of electrical power transmission. Another interesting feature of this particular exhibit will be the transmission from Niagara Falls to New York by telephone of the roar of the Falls themselves, which was more particularly noted in a recent communication to *The Electrician*. Another interesting historical exhibit will be that of the College of the City of New York, and will include Prof. Joseph Henry's own experimental induction coil, and many other rare scientific curios. One of the cells of the historical old 500-cell battery used at the College of the City of New York will also be shown. Mr. A. B. Chandler, President of the Postal Telegraphic Cable, has loaned the Exhibition an interesting frame of very early relics of the telegraph in this country. Mr. E. J. Hall, Vice-President and General Manager of the Long-Distance Telephone Company, will loan some original long-distance telephone apparatus, including the instruments used by Prof. Alexander Graham Bell at the opening of the New York and Chicago line. The Gedney Channel electrical buoys, which at night light the way to the New York Harbour, will be represented in miniature, and will be in practical operation. Mr. W. J. Hammer will also show his celebrated collection of incandescent lamps illustrating the history of the art of lamp making. Other telegraph and electrical apparatus of historic value will be on view during the period of the Convention.

**The General Electric Company.**—This concern issued its fourth annual report last week. It shows a net profit of $877,645.49 for the year ending January 31, 1896. The financial statement is a very lengthy one, and in form differs somewhat from the previous report, which makes a comparison between the two rather difficult. However, in general the last report is considered favourable to the Company.

## CORRESPONDENCE.

### THE EWING PERMEABILITY BRIDGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the interesting account of Prof. Ewing's permeability bridge, which you published in your last issue, it may not be out of place to describe an apparatus based upon the same principle, though different in certain particulars, which Mr. B. H. Bedell has been engaged upon at my suggestion for the last six months in the physical laboratory of this College.

The test-piece, A B, is fitted to two circular end discs of soft iron, shown in section. It is placed at the common axis of three cylindrical coils, *a*, *b*, *c*, of which *b* and *c* are wound with the same number of turns each, and are connected in series, so that a current passed through them circulates round A B in opposite directions.

Currents $c_1$ and $c_2$ are then passed through *a*, and through *b* and *c* respectively, in such directions that the lines of force produced by *a* in A B are drawn back through the air space

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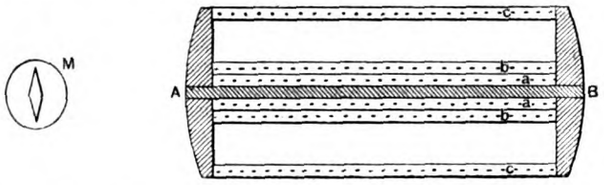
between $b$ and $c$; and by suitably adjusting $c_1$ and $c_2$ the difference of magnetic potential between A and B may be reduced to zero, and this condition indicated by the compass needle M. In fact, the air space between $b$ and $c$ takes the place of the standard bar in Prof. Ewing's apparatus.

By using air in this way as the standard substance instead of iron, it seems to me that a certain simplification is obtained. For the current $c_1$ is obviously proportional to **H**, and $c_2$ to the induction in AB, *i.e.*, to **B**, so that ammeters inserted in the circuits of $c_1$ and $c_2$ may be made to read direct to the corresponding values of **H** and **B** by suitably numbering their scales. Moreover, the instrument is "absolute," in the sense that both **H** and **B** may be obtained from its dimensions and winding by calculation, $c_1$ and $c_2$ being known.

By the use of sliding resistances in the two circuits a complete curve, up and down, may be taken in a few minutes; this, however, is a property which is also shared by Prof. Ewing's instrument.




A small error arises from the fact that the lines of force drawn back by $c_2$ include a few air lines, which pass outside the test piece in $a$. It is almost negligible, but may be completely overcome by winding on the coil of the ammeter in the $c_2$ circuit a proper number of opposing turns and passing $c_1$ through them.

It is more than likely that Prof. Ewing has already contemplated the use of air as the standard substance, and rejected it in favour of iron. He does not refer to it, however, and this must be my apology for pointing out what is, after all, a fairly obvious form of permeability bridge.—Yours, &c.,

A. P. Chattock.

Physical Laboratory, University College,
Bristol, May 11, 1896.

## TRANSPARENCY OF FILAMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to a letter which appeared in your columns a week or two ago about the transparency of incandescent lamp filaments when hot, I have noticed in frosted lamps with plain horseshoe (*i.e.*, not looped) filaments a sharp distinct shadow of the filament all round the bulb, which would appear to indicate that the filament is opaque. The lamps referred to are run at about $2\frac{1}{2}$ watts per candle-power.—Yours, &c.,

G. C. Allingham.

Eldon House, Lyndhurst-road, Hampstead, N.W.,
May 11th.

# LEGAL INTELLIGENCE.

### Clarke v. Julius Sax and Co. (Limited).

This case came before the Court of Appeal, consisting of Lords Justices Lindley, Lopes and Kay, on Monday last, for judgment on the appeal of Messrs. Julius Sax and Co. (Limited) from a decision of Mr. Justice North refusing to rectify the register of designs by striking off No. 206,870, registered by John Farrant Clarke, on the ground that it was not novel and that similar designs had been used before, the design in question consisting of a lamp for electric lighting intended for use outside shop windows so as to throw light upon the windows and articles displayed therein. The case was reported in *The Electrician* of May 1st.

Lord Justice LINDLEY, in the course of an elaborate-written judgment having referred in detail to the statutes and decided cases bearing on the subject, said that, using his own eyes, and attending to the evidence adduced on both sides, the conclusion at which he had arrived was that the design registered was nothing more nor less than an old and well-known lamp or lamp shade, with the omission of a part, which was wanted for gas or oil burners, but which was useless for an electric light. The old shape of lamp or lamp shade consisted (1) of a reflecting screen of the same shape as the reflecting screen in the registered design; (2) of a ventilating top, differing in no substantial particular from the ventilating top in the registered design; (3) of a chimney on the ventilating top, and which was omitted from the registered design, not being wanted. The omission of the chimney rendered it necessary to cover in the ventilating top; but it did not really alter the shape of the lamp or lamp shades. Mr. Clarke had, in his opinion, adopted a well-known lamp or lamp shade to electric lighting; but the shape was the old shape with the omission of a useless appendage. He (his Lordship) had no doubt that a combination of old shapes might result in a new or original design of shape; and if it was the result that design would be protected if registered under the Act. Nor did he say that even the omission of something from an old shape might not result in a new or original shape which might be protected. But when, as here, the old shape of an article well known in the United Kingdom, consisted of three shapes, of three parts placed one over the other, and the new shape was exactly like the old shape, except that the useless upper part was omitted, he could not say that the shape of what was left was new or original, or that the residuary shape had not been previously published. He came to the conclusion that the design in question being for shape, and shape only, though new in its application to electric lamps, was old in its application to other lamps, and was not one to which the Act applied. In those circumstances, in his opinion, the appeal must be allowed with costs, both in that Court and in the Court below, and an order must be made to remove the design from the register.

The other Lords Justices read judgments to the same effect.

# TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations.**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"The Alternate Current Transformer," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The New Edition is Now Ready. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

Laboratory Notes and Forms.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"Submarine Cable-Laying and Repairing."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated; price 12s. 6d. Will be ready first week in June.

"The Work of Hertz."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"Electric Lamps and Electric Lighting," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"Electric Motive Power."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"Electrical Engineering Formulæ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"Drum Armatures and Commutators."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"The Incandescent Lamp and its Manufacture."—This book written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"Practical Notes for Electrical Students."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"The Art of Electrolytic Separation of Metals."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

"Electro-Chemistry."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"Armature Windings of Electric Machines."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

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TENDERS INVITED.—The vestry of Hammersmith require tenders for (*a*) supplying and laying high-pressure and low-pressure cables and pipes, (*b*) supplying and erecting arc lamps and lamp posts, (*c*) supplying and erecting transformers and sub-station equipment, (*d*) supplying and erecting a 5-ton overhead travelling crane. Specifications, &c., can be obtained of Mr. A. H. Preece, 39 Victoria-street, London, S.W., and tenders must be delivered at the vestry offices, 57, Fulham Palace-road, Hammersmith, by noon of Wednesday, May 27th. Mr. W. P. Cockburn is vestry clerk. Some further information is given in our advertisement columns.

——— Tenders are required for the lighting of the City of Bucharest for five years. Tenders must be sent in to the Town Council by June 24th.

——— The municipal authorities of Cassa de la Selva (Gerona) invite tenders for the electric lighting of the public streets. Tenders to El Secretario del Ayuntamiento de Cassa de la Selva (Gerona), Spain.

TENDERS ACCEPTED.—For providing and fixing telephones, electric bells and fire alarms at the Brook Hospital and Ambulance Station the following tenders were received by the Metropolitan Asylums Board :—

| | |
|---|---|
| Cox-Walkers *(accepted)* | £658 |
| Single-Wire Multiple Telephone Signal Company | 2,244 |
| National Telephone Company | 2,032 |
| C. E. Zimdars | 1,900 |
| Julius Sax and Co. | 1,657 |
| W. Seymour | 1,500 |
| Strode and Co. | 1,433 |
| Furse (W. J.) and Co. | 1,024 |
| Vaughan and Brown | 1,010 |
| Private-Wire and Telephone Installation Company | 1,009 |
| Consolidated Telephone Construction & Manufacturing Co. | 784 |
| Mason, Wathes and Brown | 722 |
| Tabor and Hinchcliffe | 706 |
| L. Alwyn | 662 |
| Pearson's Automatic Fire Indicator Company | 572 |
| Brown and May | 534 |

——— The Hampstead Vestry have accepted the tender of Messrs. S. Z. de Ferranti (Limited) for the supply of a steam alternator and switchboard, at £3,397. Eleven tenders were received for the supply of a feed-water heater and steam pipes, and six for the supply of a tank and appurtenances. The tenders of the Brush Company were accepted at £942 and £408. 10s. respectively.

——— The Brighton Town Council at their last meeting discussed the tenders received for supplying 80 arc lamp standards and 100 double-carbon arc lamps. The Electric Lighting Committee's recommendation was that Messrs. Hart, Son, Peard and Co.'s tender should be accepted for the former at £2,500 (and £31. 5s. for each additional post ordered), and Messrs. Crompton and Co.'s tender for the latter at £2,200 (including the fixing of 95 lamps). A number of tenders had been sent in for the standards, amongst which was one from a local firm (Messrs. Reed and Son) for the sum of £2,460, and the Council, after discussing the Committee's recommendation, decided to give the contract for the 80 standards to the local firm at the figure quoted (£2,460).

——— The Oldham Town Council have accepted the tender of Messrs. W. A. Shaw and Co., Stockport, for wiring the new technical schools. About 30 tenders were received by the Technical Education Committee for the work.

——— The Sunderland Corporation have accepted the tender of Mr. Joseph Home, of Hartlepool, for extensions to the electricity supply station building at £1,418, and the tender of the Westoe Foundry Company for erecting iron roofs for £189.

——— The Bradford Town Council have accepted the tender of Messrs J. Moulson and Sons for the construction of a reservoir and tank at the Valley-road electricity works at £890, in place of the tender of Messrs. Broxup and Sons, who had declined to proceed with the work.

——— The Cheltenham Town Council have accepted the tender of Messrs. McDowall, Steven and Co. for the supply of 25 arc lamp standards at £9. 15*s.* each.

APPOINTMENTS VACANT.—An engineer is required to take charge of the electric light installation at New Scotland-yard. Salary 50s. a week, rising to 60s. Applications to the Receiver for the Metropolitan Police District, New Scotland-yard, S.W. Further particulars will be found in our advertisement columns.

——— The Municipal Technical Institute of the Borough of Salford invite applications for the post of (1) Chief Lecturer in Chemistry (salary £200); (2) Chief Lecturer in Dyeing (£150); (3) Art Master (£220); (4) an instrument maker (£2 per week). Some further information is given in our advertisement columns, and all particulars can be obtained of the secretary at the Institute, Peel Park, Salford.

DISSOLUTION OF PARTNERSHIP.—Messrs. Harry Patterson and George James Harford, electricians, 49, Moorfields, London, E.C., have dissolved partnership.

REMOVAL NOTICE.—The I. E. S. Accumulator Company (Limited) have removed from Palace Chambers, Westminster, to 3, Delahay-street, Westminster, London, S.W. The Company's new telephone number is 3384 ; telegraphic address, "Lucubrate, London." The works remain at Woking, Surrey.

LIQUIDATIONS.—It has been decided to wind up the Fareham Electric Light Company (Limited), and the Managing Director (Mr. J. Blake) has been appointed liquidator. This decision has been arrived at owing to the purchase of the Company's undertaking by the District Council.

——— A meeting is to be held at Messrs. Jackson, Pixley and Co.'s offices, 58, Coleman-street, E.C., on June 22nd, at 2 p.m., to receive an account of the winding up of the Boy Messengers and Electric Call Company (Limited).

THE JANDUS ARC LAMP.—We have just received from Messrs. Drake and Gorham, the sole agents for this lamp, a long list of testimonials from installers and users. These testimonials are practically all dated the current year, and show a uniform success for the lamp. The list should prove useful to the trade.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from May 6th to May 13th, with the ports of destination :—

*Argentina*—Buenos Ayres, £73; Pasages, £97; Rosario, £831. *Australasia*—Adelaide, £120; Albany, £2,634; Fremantle, £949; Rockhampton, £97; Sydney, £244; Townsville, £12; Wellington, £274. *Canary Islands*—Las Palmas, £50. *Belgium*—Antwerp, £30; Ghent, £18. *Ceylon*—Colombo, £12. *Channel Islands*—Jersey and Guernsey, £130. *China*—Shanghai, £228. *Germany*—Dantzig, £23; Hamburg, £820. *Egypt*—Alexandria, £38. *France*—Boulogne, £10. *Holland*—Amsterdam, £337. *Hong Kong*, £99. *India*—Calcutta, £292. *Japan*—Yokohama, £110. *Russia*—Libau, £83; St. Petersburg, £858. *Siam*—Bangkok, £184. *South Africa*—Cape Town, £496; Delagoa Bay, £170; Durban, £30; East London, £1,497; Port Elizabeth, £133. *Spain*—Granada, £37; Seville, £7. *Straits Settlements*—Singapore, £13. *Sweden*—Gothenburg, £61. *Uruguay*—Monte Video, £145.

*Foreign-Made Electrical Apparatus and Material.*—Foreign made goods have been exported from this country, as follows :—

*Australasia*—Brisbane, £42.

DUNCAN'S MANUAL.—We have received a copy of the 19th edition (1896) of the useful "Manual of British, Foreign and Colonial Tramway, Omnibus and Electric Railway Companies," issued by Messrs. T. J. Whiting and Sons, 7A, South-place, London, E.C, price 3s. 6d. The manual contains a vast amount of information compiled in handy form, and will be found of service to those seeking information relating to the *personnel* of the principal tramway, omnibus and electric railway companies. The information includes a digest of the last accounts published by the companies.

SCOTLAND.—Those of our readers who contemplate a visit to Scotland during the coming summer will find an official guide of summer tours, written by Mr. David MacBrayne, of much service. The guide gives time tables, list of fares, steamer routes, &c., and is embellished with a number of illustrations and several good maps. Copies of the guide can be obtained at 119, Hope-street, Glasgow.

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ABERDEEN.—Negotiations are proceeding between the Town Council and the Harbour Commissioners in regard to the electric lighting of the quay. It is calculated that about 70 arc lamps would be required, and the cost of these would be about £800 per annum. The Commissioners are anxious to obtain electric current at a reduced rate, and it is probable that the Council will meet them in the matter.

ALLEGED FRAUD.—At the Mansion House, London, last week, Arthur Stephen Ford, described as an electrical engineer, of Ironmonger-lane, E.C., was charged, along with William W. Carne, Alfred Jacobs, Julius Bellot, Charles G. H. Teniswood, and Adolphus Dresel, with conspiring to obtain £1,500 from a Mr. Joseph Morrison, described as a merchant, of 63, Queen Victoria-street, London, by false pretences, and with inciting him to receive stolen property. The evidence showed that Mr. Ford and the prosecutor had had certain business transactions together, the prosecutor having lent Ford about £300. On making application for payment, the defendant, it was alleged, offered to dispose of three £1,000 banknotes, which had been stolen in 1893 from the Bank of Scotland, suggesting that the prosecutor should release him from his debt, and pay him a certain sum, taking over the three £1,000 notes in settlement. This the prosecutor appeared to agree to do, but at once communicated with the City police. The defendants denied any knowledge of the business whatever.

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The case had not proceeded far before Teniswood and Dresel were discharged from the case, and at the adjournment on Wednesday the others were admitted to bail in their own recognizances. The case was proceeded with yesterday (Thursday), when the cross-examination of Morrison was resumed, Mr. Raphael, the solicitor for Jacobs, contending that no reliance should be placed on his evidence, and that he had conducted a fictitious business, a statement which Morrison denied. In the end the Lord Mayor dismissed the charge against all the defendants.

Asylum Lighting.—The Governors of the Armagh County Asylum, recognising the many advantages of the electric light, have decided to put in an installation at the new asylum building. A committee has been formed to settle details and to supervise the execution of the scheme.

Autocars.—A meeting was held on Monday at Walsall of the manufacturers of Birmingham and Walsall in the trades likely to be affected by the introduction of the autocar into general use. Amongst the resolutions approved were the following:—That the rate of speed in towns should not exceed five miles per hour and 10 miles in the country; in the case of a horse-drawn vehicle meeting an autocar in a road too narrow for them to pass, the autocar to give way; that while any tax remains on horse-drawn vehicles this tax should equally apply to the autocar; that all autocars be numbered. These suggestions were unanimously approved, and it was decided to form an association, called the Road Safety Association, to urge the embodiment of the above suggestions in the Locomotive and Highways Bill now before Parliament.

Bath.—The City Council have decided to adopt the recommendation of the Electric Lighting Committee to purchase the undertaking, machinery, &c. (except the arc lighting plant) of the City of Bath Electric Lighting Company, on the terms of Prof. A. B. W. Kennedy's report, an abstract of which appeared in our last issue. The Company, however, strongly object to the terms of the transfer, as they contend that the arc lighting plant should also be taken over by the Corporation at Prof. Kennedy's valuation, viz., £1,954. With a view to settling this point, at the invitation of Sir Courtenay Boyle, K.C.B., a conference was held on Monday last at the Board of Trade between representatives of the Company and the Corporation. The Company was represented at the Conference by Mr. Sydney Morse, who submitted that the arc lighting plant should be taken over by the Council, as it would not be of the slightest value to the Company if left on their hands, and that some allowance ought also to be made for the very heavy preliminary expenses (£4,512) which the Company had incurred. Sir Courtenay Boyle's decision was adverse to the Company on both points. An early meeting of the Council is to be held for the purpose of arranging for the completion of the purchase.

Bangor.—In consequence of the refusal of the Board of Trade to grant the Town Council's application for an electric lighting licence the Manchester Edison-Swan Company have already given notice of their intention to apply for a Provisional Order. From the evidence adduced at the recent Board of Trade inquiry it is considered that an electricity supply station would prove successful, and the Manchester Edison-Swan Company are prepared to make the most of the Council's lost opportunities. The Company's application may, however, be objected to, as the majority of the Council are still anxious, notwithstanding the strenuous opposition of the gas interest, to establish electricity supply works.

Beauly (Rossshire).—In view of the arrangements for the installation of the electric light at Beaufort Castle, some of the principal residents are making inquiries as to the practicability of lighting the village electrically. It is considered that sufficient water power can be obtained from the Falls of Kilmorack, and an electrical engineer has been commissioned to prepare a report on the matter.

Blackburn.—The Electricity Committee intend to apply to the Local Government Board for sanction to borrow £10,000 for electric light extension purposes. In consequence of the Committee having received a number of applications from the Preston New-road district, and from people who have hitherto employed their own generating plant, the capacity of the plant at the station has been practically exhausted, and the extensions will have to be carried out immediately.

Cheltenham.—The Electric Lighting Committee have decided to put in a new boiler at the electricity supply station. The applications for current continue to come in, and at the present time there is an equivalent of 6,609 8-c.p. lamps connected, while 600 or 700 more are waiting to be supplied.

Country House Lighting.—Sir William Arrol intends to instal the electric light at his residence, Seafield, near Ayr, and current is to be taken from the Corporation mains, the Council having decided to make the necessary extension.

Darjeeling (India).—Some time ago we referred to the proposal for the erection of electricity supply works in this town, and from latest advices we learn that the Bengal Government has now approved the plans and estimates of the scheme.

Fareham.—Mr. E. Manville has presented his report to the Council on the condition of the electric light works. The cost of putting the wires underground and of altering the position of certain of the lamps is put at £1,428, and the Council are further recommended to duplicate the plant at the station at a cost of £1,025. The Electric Light Committee approved of these suggestions, but the Council have decided to refer the matter back for further consideration.

Fulham (London).—Mr. F. H. Medhurst has prepared an elaborate report on the proposed joint electric lighting and refuse destructor scheme. The Vestry are recommended to apply for a Provisional Electric Lighting Order, so as to be in a position to proceed with both projects simultaneously. Mr. Medhurst is of opinion that the high-tension alternating-current system, with a low-tension network of mains for private supply, would be best suited to meet the requirements of the district, and by utilising the energy produced by the combustion of the refuse the cost per unit would not exceed 2·3d. The total capital outlay, including the erection of a 14-cell destructor and the erection and equipment of electricity supply works capable of generating 372,000 units per annum, would be £54,000. The working expenses, sinking fund, interest, &c., would come to £7,700, and the estimated revenue to £9,953, leaving a profit of £1,659.

Glasgow.—Prof. Becker, who has for some time been experimenting at the Observatory with electric clocks with the view of putting in an installation to give uniform time to the whole city, has presented a report recommending the removal of the present installation at the Observatory to the Municipal Buildings, from which, by way of experiment, a central area with 10 wall timepieces will be worked. In the event of the experiment proving satisfactory the system will be extended.——The Electro-Magnetic Traction Company of Philadelphia, through their local representative, have offered to equip from three to five miles of the Corporation tramways on their underground system of traction as an experiment. The proposal is at present under the consideration of the Tramway Committee.

Halstead (Essex).—Messrs. Crompton and Co. have submitted to the District Council plans and specifications of a scheme for the electric lighting of the district. The matter is under consideration.

Harrogate.—The Town Council have decided to apply to the Local Government Board for sanction to borrow £30,000 for electric lighting and other purposes.

Hotel Lighting.—The Three Nuns Hotel, an extensive building at Aldgate, London, is now lighted electrically, current being supplied by an independent plant.

Islington.—The Vestry have now decided to proceed with the scheme of electric light extensions referred to in our issue of the 17th ult. The minutes of the Electric Lighting Committee, presented at the last sitting, contained the following recommendations:—(1) That it be referred back to the Committee to at once take steps for placing orders for the additional plant mentioned in the report recently presented by the electrical engineer (Mr. Albert Gay), and for the necessary extension of the station to accommodate the plant, at an estimated cost of £23,750, in order that it may be running by next winter; (2) that the mains be extended from Seven Sisters-road to the "Archway" Tavern, Highgate Hill, at an estimated cost of £5,000; and (3) that conduits and mains be at once laid in the Caledonian-road, at an estimated cost of £9,000. In reference to the latter recommendation, it was stated that several applications has been received from the Caledonian-road district, including one for an equivalent of 3,000 8-c.p. lamps. The Committee's recommendations were agreed to. In addition to these extensions the question of laying mains in the Essex and Camden-roads (almost the two extremes of the Vestry's area) is under consideration, and, if the proposals before the committee are carried out, will involve an estimated outlay of £6,549 and £4,035 respectively. Although the Vestry only commenced to supply current for private purposes in March last there is already an equivalent of 7,436 8 c.p. lamps connected, while 30 or 40 customers are waiting to be connected. The capacity of the present plant is 14,000 8 c.p. lamps, but the additional machinery proposed to be put down will increase this figure to 30,000. It is seldom that such an elaborate scheme of extensions has to be undertaken within three months of the commencement of supply, and we understand that still further extensions are under consideration.

Kingswood (Bristol).—The District Council have received an offer from the Town and Village Electric Light and Power Company to dispose of their electricity supply works, and the matter has been referred to the Lighting Committee for consideration and report.

Kirkcaldy.—A project is on foot for the introduction of the electric light into Kirkcaldy, and a scheme for the construction of an electric tramway between Kirkcaldy and Dysart is also being formulated.

Merthyr Tydfil.—The Board of Trade have granted Mr. J. C. Howell's application for a Provisional Order for this district, but

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the radius of the area of supply has been reduced from a mile to half-a-mile of the centre of the town. The District Council have approved the restriction.

MIDDLESBOROUGH.—A recommendation by the General Purposes Committee that no further action be taken at present in the electric lighting question led to a long and animated discussion at the meeting of the Town Council on Tuesday last. Alderman Jones moved that steps be at once taken to establish electricity supply works at an estimated outlay of £21,000, and contended that the Council ought to follow the advice of their consulting engineer (Mr. R. Hammond), who recommended them to erect a supply station forthwith. The discussion of the matter was adjourned.

MILL LIGHTING.—Messrs. Sewell and Hulton's mill, Pendleton, is to be lighted electrically.

MUCH WOOLTON (LANCS.).—The District Council have received a letter from the Board of Trade relative to the inquiry recently held by Major Cardew into the application of the Liverpool District Lighting Company for a Provisional Order for Much Woolton, Garston, Allerton, &c. Major Cardew, it is stated, recommended that the Company be allowed to make a maximum charge of 10d. per unit, and that a clause be inserted in the Order providing for a revision of the charges at the end of three years. The Council have approved the Company's application.

NEWPORT.—The demand for electric current continues to improve in a promising manner. The Harbour Commissioners have decided to take current from the Corporation for lighting the new excursion pontoon.

NORTHAM (WESTERN AUSTRALIA).—The Electric Power Company have decided to erect their works at this town, where a huge dam for the Company is being constructed on the Mortlock River, tests having proved that the bed of the river carries strong supplies of permanent water.

OSTEND.—It is stated that, notwithstanding the death of Col. North, it has been decided to complete his big scheme at Mariakerke, in the western district of Ostend, which includes an electric railway amongst other features. The whole of the work is to be completed in two years.

PARIS.—M. de Selves, the Director General of French Posts and Telegraphs, and who was a delegate to the International Telegraphic Conference at Paris in 1890, has been appointed Prefect of the Seine. In this position he will have much influence on the future of French telephonic improvements, a subject in which M. de Selves takes a great interest.

STAFFORD.—The Town Council recently offered to supply current for the electric lighting of the County Council buildings at 8d. per unit, but the County Council have decided to put down an independent generating plant unless current can be obtained at 5d.

ST. GEORGE'S (HANOVER-SQUARE, LONDON).—The Special Committee recently appointed to consider the electric lighting and refuse destructor questions have presented a report in which it is recommended that no further action be taken at present owing to the large initial capital outlay involved, viz., £70,000. The Vestry are, however, advised, in the event of the neighbouring Vestry of St. James adopting the electric light, to try the experiment of extending the mains from Piccadilly to Knightsbridge at an annual cost of £1,230.

SUNDERAND.—The Town Council have decided to reduce the charge for electric current from 6d. to 5d. per unit.

SWANSEA.—The Electric Lighting Committee are endeavouring to revive their joint electric lighting, tramway and dust destructor scheme, and with this object negotiations are at present in progress between the Committee and the Tramway Company. Both parties are anxious to come to an agreement, the Committee because they wish to see electricity works established in the town, and the Company because they desire to introduce some improved system of mechanical traction on the tramways. In the event of the negotiations not having a satisfactory termination the Tramways Company intend to approach Mr. J. C. Howell, who recently offered to take over the Council's Provisional Order.

TELEPHONE TRUNK LINES.—Replying to a question in the House of Commons as to whether the Post Office is now prepared to give the same facilities for using trunk telephone lines (with respect to hours of service, &c.), as existed previous to the Post Office taking over the lines, Mr. Hanbury stated that to the north of the Thames the old facilities remained, as the National Company still worked these trunk lines, under Post Office control. Facilities are now being experimentally given in the South of England, and this experiment is about to be extended. Until the result is known no pledge could be given as to the permanent character of the arrangement. In connection with this subject, the Post Office announces that with a view to afford facilities for telephone trunk wire communication at night and on Sundays at places where the post offices are not open continuously, it has been decided that trunk circuits are to be switched through at the post offices to the National Company's exchanges, one end of each circuit being retained at a post office at which a continuous service is given. This post office will be known as the "controlling" office. The arrangements have been made so as not to prevent the trunk circuits being used at the post offices at any hour of the night or on Sundays, and these special arrangements will terminate on the resumption of trunk working on the following morning if a week day, or, in the case of Sundays, when trunk working is resumed on Monday morning. The arrangement comes into operation forthwith at the following offices:—Bath, Weston-super-Mare and Taunton ("controlling" office, Bristol); Totnes and Dartmouth (Exeter); Torquay (Plymouth); Bournemouth and Winchester (Southampton); Worthing, Newhaven, Lewes, Eastbourne and Hastings (Brighton); Reading, Slough, Guildford, Sevenoaks, Tunbridge Wells, Gravesend, Chatham, Maidstone, Canterbury and Sittingbourne (London); and Ramsgate and Sandwich (Dover).

TRAMWAY RAILS.—The adoption of electric traction for tramways renders any device for reducing the cost of the construction of permanent way of general interest to our readers. It is stated that the Leeds Corporation are experimenting with a new type of tramway rail designed by Mr. W. Towler. This rail is in two pieces, the upper portion of which can be removed and replaced when worn without disturbing the lower section. By bending the flanges of the upper section so as to clip the head of the under rail, the two sections can be securely held. There are a number of advantages claimed for this arrangement, including simplicity of construction, the saving of time, labour, and interruption of traffic in the relaying of worn rails, and especially economy, as it is estimated that the upper section of the rail can be replaced at the cost of a little over £500 per mile, against the present cost of over £1,700 per mile.

TUNBRIDGE WELLS.—The Borough Electrical Engineer's report presented at the last meeting of the Council proves that the electric light is making steady progress. In October last there was only an equivalent of 740 8 c.p. lamps connected, but on March 31st this number had increased to 7,024. The accounts for the half-year showed that a profit of £737. 13s. had been made, and the working cost only amounted to 2·27d. per unit.

WALSALL.—Owing to the rapid progress made by the electricity supply works considerable extensions will shortly have to be made in order to meet the increasing demand for current. The Council have decided to aquire so much of the South Staffordshire Tramways Company's system as lies within their jurisdiction.

WELLS.—The City Council have succeeded in placing themselves in an embarassing position over the public lighting question. First of all it was decided to purchase the Gas Company's undertaking, but early in March last the Council passed a resolution in favour of the establishment of electricity supply works and of borrowing £16,000 for that purpose. A special meeting of the Council was held on Monday last to clear up matters, when it was decided to obtain parliamentary sanction to their decision to purchase the gas undertaking and to postpone the electric light question for a time.

## COMPANIES' MEETINGS AND REPORTS.

### Western and Brazilian Telegraph Company (Limited).

The thirty-first ordinary general meeting of this Company was held yesterday at Winchester House, Old Broad-street, London, under the presidency of Mr. W. S. Andrews.

The SECRETARY (Mr. R. M. Cunningham) read the notice calling the meeting and the minutes of the thirtieth ordinary general meeting, held in November, 1895. The report of the Directors was taken as read.

The CHAIRMAN said: Gentlemen, there is very little for me to tell you this half year, the period having been pretty uneventful. As usual, I will deal with the receipts first. Our takings have been £80,315, as compared with £82,815 in the corresponding period of the previous year, showing a reduction in the past half year of £2,500. You would naturally suppose that that means a falling off in our trade, but that supposition would be erroneous. As a fact, although the amount of money received is smaller the business transacted has been larger. We have had the same unpleasant experience repeated this time from which we have had to suffer before. It is unfortunately not a new experience that, partly from losses in exchange and partly from other causes, our messages produced less. Of course, it would be more satisfactory to come before you with an increase of receipts than a diminution, because you would have the loss per word of the decreased number besides the loss on exchange. We have not had an increase by leaps and bounds, but there has been a moderate increase pretty well all round, and the average of it comes out at 10½ per cent. on the number of words, including the business from the West Coast of South America, which has continued to increase in a very satisfactory manner. The

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reason of the loss in money, although the increase of traffic has continued, we must seek in the reductions in the tariffs that have been made from time to time, and from the still further loss which has been sustained in exchange, particularly during the half-year under review. I daresay you will be rather surprised when I tell you—what I have had to tell you before—that, as compared with the par of exchange, ourselves and the Platino Company show an ingathering of £40,000 less than we should have done at the par of exchange. Of course that means a lot of money and also a lot of dividend that we lose, but it arises from a cause which, unfortunately, it is not in our power to remedy. It is the old story, that with a satisfactory exchange we should have nothing whatever to complain of, because, owing to your assistance from time to time, we have been able to put by money enough to duplicate our lines, with the object, as we have said, of holding our own in attracting traffic. We have held our own very perfectly in that respect, because we have continually shown an increase in the quantity of business done. The only point where we have not succeeded, and where it has not been in our power to succeed, is that which is beyond our control altogether—namely, the exchange. As an illustration of the working, I have no doubt that you have seen in the newspapers a notice about the boat race. It was sent over the lines of the Eastern Telegraph, the Brazilian Submarine, and of this Company in something under a minute. I believe it reached Valparaiso, the terminus of the line, in 45 seconds. That is a distance of 8,700 miles, as the Managing Director justly observes. That sounds very wonderful, and I do not mean to say that all the staff concerned in the companies having to do with it do not deserve credit. They do; but it is not so wonderful as it looks, and for this reason. The line from end to end is practically one continuous homogeneous system. The clerks throughout the system are sitting in the same office. They are sitting at tables which are close to one another, and one man is working the apparatus here and another is working it there, so that really when the first signal appears from this end, say, the clerk on the left can see it immediately, and pop it on to the next station without the loss of any time at all. I see that a gentlemen differs from me in that, but practically the interval is so small that you may almost neglect it, and, therefore, the transmission was almost simultaneous, so to say, from end to end of the line. There are several transmissions, but it does not really matter very much. They all come on in such a way that they do not cause a loss of time. There is one thing we may deduce from the facts that I have just brought to your notice—namely, that from a business point of view this permanent contiguity of the clerks and the apparatus and the homogeneous working offer very distinct and considerable advantages to those who want to use our telegraphs. To that extent, therefore, it is highly satisfactory and encouraging. There is another fact which has occurred this half-year—that is, that the number of words per message has dropped again. It has fallen to nine, which, of course, adds somewhat to our expenses. I do not think I need deal further with the revenue account. If we turn to the expenses account we cannot, of course, expect to see a decrease in the expenses of our clerkage and so on, with more work to handle. Therefore the expenses under abstract A show an increase in clerkage of £1,276. Of course, this refers to the men who are occupied in Brazil—a very unhealthy climate, I am sorry to say—in earning our money for us. The maintenance under the same head exhibits an increase of some £1,497, but £474 of that was spent in connection with certain apparatus, and is non-recurrent, and £798 was spent on repairs to cables. We hired tugs near Monte Video when our ship the "Norseman" was occupied a long way off in the north. If we are so fortunate in the future as to have interruptions which cannot be dealt with in that we propose to make an alteration in the heading "B—the ships," and make it "B—ships and maintenance of cables," because we think that is the proper place to put an item of this kind. I may say with respect to this outlay that it is more economical than it would have been to wait for the repair till our ship was disengaged, and then to have sent her down from the north to the south—a distance of thousands of miles—at great expenditure of coal and loss of time. There is another apparent increase of £430, but that is really only a matter of account. Instead of charging the insurance in one sum in the year we have split it into two, and thus half of it appears this half-year instead of the whole of it in our next account. With regard to B—ships—I have nothing much to trouble you with. There is a small reduction of £129. There is an item of £555 for one of the ships which was laid up, but that will now disappear, so that I need not labour it. C, expenses in London, shows a small diminution of £94. In the general account we exhibit some further reductions which I do not propose to trouble you with, under the heads of cable for repairs, depreciation of the Norseman (of course there is less to depreciate there each year), and the item of the training school. The upshot of all is that the expenses show an increase of £1,718, as compared with those for the half-year to December, 1894. We bring down a balance of £42,192, to which we add £5,803 brought forward from the previous half-year, and £4,618, the dividend we received from the Platino Company. These items added together produce £52,614. Against this there has been a charge of £11,148 for debenture interest, £7,952 for debenture redemption fund, and after placing £3,000 to reserve, we are able to recommend a dividend of 5s. 3d. a share, carrying £4,952 to the current half-year. You have noticed, of course, that the dividend now recommended, with that paid for the previous half-year, makes an average of 3 per cent. for 1895, or the same amount as was paid in 1894. I wish we could have done better; but I must confess that at times I feared we should not be able to do so well. With respect to the current period, I think I ought to say that it is likely to turn out less favourably than the half-year we are dealing with. The exchange all through has been lower, and has reached what we hope will prove a record price; and the business, besides, has not shown the same growth and elasticity as it has done all the half-years we have had to deal with up to the present time. There is no doubt that a good deal of this arises from the fact of the recent severe illnesses in Brazil. We have been very unfortunate ourselves in loss of men, and merchants have actually closed their offices and gone up into the interior because the risk to life has been so great. In fact, the period has been one of extreme distress all through the country. I daresay you saw an account in the newspapers of an Italian man-of-war at Rio, who lost half of her crew, including all the officers. There is no doubt that we are passing through a period of great difficulty, and consequently we are experiencing more or less the trouble that always comes of difficulties; but, at the same time, I do feel that at the back of all this there is a big potentiality. We are dealing with a country of enormous magnitude—a country possessing immense capacity for progress, and one which I think most people will agree with me is bound to improve. You have india-rubber, coffee, cocoa, corn, cattle—all sorts of those things which the world wants are produced in Brazil, and that is a fact which must tell in time. I believe that eventually the United States of Brazil will emerge from all her trouble, and take up that great commercial position which, in my opinion, is awaiting her. We fortunately continue on excellent terms with the Government, and our exertions are always directed to the object of maintaining and improving our present very excellent relations. No doubt you have noticed the paragraph in the report with respect to the ships. You know that we were left with two of them laid up when we bought the new "Norseman" with the object of being enabled to do with only one ship. We have sold the "Viking" at a fairly satisfactory price, and I believe that the purchaser has got a very excellent and a very cheap ship. We had to spend some money upon her because it was necessary, of course, for her to preserve her classification as A1 at Lloyd's, and that she did. Then we thought we might succeed in getting a charter for the "Norseman," but I regret to say that she did not turn out well when she came to be examined, and our surveyor strongly advised us to spend no more money on her. We had had no advice of such a character previously, but on a very thorough examination being made of the ship, it seems that her ribs had been very much strained, distorted and injured in a great storm she was in on the coast of Brazil. They reported that so much injury had been done to the ship that it would cost as much to repair her as to buy a new vessel, and she had to be sold at a considerable loss, which has been written off the reserve fund. We have a small balance to receive of £1,399, and that will complete the account as regards these ships, which we have to maintain, so to say, for no purpose. They will disappear from our accounts, and the item which you have seen from time to time of maintenance of ships in dock will disappear with them. We have only got our one steamship, which is a very excellent vessel, and does her work wonderfully well. There is no change as regards the purchase of our lines by the Government, and, as far as one can see—this is a matter of personal opinion—I do not think there is likely to be much change in the present position unless there is a considerable improvement in the finances of Brazil. When that takes place we have no reason to believe that this question will not be revived; in fact, it is still in a state of torpid existence. The power of purchase remains. My impression is that it will be continued until the Government are ready to deal with the question. There is another little crumb of comfort—although only a small crumb—namely, that exchange seems now to be improving. I believe there is a good coffee crop—the largest they have had for a long time—and that will bring more active business, and send more money into the country, and we are told that the exchange is improving. A Telegraph Conference to consider telegraph matters is to meet in Buda Pesth in June. It is a conference of all the States and parties interested in telegraphy, and as usual they have invited the companies and given them a deliberative voice in the Conference, although, not being parties to the treaty, our Company has no voice. I do not think anything is likely to occur there of any considerable interest for us, but we shall be represented, and everything will be watched in our behalf. I have nothing further to add, except to propose—

*"That the report and accounts to December 31, 1895, now submitted, be and are hereby approved and adopted, and that a dividend of 5s. 3d. per share, free of income tax, making, with the interim dividend paid in November last, £3 per cent. for the year 1895, be and is hereby declared payable on the 15th inst."*

Mr. C. W. EARLE seconded the motion.

Mr. W. GRIFFITH thought it matter for regret that the Chairman had not been able to give them any assurance that the Brazilian Government really intended to carry out the very important proposal which had been made to them for acquiring their undertaking. Would it not be possible to charge higher tariffs and thus recoup the loss they sustained by exchange?

Mr. A. R. GRANVILLE asked a question relative to the amount of depreciation of "Norseman No. 1."

The CHAIRMAN: We dealt with this matter in 1894. You will notice in the reserve fund account that we say, "Depreciation written off 'Norseman' B No. 1," £13,100. This exchange business and the increase in tariffs have had the most careful attention of the Directors and of everyone else interested in the traffic, but our difficulty lies in this—that we are not the only line. As has been said, we are open to competition, and if we were to put our rates up and the others did not do so, we should lose the trade. Until, therefore, we can succeed in persuading our competitors to put up their rates to cover their loss by exchange, we cannot do it.

A SHAREHOLDER inquired whether the Company's revenue benefited by the Amazon Telegraph.

The CHAIRMAN: Yes, to the extent of the traffic it will do so.

Lord Richard H. Browne and Mr. John Coppen were then re-elected Directors, and Messrs. Turquand, Youngs, Bishop and Clarke as auditors.

A cordial vote of thanks to the Chairman, Directors, Managing Director, and Staff terminated the proceedings.

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## Brazilian Submarine Telegraph Company (Limited).

The forty-fifth *ordinary* general meeting of the shareholders of the Brazilian Submarine Telegraph Company (Limited), was held in Winchester House, Old Broad-street, on Wednesday last, Lord Sackville A. Cecil presiding.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting and the minutes of the previous meeting, the latter being signed as correctly entered by the Chairman.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, before we proceed with the ordinary business I am sure the first thing which will strike you for remark is the absence *from* the chair of Sir John Pender, and I am confident that I am only anticipating your wishes in giving expression on behalf of this meeting to the feelings of sincere sympathy with him and his family felt by all here present *under* the circumstances of his long-continuing and dangerous illness. It is but a hackneyed phrase that Sir John Pender's name is a household word in submarine telegraphy, and although he only joined this Company officially at the death of the late Chairman, Sir James Anderson (himself a man of world-wide renown), some three years ago, he has been interested in this Company, as he himself told us at one of his early meetings, from its very foundation; and we felt that his acceptance of the chairmanship when it fell vacant did equal honour to this Company and to himself. From his connection with our allies, from his grasp of the large problems of international telegraphy, and from his intimacy and acquaintance with all concerned in this great branch of scientific and commercial progress, he was peculiarly fitted to represent this Company. We miss his accustomed presence here as a personal loss, and we will wish him what I am pleased to be assured he enjoys as far as possible, a full measure of comfort and contentment. This, gentlemen, as you will remember is our interim meeting. You will agree with me that it is not opportune to discuss large and important questions of policy which must ever be watched by your representatives on the Board, and, indeed, I doubt if their discussion at shareholders' meetings is very profitable for the interests of any company. At the same time we have nothing in our accounts to hide; and if, after moving the usual resolution, any proprietor thinks fit to ask me questions with respect to the accounts, it will most certainly be my desire to give him in reply such information as seems proper. With your leave I will now turn to the report and accounts, which you have taken as read. In paragraph 2 of the report you will see it stated that the receipts for the half-year ended December 31st last were £106,168, which is a decrease of £2,038 upon the previous half-year, although an increase of £1,242 on the corresponding half-year of 1894. The decrease of message receipts is—to be precise—£2,104, and the figure £2,038 is reached by slight adjustments of interest and transfer fees, which are £66 more. There were satisfactory increases in the receipts from our traffic with the West Coast of Africa, the Cape of Good Hope and other South African Colonies and States, and also with the West Coast of South America. The falling off in receipts has arisen on the east side of South America, that stretch of country represented on the map by the sea board of Brazil, Uruguay and Argentina, and it is sufficiently accounted for by the fact that for four months of the half-year, viz., from September 1st to December 31st, the charges from this side of the Atlantic were reduced by 70 centimes, or nearly 7d. a word. The decrease which would have resulted from that reduction would have made a much larger inroad into our total traffic receipts but for the improved rate of average value of the Brazilian currency, in which a large portion of our income is collected, and also for some slight compensation in the increased volume of the traffic carried. I should like here to say a few words about some considerations upon the limits of compensation for low rates which may be desirable from increased volume of traffic arising in consequence. It is a subject upon which there is still a great deal of misconception outside the small circle of those immediately engaged in the conduct of telegraphic business, The general subject was treated some years ago by the late M. Vinchent, who has been regarded as the pioneer of cheap telegraphy in Belgium, whom it was my good fortune to know personally. He has left a record of his investigations which is still cited as canon with regard to overland telegraphy. Most of his conclusions then arrived at apply with extra force to submarine cables on account of their much greater cost of construction. It is most to be wished that all who approach this subject should appreciate that there is not much real analogy between the results to be anticipated from lowering postages or carrying rates of commodities and those of lowering telegraph rates, and any inferences drawn from analogy between them require most careful scrutiny. A cable once full you have to lay down another, just like building an entire new railway, or constructing a new road from end to end of your system, at large initial expenses, which new way has to be manned and maintained in addition to what already exists; and so after a certain turning point which in telegraphy may soon be reached, you have, besides the additional working expenses, to contemplate interest on freshly sunk capital. Those economists who may be aiming at universal cheap telegraphy for the social purposes of everyday life, had a great deal more before them than is always realised, and as regards the merchant—our chief customer, perhaps—he, with his registered addresses and codes, already possesses a larger measure of cheap telegraphy than, as a wise business man, he will hasten publicly to admit. These considerations lead up to the question of the best appliances for getting the maximum duty out of lines already laid, and your Board have lately entered into an agreement whereby we should obtain the use of quite the most modern automatic appliances for signalling through long cables. They are distinct advances on anything hitherto accomplished, and although they are rather costly we shall probably be obliged to bring them into use before long for the sake of the accuracy and increased carrying capacity we shall obtain. We are preparing generally for the unpleasant prospect of having to do the increase of our work at less profit, and personally I look for some increase on our working expenses in the future. I would simply remark here that in this industrial progress it is those equipped with the best machinery and backed with means who stand the best chance in the race. The total expenses chargeable against the half-year amounted to £21,623, which, compared with the previous half-year, were £494 more. There is a decrease in the London expenses of £371 and an increase in the expenses at stations of £289, and in other items of expenditure an increase of £576. The main item of increase of expenditure at stations is salaries and pension fund, and I am quite certain that the proprietors will not grudge their staff at foreign stations—Pernambuco, St. Vincent, and Madeira—the advantages they have now obtained of being put on a scale and in a position as regards pension in line with the staff of other companies. The increase in other expenses of £576 is entirely due to more repairs having been done to cables and shore ends. This item of cable repairs I need only remind you is an exceedingly variable one. It baffles all forecasting—and, I was going to say, control or calculation either. A fault may open up at any moment which will put the Company to an expense of thousands, or to even a more serious draft on the reserve. The last big fault which I recollect cost us, I think, between £8,000 and £10,000, to repair, and was nothing so very wonderful either as regards difficulty of the repair, though it was admirably done by the captain and crew of the ship "Mirror." I therefore make no apology for my colleagues and myself in having again placed a good sum to the credit of the reserve fund, or in view of competition, bad trade, and low exchanges, for having carried forward a rather unusually large sum to the credit of the current half which is the closing one of our financial year. This is not the half-year when your Directors come before their fellow proprietors for re-election, but in the absence of our Chairman through illness, and precluded as we are for the present from the advantage of Mr. Brodrick's assistance at the deliberations of the Board, he having accepted office in the Government, we feel that we shall have the hearty support of the proprietors in having elected Sir Albert Leppoc Cappel to a casual vacancy on the Board. Sir Albert has occupied the distinguished position of Director General of Indian Telegraphs, and has for many years been led to make the telegraphic communications of the world his peculiar study. In having gained him for a colleague on the board, we feel increased confidence in approaching the problems of the future which may be before us. We are on the eve of the Quinquennial Telegraph Conference at Buda Pesth next month, and some of the questions down for discussion are again very important for all the cable companies. We venture to hope that the submarine telegraph companies have now made good their claim to submit their views on such subjects, and that their views will continue to receive that consideration which is due to the representations of the largest and earliest pioneers of international telegraphy. Though not falling exactly within the limits of the half-year to which the accounts relate, I ought not, perhaps, to close without a reference to the Amazon telegraph extension to Manaos, which has been taken up with spirit, and the cables laid by the exertions of our allies, the Western and Brazilian Company. The line will act as a feeder to the joint undertaking, and will, we hope, settle down into a successful one. On this side of the Atlantic we have not been idle in the joint interest. Together with our allies, the Eastern Telegraph Company, and with the Telegraph Construction and Maintenance Company, we have joined in a new company called the German Telegraph Company, or, more correctly, the Deutsche See-Telegraph Gesellschaft, having for its object the laying of a cable from Emden in Germany to Vigo in Spain, whence there is a short cable to Lisbon, where our main cable diverges. That new cable is in course of construction, and when we next meet I hope we may be able to report further with respect to it, but if our hopes are realised it should carry a valuable North European traffic for our route, much of which is now lost to us. He concluded by formally moving the adoption of the report and accounts.

Mr. FREDERICK YOULE seconded the resolution, which was carried unanimously, and a vote of thanks having been accorded to the Board of Directors, for which the Chairman expressed his acknowledgment, the proceedings ended.

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**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31 1/16d. per oz. (May 14th). Consols (2½ per cent.) 111⅝—112 for money, 111 15/16—112 1/16 for account; 2½ per cent. 107⅞—107⅞ (May 14th). Stock Exchange Settling Days: Consols, June 1st; Stocks and Shares Continuation Day, May 27th; Ticket Day, May 28th; Pay Day, May 29th; Mining Share Carry-over Day, May 26th.

**ELECTROLYTIC PROCESSES.**—At the last meeting of the Camden Syndicate, on Tuesday, reference was made by the Chairman (Mr. W. A. Harper) to the formation of the Smelting Company of Australia (Limited), which had been established to take over the Syndicate's interest in certain electrolytic patents and processes for the treatment of all kinds of ores and the establishment of large central metallurgical works in Australia. He stated that the establishment of the Smelting Company's works had already led to great activity in mining in New South Wales, and, with regard to the electrolytic process for the recovery of zinc, he had visited Berlin and had satisfied himself that Messrs. Siemens and Halske had succeeded in obtaining zinc as cheaply, as simply, and perhaps more effectively than any other previously thought-out electrolytic scheme. Messrs. Siemens and Halske were now proceeding with the construction of the first instalment of their electrolytic plant for Illawarra, and that well-known firm were taking full responsibility for the success of the working of the plant.

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## West India and Panama Telegraph Company (Limited.)

The report of the Directors of this Company for the half-year to December 31st last will be submitted to the general meeting, to be held at Winchester House, London, E.C., on Wednesday next, at 12 o'clock. The report states that the amount to credit of revenue is £33,558. 3s., against £33,243. 4s. 4d. for the corresponding half-year of 1894, and the expenses have been £19,676. 5s. 11d., against £23,613. 14s. 8d., leaving a balance of £13,881. 17s. 1d., which, with £1,421. 7s. 2d., brought forward, makes a total of £15,303. 4s. 3d., to be dealt with as follows:—

| | | | |
|---|---|---|---|
| First Preference Shares— | | | |
| Dividend, 6 months to December 31st, 6s. per share... | £10,368 | 18 | 0 |
| Second Preference Shares— | | | |
| Dividend, 6 months to December 31st, 6s. per share... | 1,400 | 14 | 0 |
| Ordinary Shares— | | | |
| 6d. per share (free of income tax) ..... | 2,208 | 0 | 6 |
| Balance to current half-year's account ... ..... | 1,325 | 11 | 9 |
| | £15,303 | 4 | 3 |

The traffic receipts for the six months show an increase of £1,083. 1s. 3d., compared with the corresponding period of 1894. The expenses of repairing cables amounted to £7,097. 9s. 3d., being £3,403. 13s. 7d. less than for the corresponding period. This decrease is chiefly due to the smaller quantity of cable used, and to the Company's s.s. "Grappler" having been credited with the cost of freight on cable carried out by her to the West Indies in August last. The "Duchess of Marlborough" is still out of commission.

The amount of the subsidies is £1,000 less than in the corresponding period, owing to the termination of the contract with the French colony of Guadeloupe, which formerly paid the Company £2,000 per annum.

Since the close of the half-year, the Directors report that St. Vincent has reduced its subsidy from £600 to £400 for the year commencing April 1st, on the ground of the depressed financial condition of the colony. The telegraphic service of this colony with a subsidy of £600 is carried on at an actual loss of about £1,100 per annum, without counting any interest on capital. The traffic receipts do not meet the office expenses, and even the original subsidy of £800 per annum was quite inadequate to defray the proportionate cost of maintaining the system. This further reduction of the subsidy is considered by the Directors to be most discouraging. The existence of the telegraph at St. Vincent, as well as at several other of the British Colonies served by the Company, is of far more importance to Imperial and Colonial administration than to commercial interests; and the communication having to be maintained at such stations at a loss is a result that could not have been contemplated when the Company was formed.

Mr. William Andrews offers himself for re-election as Director, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co.

## NEW COMPANIES, STATUTORY RETURNS, &c.

*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1896, pages *318-346, &c., &c.*

**BLACKHEATH AND GREENWICH DISTRICT ELECTRIC LIGHT COMPANY (LIMITED).**—This Company was registered on May 11th with a nominal capital of £5,000, in £1 shares, to apply for, obtain and carry out the terms of a Provisional Electric Lighting Order or Licence, to construct, lay down, establish, fix and carry out all necessary cables, wires, lines, accumulators, lamps and works, to generate, accumulate, distribute and supply electricity, and to carry on the business of an electric light company in all its branches, electricians, mechanical and electrical engineers, suppliers of electricity, and manufacturers of and dealers in all kinds of electrical apparatus. Amongst the first subscribers are: W. Claude Johnson, civil engineer, Charles E. S. Phillips, and Alfred F. Yarrow, each with 100 shares.

**HENRY SMITH AND CO. (KIEFF) (LIMITED).**—This Company was registered on April 29th, with a nominal capital of £50,000, in £10 shares, to acquire the business carried on by Messrs. H. P. Smith, S. Wachtel and E. Agar, at Kieff, Russia, under the style of "Henry Smith and Co.," to carry on the business of manufacturers and importers of, and dealers in engines and machinery, telegraph, telephone and electrical engineers, railway and tramway contractors, &c. The first Directors are H. P. Smith, and S. Wachtel.

**SUSSMANN ELECTRIC MINERS' LAMP COMPANY (LIMITED).**—This Company was registered on May 6th with a capital of £80,000 in 39,250 £7 per Cent. Cumulative Preference, 39,250 Ordinary, and 1,500 Deferred shares, all of £1 each, to enter and carry into effect an agreement with the Electric Exploitation Company (Limited), and also an agreement with the Edison and Swan United Electric Company (Limited), to acquire any patents or rights obtained, or to be obtained, for the United Kingdom for improvements in secondary batteries, and in connection with the manufacture and use of galvanic batteries, miners' and other lamps, electrical apparatus, telegraphs, telephones, electric motors and power supply apparatus, to carry on the business of an electric light and power and telegraph and telephone company in all or any of its branches, and to carry on the business of electricians, electrical and mechanical engineers, chemical engineers, suppliers of electricity, and manufacturers of all kinds of electrical appliances. The first subscribers, with one share each, are: E. Dyke, H. H. Lale, H. A. Grimsdick, M. Frayne, H. Thomas, W. Hutton, J. A. Wilkins and E. Day.

**DOVER ELECTRICITY SUPPLY COMPANY (LIMITED).**—The annual return to March 25th has been filed; 4,680 shares have been taken up out of a capital of £50,000, in £5 shares, and the full amount has been called.

**METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return to April 14th has been filed. The nominal capital is £500,000, divided into 49,900 Ordinary and 100 Founders' shares of £10 each. The whole of these have been taken up, 2,132 have been issued as fully paid, and the full amount has been called on the remaining 47,868.

**PHOSPHOR-BRONZE COMPANY (LIMITED).**—The annual return to April 10th has been filed. The nominal capital is £90,000, in 15,000 Ordinary and 15,000 Preference shares of £3 each; 8,375 of the latter and 7,335 of the former have been taken up, the full amount has been called, and paid.

**ROSE AND BIRD (LIMITED).**—The annual return to May 5th has been filed. The whole nominal capital of £3,000, in 2,000 Ordinary and 1,000 Founders' shares of £1 each, has been taken up. The Founders' shares have been issued as fully paid, and all the Ordinary shares have been paid up.

**ROUND'S ACCUMULATOR COMPANY (LIMITED).**—The statutory return of this Company to January 31st has just been filed; 6,040 shares have been taken up out of a capital of £10,000, in £1 shares, and 6,000 of these have been issued as fully paid; £1 per share has been called on 33 and 5s. per share on the remaining 7 shares.

**WILLANS AND ROBINSON (LIMITED).**—The annual return to April 22nd has been filed. The nominal capital is £300,000, divided into 30,000 £6 per Cent. Cumulative Preference and 30,000 Ordinary shares of £10 each; 22,500 of each class have been taken up, and 14,463 Preference and 14,462 Ordinary have been issued as fully paid. The full amount has been called on the remainder.

## CITY NOTES.

**CAMBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED).**—The total revenue of this Company from the sale of current, meter rents, &c., for the quarter ended March 31st last amounted to £1,828. 9s. 10d., against £1,322. 16s. 9d. in the corresponding quarter of 1895. The number of units sold was 65,425, and there was an equivalent of 15,952 8 c.p. lamps connected to the Company's mains.

**CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).**—Letters of allotment and regret for the recent issue of 12,000 ordinary shares of this Company have been posted.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended May 10th were £909, against £832 in the corresponding week of 1895, an increase of £77. The total receipts for the half-year amount to £17,936, against £17,815 for the corresponding period of 1895, an increase of £121.

**COUNTY OF LONDON AND BRUSH PROVINCIAL ELECTRIC LIGHTING COMPANY (LIMITED).**—From our advertisement columns it will be seen that the Electric and General Investment Company (Limited), of 1 and 2, Great Winchester-street, London, E.C., invite applications on behalf of this Company for 10,000 cumulative Six per Cent. Preference shares of £10 each, at a premium of £2 per share, payable £1 on application, £2 on allotment, £2 on September 1, £2 on November 2, £2 on January 1, 1897, and £3 on March 1, 1897. The Company has an authorised capital of £800,000, divided into 40,000 cumulative Six per Cent. Preference, and 40,000 Ordinary shares of £10 each; 10,000 Preference and 22,475 Ordinary shares have already been subscribed for. The Directors have, in addition, power to issue debentures to the extent of £400,000. The present issue is made in order to provide funds for the further development of the Company's operations, and applications from existing shareholders will be preferentially considered. The Company holds Provisional Orders for the parishes of St. James' and St. John (Clerkenwell) and St. Luke, Middlesex, St. George-the-Martyr, Southwark, and the districts of the Wandsworth and St. Olave District Board of Works (Surrey); and the Company also hold controlling interests in the Bournemouth and District Electric Supply Company, the Dover Electricity Supply Company and the Richmond (Surrey) Electric Light and Power Company (Limited). The full payment of 6 per cent. per annum has been paid on the existing Preference shares for the year 1895, and the Directors consider the earnings during the present year will suffice to pay the dividends on the Preference shares, including the present issue. The subscription lists opened yesterday (Thursday), and will close to day (Friday) at 4 p.m., for both town and country.

**EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).**—The Most Honourable the Marquess of Tweeddale has been appointed Deputy-Chairman of this Company.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 10th inst. amounted to £1,162. The amount for the corresponding week last year was £1,159.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended May 8th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,580.



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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name | Previous Week's Price, May 6. | Price Wednesday, May 13. | Rate per Cent. Yielded. £ s. d. | Dividend Due | Business Done During Week Ending May 9. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 50 52 | 49 51 | 4 18 0 | Jan., Apr., July, Oct. | 51½ | 49¾ |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 92½ 93½ | 91½ 92½ | 5 8 1 | " " | 93¾ | 90½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9¾ 10¼ | 9¼ 9¾ | .. .. | .. .. | 10¼ | 9¼ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 10 | January and July | 100½ | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10½ 11 | 10 11 | .. .. | .. .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 14½ 15 | 14¾ 15½ | 4 11 10 | Mar., June, Oct., Dec. | 15 | 14½ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 117 | 113 117 | 4 6 7 | June and December | .. | .. |
| 10,000,000 | $100 | $3½ | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 2 10 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 13 | 12 13 | 6 8 1 | February and August | 12⅜ | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20½ 21½ | 20 21 | 4 15 8 | " " | .. | .. |
| 12,981 | 5 | 2/0 | Direct Spanish (fully paid) | 4 5 | 4 5 | 4 0 0 | April and October | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 15 8 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 106% 109% | 109% 109% | 4 3 9 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10 | 9½ 10 | 4 0 0 | Jan., Apr., July, Oct. | 9⅛ | 9⅛ |
| 400,000 | 10 | 2/6 | Eastern | 17 17½ | 17 17½ | 3 14 4 | " " | 17⅛ | 17½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18 18½ | 18 18½ | 3 4 10 | " " | 18⅞ | 18¼ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 129 132 | 130 133 | 3 0 2 | May and November | 132½ | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 109 | 106 109 | 4 12 10 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 18½ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅞ | 18⅛ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 131 134 | 3 0 3 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 101 105 | 101 105 | 4 16 7 | January and July | 103⅛ | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 16 7 | " " | 102½ | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 108 | 105 108 | 3 14 9 | February & August | 105 | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 110% 113% | 110% 113% | 3 10 10 | May and November | 110 | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust | 10½ 11 | 10½ 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅜ | 10⅛ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 16½ 17½ | 17 17⅛ | 3 8 7 | " " | 17⅝ | 17 |
| 150,000 | 10 | 10/0 | Great Northern | 23 24 | 23 24 | 4 3 4 | Jan., April, and July | 23⅛ | 23¼ |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 14 4 | March & September | .. | .. |
| 17,000 | 25 | 12/6 | Indo-European | 53 55 | 54 57 | 4 7 9 | May and November | 55⅛ | 54⅛ |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 109 112 | 5 8 1 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 11 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 5½ 6½ | 6 7 | .. .. | April and October | 6⅛ | 5⅛ |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 133 138 | 135 140 | 4 5 9 | " " | 137⅛ | .. |
| 15,609 | 10 | 2/0 | West African Telegraph | 6 7 | 6 7 | .. .. | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 105 | 102 105 | 4 16 2 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. .. | January and July | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 97 102 | 97 102 | 8 0 0 | June and December | .. | .. |
| 88,321 | 10 | 1/3 | West India and Panama | 1⅜ 1⅝ | 1⅜ 1⅝ | .. .. | " " | 1⅝ | 1⅜ |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 11⅝ | 11⅜ 11⅝ | 5 2 2 | May and November | 11⅝ | 11⅜ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9⅜ 10⅛ | 9⅜ 10⅛ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 11 6 | June and December | .. | .. |
| 64,248 | 15 | 3/0 | Western and Brazilian | 9 9⅜ | 9⅛ 9⅜ | 4 12 4 | May and November | 9⅜ | 9⅛ |
| 33,129 | 7½ | 3/0 | Do. 5 per Cent. Cumulative Preferred | 6½ 7 | 6⅝ 7⅛ | .. .. | .. | 7 | 6⅛ |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2⅝ 3 | 2⅝ 3 | .. .. | .. | .. | .. |
| £165,200 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 104 108 | 104 108 | 5 12 8 | February & August | .. | .. |
| £200,400 | 100 | 6% | Do. 6% Mort. Debs., Series "B" 1910 | 104 108 | 104 108 | 5 12 8 | " " | .. | .. |
| £1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 2 0 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 5 | 102 105 | 5 15 6 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3 3½ | 3 3½ | .. .. | .. | 3⅛ | .. |
| 224,550 | 10/0 | 1½d. | Consolidated Telephone Const. & Maintenance | 1/8 1/8 | 1/8 1/8 | .. .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | 1/8 1/8 | 1/8 1/8 | .. .. | Yearly | .. | .. |
| 424,597 | 5 | 3/0 | National | 7⅞ 8⅛ | 7¾ 8 | 3 8 9 | June and December | 8⅛ | 7⅞ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 18 | 16 18 | 3 6 8 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16¼ 17½ | 16⅜ 17⅝ | 3 8 7 | " " | 17⅝ | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6¾ 7 | 6¾ 7 | 3 11 5 | " " | 6⅞ | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 4½% (red.) | 108 111 | 107 110 | 3 4 4 | January and July | 109 | 107⅛ |
| 58,000 | 5 | 3/0 | United River Plate | 3½ 4 | 3½ 4 | .. .. | " " | 3⅛ | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 97 102 | 97 102 | 4 19 9 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ 15½ | 14½ 15½ | 3 4 6 | .. | .. | .. |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 15½ 17 | 16½ 17 | 3 10 7 | .. | 17 | 16¾ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 138 | 134 138 | 3 13 5 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. .. | .. | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 7⅞ 8 | 8 8½ | .. .. | .. | 8 | 7⅞ |
| £67,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | .. .. | .. | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. .. | .. | 8⅝ | 8⅛ |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ 13½ | 12½ 13½ | .. .. | .. | 12⅜ | .. |
| 8,322 | £5 | .. | Flou-e-to-House Electric | .. .. | .. .. | .. .. | .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. .. | .. .. | .. .. | .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. .. | January and July | .. | .. |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 7⅞ 7⅞ | 7⅞ 8 | 3 15 0 | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | .. .. | .. .. | .. .. | .. | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13 14 | 14 15 | 2 13 4 | .. | 13⅜ | 13⅛ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 123 | 120 123 | 3 14 3 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9 9½ | 9 9½ | .. .. | .. | .. | .. |
| .. | .. | .. | Rand Electric | ⅜ ½ prem. | ⅜ ½ prem. | .. .. | .. | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 10½ 10⅝ | 10½ 10⅝ | .. .. | .. | .. | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 3 6 | .. | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9½ 10 | 9¼ 10 | 3 8 4 | .. | 10 | 9⅜ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1⅜ 1⅝ | 1⅜ 1⅝ | 5 3 8 | .. | 1⅝ | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅜ 1⅝ | 1⅝ 1⅞ | 3 4 0 | .. | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 114 | 111 114 | 4 0 0 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United | 1½ 1⅝ | 1½ 1⅝ | .. .. | .. | 1⅝ | .. |
| £100,000 | Stock | 4½% | Do. 4% Mortgage Debenture Stock | 104 107 | 104 107 | 4 5 6 | .. | .. | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. .. | .. .. | .. .. | .. | .. | .. |
| 119,000 | 2 | .. | Electric Construction | 1⅜ 1⅝ | 1⅜ 1⅝ | .. .. | .. | .. | .. |
| 12,845 | 2 | 2/0 | Do. 7 per Cent. Cumulative Pref. | 2½ 2⅝ | 2⅜ 3 | 4 13 4 | .. | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅜ ½ | ⅜ ½ | .. .. | .. | .. | .. |
| 29,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. .. | .. | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23½ 24½ | 23½ 24½ | 4 1 8 | February & August | 24 | 22¼ |
| £200,000 | 100 | 4½% | * Do. 4½ per Cent. Debentures, 1896 | .. .. | .. .. | .. .. | March & September | .. | .. |
| 15,095 | £10 | .. | International Okonite Ordinary | .. .. | .. .. | .. .. | .. | .. | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. .. | .. .. | .. .. | .. | .. | .. |
| 20,000 | 9 | .. | Manchester Edison-Swan "A" (£1 5s. paid) | ¼ ½ | ¼ ½ | .. .. | December and June | .. | .. |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 41 | 38 41 | 4 7 10 | .. | .. | .. |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 105 | 102 105 | 4 16 10 | March and July | 40½ | 39 |
| 37,514 | £5 | — | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. .. | .. .. | .. .. | January and July | .. | .. |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. .. | .. .. | .. .. | .. | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16½ 17½ | 16½ 17½ | 3 8 7 | .. | .. | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 16½ 17½ | 16½ 17½ | 4 0 0 | .. | 17½ | 16⅞ |
| £50,000 | Stock | 4½% | Do. 4½% Mort ge Debenture Stock | 108 113 | 109 114 | 3 10 9 | .. | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | 113 | 112½ |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 41 43 | 41 43 | 2 18 2 | May and November | 42 | 41⅝ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15 | 14⅜ 15½ | 3 5 7 | .. | 14⅜ | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 133 135 | 133 135 | 2 19 3 | May and November | .. | .. |
| £7,500 | £10 | 3½% | Liverpool Overhead Railway | 14⅞ 14⅞ | 14⅛ 14½ | 1 18 7 | .. | .. | .. |
| 10,000 | 16 | 5% | Do. 5% Preference | 16⅜ 16⅝ | 17 17½ | 2 19 5 | .. | .. | .. |
| 135,000 | Stock | 4% | Do. 4% Debenture | 114½ 116½ | 114½ 116½ | 3 10 2 | January and July | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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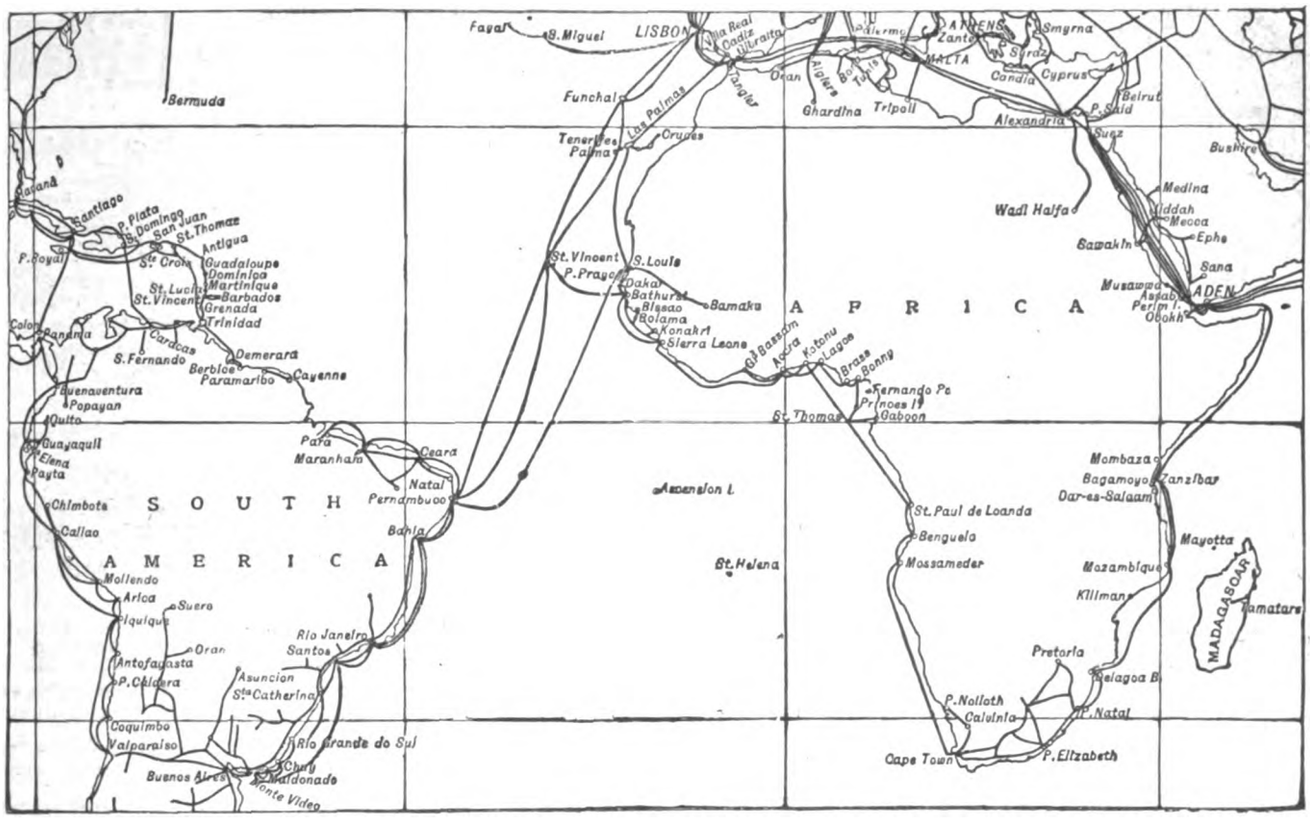


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| ,, All other Stations | 4 | 6 |
| Uruguay—All Stations | 4 | 6 |
| Argentine Republic—All Stations | 4 | 6 |
| Paraguay—All Stations | 4 | 6 |
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RICHABD COLLETT, *Secretary*,

Brazilian Submarine Telegraph Co., Winchester House, Old Broad Street.

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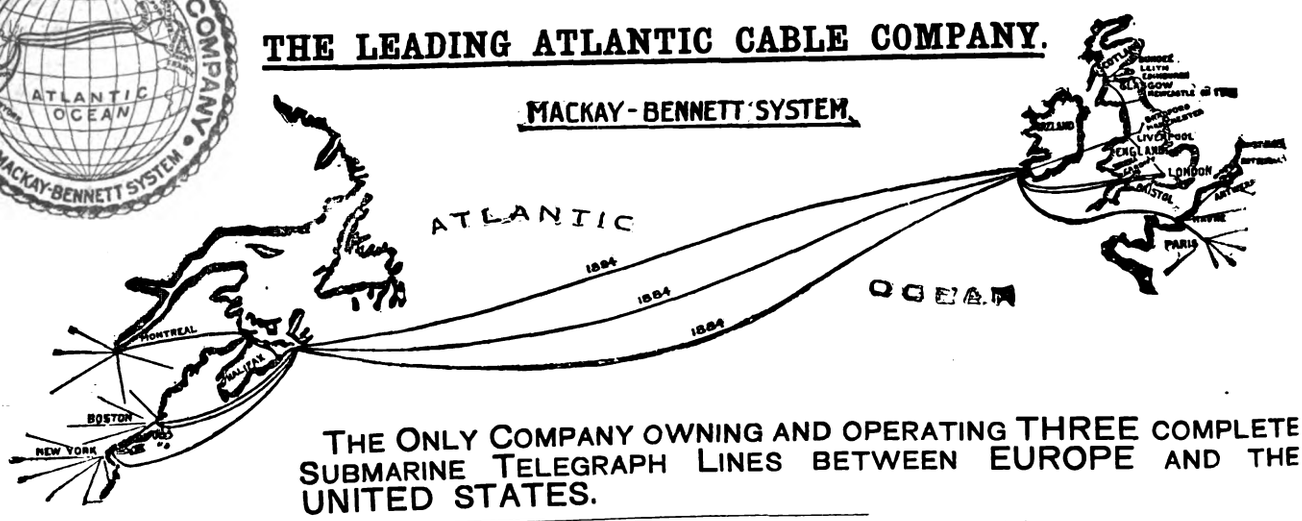
MACKAY-BENNETT SYSTEM.

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Candidates must have had previous experience in a similar appointment with a Company or Corporation supplying electricity under Parliamentary powers and be competent to design and supervise the construction of the generating station, plant, machinery, cables and appliances necessary to generate and supply electricity for public and private lighting on the low tension direct current system. The Engineer appointed will be required to devote his whole time to the service of the Corporation.

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St. Peter's Churchyard, Silver-street, Lincoln, 18th May, 1896.

H. K. HEBB, Clerk of the Urban Sanitary Authority and Deputy Town Clerk.

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By order,

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Conditions of appointment, and forms of application, may be obtained from the Secretary, at the Institute, Holloway-road, London, N.

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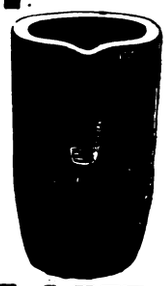

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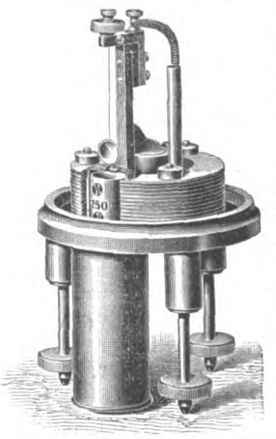

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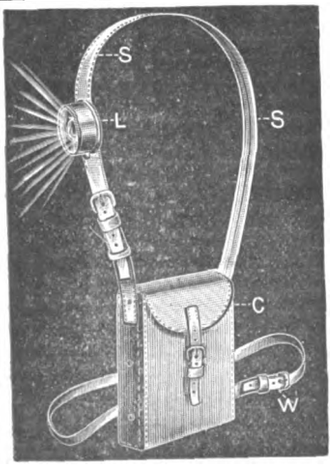


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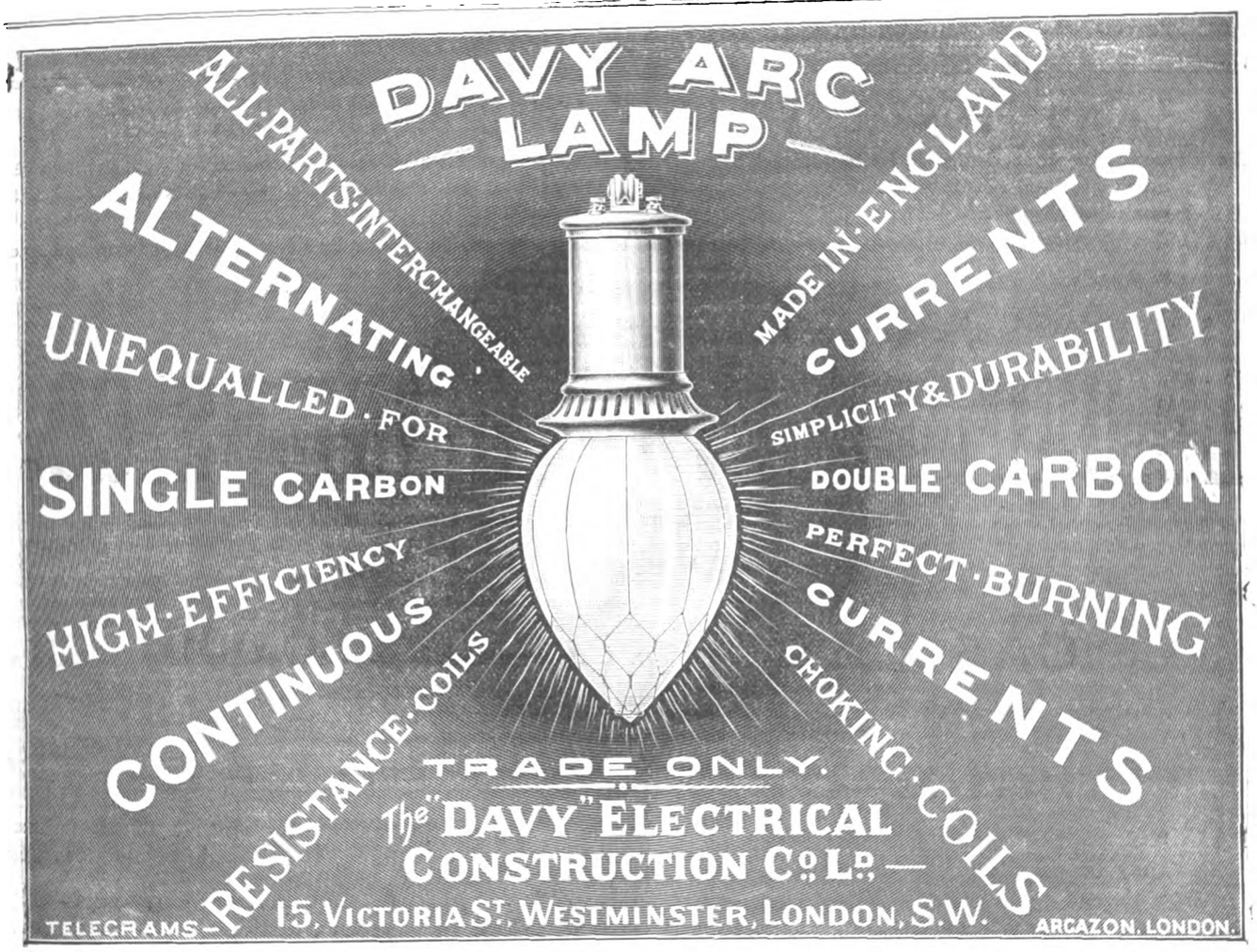


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| Horsekeeper's wages and yard expenses | 42,367 | 14 | 7 |
| Horse stock, less sales and carcases | 48,826 | 10 | 3 |
| *Maintenance.* | | | |
| Food | 119,016 | 0 | 6 |
| Bedding, shoeing, and Veterinary service | 14,804 | 17 | 9 |
| *General.* | | | |
| Harness, stable expenses, &c. | 12,209 | 14 | 10 |
| Total | £237,224 | 17 | 11 |

Dividing £237,224. 17s. 11d. by 10,693,359 miles, equals 5·32 pence per omnibus per mile.

This is exclusive of drivers and conductors, office expenses, and general administration.

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# THE LONDON ELECTRIC OMNIBUS COMPANY, LIMITED.—*Continued.*

The following figures are based on the actual results obtained during the running of the electric omnibus 5,000 miles through the traffic of London streets.

COST OF RUNNING 911 ELECTRIC OMNIBUSES FOR SIX MONTHS—13,264,160 MILES.

| | £ | s. | d. |
|---|---|---|---|
| Fuel, Oil, and Stores | 24,633 | 8 | 9 |
| Motive Power, wages, engine-drivers, stokers, &c. | 6,632 | 1 | 7 |
| Maintenance of Station plant, repairs, &c. | 14,093 | 15 | 6 |
| Maintenance of accumulators, motors, and gear | 60,794 | 1 | 4 |
| Station superintendence | 17,286 | 18 | 6 |
| Car sundries | 11,827 | 4 | 2 |
| Total | £135,267 | 9 | 10 |

Dividing £135,267 9s. 10d. by 13,264,160 miles (one of the advantages of the Electric Omnibus is that it runs a greater number of miles in the same working hours), equals 2·44 pence per Omnibus per mile.

This is exclusive of drivers and conductors, office expenses, and general administration.

The published accounts of the London General Omnibus Company, from their balance sheet of the 31st December, 1894, show an available profit for six months on the running of 911 Omnibuses sufficient to pay £75 clear profit per 'bus per annum.

The saving effected by the Electric System is the difference between 5·32 pence per Omnibus per mile, cost of horse traction, and 2·44 pence per Omnibus per mile, the cost of this Company's traction. Therefore, a saving is effected of 2·88 pence per Omnibus per mile on each Omnibus of the Company, irrespective of the number of Omnibuses run.

The working capital allowed for in this Company is sufficient to provide for 125 Omnibuses, running 70,000 miles per week. Ignoring what may be called the ordinary profit of £75 per 'bus per annum, as shown above, and taking only the saving, the 2·88 pence multiplied by 70,000 miles per week, multiplied again by 52 weeks, equals £43,680, sufficient to pay a handsome dividend on the Company's capital of £250,000.

The dividend-earning prospects of this Company are enhanced by the fact that it is intended to form subsidiary companies for provincial towns, in which this, as the parent company for England, will retain valuable interests.

The President of the Local Government Board (the Rt. Hon. H. Chaplin, M.P.) announced some time ago that the Government intended to bring in a Bill for removing the existing restrictions for the running of Horseless Vehicles on the roads and streets. This has now been done. The Company will set to work immediately after allotment in building the Ward Omnibuses, so as to be ready for traffic as soon as the Act is passed.

The Directors, while perfectly free to use the best Accumulator to be obtained in the open market, have secured on favourable terms for this Company the use of a new Electric Accumulator the size and weight of which are considerably less than those hitherto in ordinary use, without any sacrifice of efficiency; whilst it has other additional advantages, such as reduced cost of manufacture.

The following contracts have been entered into (1) dated the 19th May, 1896, between Mr. Radcliffe Ward and the Company, under which the Company acquires an exclusive licence for England for the patents set out in the Schedule at the price of £100,000, of which £20,000 will be paid in cash, and the balance will be satisfied in fully paid shares, which will not participate in dividends until after sufficient profits have been earned to pay, in any one year, a dividend of 7 per cent. upon the remainder of the Shares; (2) dated the 19th May, 1896, and made between The Sola Accumulator Company and this Company; granting them the sole monopoly for omnibuses and cabs for London.

The Vendor under the former Contract, who is the promotor of the Company, has fixed the purchase money to be paid by the Company as above-mentioned, and agrees to pay all printing, advertising, and other preliminary expenses attending the incorporation and formation of the Company up to allotment. During his negotiations for the formation of the Company Agreements have been entered into with various parties in connection therewith, and as to the above expenses and the issue of the capital now offered, and with persons interested in the purchase money, to none of which the Company is a party. Applicants for shares must be deemed to have had notice of these agreements, and to have waived all right to any particulars thereof, whether under Section 38 of the Companies Act, 1867, or otherwise.

The Memorandum and Articles of Association, with copies of the above-mentioned Contracts, may be seen at the offices of the Solicitors of the Company.

Applications for Shares may be made on the accompanying form, and forwarded to the Bankers of the Company with the amount of the deposit. If no allotment is made, the deposit will be returned in full, and where the number of shares allotted is less than that applied for, the balance will be applied towards the payment due on allotment, and any excess returned to the applicant.

Mr. William Marshall and Mr. Radcliffe Ward, Directors of the Company, are the Vendors.

Prospectuses and Forms of Application for shares can be obtained from the Bankers, Solicitors, and Brokers, and at the offices of the Company.

*London, 19th May*, 1896.

## REPORT ON THE SYSTEM OF THE

# LONDON ELECTRIC OMNIBUS COMPANY, LIMITED,

### By CHARLES E. SPAGNOLETTI, Esq., M.I.C.E.,

**Past Pres. Inst. Electrical Engineers; Consulting Engineer to the Great Western Railway, Metropolitan Railway; and Consulting Electrical Engineer, City and South London Electric Railway during construction.**

To the Directors of

THE LONDON ELECTRIC OMNIBUS COMPANY, LIMITED,

(WARD'S SYSTEM).

GENTLEMEN,

There can be no doubt that the next few years will bring about a total change in the system and means of conveyance at present in use, and electricity will play a very prominent part in this change. There is no science in which improvements have been so rapidly developed as in that of electricity, and the continued advances now being made tend to cheapen and, in every possible way, extend its use.

It has already shown its commercial adaptability for traction purposes in Electrical Tramways and Electrical Railways, and the extension of these now being made is an additional proof of its value for such purposes.

From the results of Mr. Radcliffe Ward's long experience and practical work, I consider there is every prospect of success for your Company. There can be no doubt that for street traffic, Electricity possesses many and great advantages over other systems. It is free from smell of oil vapour, heat and explosions; is silent, clean, and easily worked and controlled.

Horseless Vehicles on this system will afford great advantages, inasmuch as they will take up less space, can turn in less space, and can be stopped and started very quickly.

There will be less pollution in the streets, which in hot weather are at times most offensive owing to vapour and dust, and I believe are responsible for much sickness. They will avoid the cruel strain put on horses in starting vehicles to which they are attached, particularly on wood and asphalt pavements when wetted by rain or watering, and the rapid introduction of such a system is very greatly to be desired.

The less the number of horses, the greater will be the mitigation of the present evil.

I find that Mr. Ward's recent improvements include details which, in my opinion, will greatly add to the comfort of passengers, economy in the cost of maintaining the vehicles, and to the life of the Accumulators used for such purposes.

The system of gearing the motors to the axles I believe is novel, and will prove efficient and economical.

I may state in conclusion that I have been induced to accept the position of Consulting Electrical Engineer in your Company, as I strongly believe in the future success of the undertaking.

I am, yours, &c.,

(Signed)

*London, 16th May*, 1896. CHARLES E. SPAGNOLETTI.

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**This Form may be cut out and sent entire to mpany's Bankers, Messrs. Glyn, Mills, Currie and Co., with cheque for the amount of the deposit.**

# THE LONDON ELECTRIC OMNIBUS COMPANY, LIMITED.

*CAPITAL - - - - - - - - £250,000.*

No.....

Divided into 250,000 Shares of £1 each.

## ISSUE OF 170,000 SHARES OF £1 EACH.

FORM OF APPLICATION FOR SHARES.

To the Directors of THE LONDON ELECTRIC OMNIBUS COMPANY, LIMITED.

GENTLEMEN,—Having paid to your Bankers the sum of £....., being a deposit of 5s. per Share on application for ..... Shares of £1 each in The London Electric Omnibus Company, Limited, I hereby request that you will allot me these Shares, and I hereby agree to accept the same, or any less number that you may allot to me, upon the terms of the Prospectus, dated the ..... 1896, and subject to the Memorandum and Articles of Association of the Company, and to pay the subsequent instalments when due; and I authorise you to place my name on the Register of Members in respect of the Shares allotted to me.

Signature .....

Name (in full) .....

Address .....

Profession or Description .....

Date ..... 1896.

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# Use "Blackley Tape"

FOR THE "EFFICIENT" PROTECTION

*Sole Manufacturers,*

## CONNOLLY BROTHERS,

**Blackley, MANCHESTER,**

INSULATED WIRE and CABLE MAKERS.

Telephone No 2361 Telegraphic Addres : "Connollys Blackley."

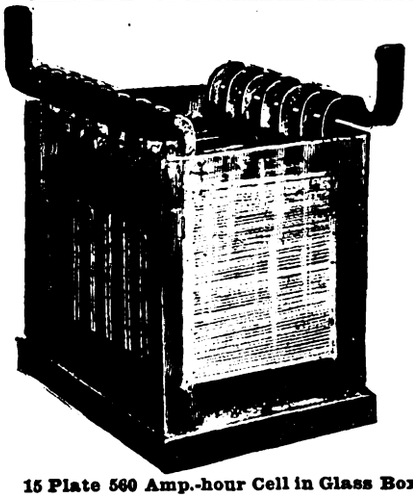
**ORDERS EXECUTED FROM STOCK.**

**LONDON AGENCY: C. F. QUICKE, 72, Finsbury Pavement, E.C.**

**of Insulated Wire Joints.**

*Does not Stick to or Dirty the Fingers.*

**No Solution Required.**



15 Plate 560 Amp.-hour Cell in Glass Box

# PRITCHETT ACCUMULATORS

**PLANTÉ TYPE.**

**From the ELECTRICAL STANDARDIZING INSTITUTION, LONDON.**

"The Cells we use for standardising purposes were supplied to us by yourselves in September, 1892, and have been in constant use ever since.

"The normal maximum output was stated to be 250 amperes per cell, that is, nearly 18 amperes per positive plate nine inches square, but we sometimes discharge them for short periods at three times this rate, so that each positive plate gives 54 amperes; indeed, they are occasionally deliberately short-circuited. Up to the present time no repairs have been needed, and they continue to do their work satisfactorily.

"You agreed to supply us with Cells which could be practically short-circuited without undue deterioration, and this we consider you have done."

**TWO RECENT TESTIMONIALS.**

***Price Lists and Trade Terms on Application.***

**From Messrs. F. H. ROYCE & CO., Ltd., MANCHESTER.**

"We have very great pleasure in testifying to the excellence of your Accumulators. We have, during the last few years, purchased a very considerable number of you as you know, and have always considered them, as we do now, the best in the market owing to the very great mechanical strength and large surface of the plates.

"If it would be of service to you at any time, we have no doubt we could get many of our customers using these Accumulators to give equally strong testimony as to their excellent features."

**PRITCHETTS & GOLD, 31, Soho Sq., LONDON, W.**

*Sole Agents for Great Britain and Ireland for* Messrs VENNER & SILLAR, 10, Delahay Street, WESTMINSTER.

*Crompton & Co., Ltd.* — *See Important Announcement on page vi.*

# DAVEY, PAXMAN & CO.,

## ENGINEERS, COLCHESTER.

**London Office: 78 (late 139), QUEEN VICTORIA STREET, E.C.**

MAKERS OF A GREAT VARIETY OF STEAM ENGINES & BOILERS.

**SPECIALITY: Steady Running Engines for Electric Lighting.**

**CATALOGUES,**

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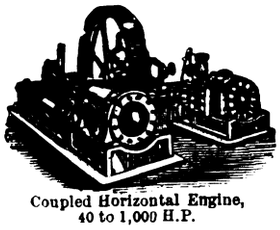
**PHOTOS, &c.**

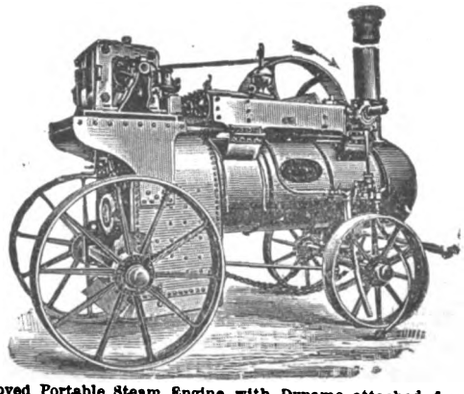
**POST FREE.**

**TELEGRAPHIC ADDRESS:**

**"PAXMAN COLCHESTER."**



Coupled Horizontal Engine, 40 to 1,000 H.P.



Improved Portable Steam Engine, with Dynamo attached, forming a portable electric light plant. Single cylinder 4 to 12 h.p.; double cylinder. 8 to 25 h.p.; compound, 8 to 30 h.p. nominal.

Horizontal High Pressure Coupled Compound Engine. 12 to 1,000 H P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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 940. [Vol. No. 4. XXXVII.] FRIDAY, MAY 22, 1896. PRICE SIXPENCE.


## NOTES.

As we go to press the announcement reaches us that a Special General Meeting of the members only of the Institution of Electrical Engineers will be held on Friday next, the 29th inst., at 4 p.m., at the offices of the Institution. This meeting has been summoned "for the purpose of considering and, if approved, passing resolutions altering the regulations contained in the Articles of Association of the Institution (in order that such resolutions, if confirmed by a subsequent meeting, may become Special Resolutions)." A copy of the proposed resolutions is before us, and we hope to publish these in our next issue.

During the past week the investing public has been asked to subscribe to two concerns, with an aggregate authorised capital of £1,000,000 sterling, the objects of both being the promotion of the mechanically and electrically propelled vehicle industry. The larger of these concerns, calling itself "The Great Horseless Carriage Company," has a capital of £750,000, of which one-third is for working capital; while the smaller, styled "The London Electric Omnibus Company," contemplates an issue of 170,000 shares, the vendor patentee, Mr. Radcliffe Ward, receiving £100,000, of which £20,000 only is in cash, for the sale of his rights in the electric omnibus he has been pioneering. There is an unmistakable inclination on the part of investors, at the present moment, to put their money in large, not to say altogether huge, amounts into concerns relating to the manufacture of cycles and other horseless vehicles, and it would not surprise us to hear that either or both of these two concerns had been able to go to allotment. At the same time it will probably occur to those who are acquainted with the present development of horseless carriage traffic, that the Bill rendering such traffic legal in public thoroughfares has not yet become law; and, further, that it would be extremely curious and inexplicable if electric accumulator omnibuses running on ordinary roads could be made to pay, while electric accumulator cars running on tramrails apparently cannot. It naturally strikes us as being easier to make a success of any system of mechanical traction on the smooth track of a tramway than on the uncertain and more difficult common road. But, the commercially successful accumulator tramcar—where is it?

Considerable interest attaches to the statement of accounts f the Belfast electric supply concern, just published for the year ended December 31, 1895. In a recent issue we announced that the Belfast municipal authorities had decided not to proceed with their original scheme of building a number of gas engine sub-stations, fed from the municipal gas works, but were about to erect a large steam station; and we remarked that the absence of particulars as to the working expenses of the Belfast system prevented us from drawing any final conclusions about the matter. Now, however, we are in possession of data which makes possible an accurate comparison between the gas-driven station and other stations.

A total of 95,126 units have been generated, with a total consumption of 4,454,667 cubic ft. of fuel gas from the town mains, or 46·8 cubic ft. per unit generated. The price paid for gas was 2s. 3d. per 1,000 cubic ft., or 1·26d. per unit generated. Of the total amount generated in the year, 82,197 units have been sold during the hours when the charge has been 7d. per unit, and 574 units in the time when 4d. per unit was charged. The units sold, therefore, have amounted to 87 per cent.; and if we deduct from the remainder the 3,822 units used on the works for lighting, starting the engines, &c., the residue represents a loss of only 9 per cent. of the total energy generated. The energy wasted in the batteries has been 6,304 units, and in the mains 2,229 units, figures which correspond respectively to 6·7 per cent. and 2·3 per cent. of the total generated. Accordingly, the consumption of fuel gas per unit sold has been 53·7 cubic ft., the cost of which has been 1·45d.

It has been alleged against gas engines that their consumption of lubricating oil is a more serious item than with steam engines of equal size. The total cost of lubricating oil, waste, circulating water and stores, at Belfast, has been £80. 4s. 3d., or 0·202d. per unit generated, or 0·232d. per unit sold. It cannot be alleged that either of these figures is excessive. Higher figures are often reached in steam-driven stations. In fact, the total generating expenses have not exceeded 2·82d. per unit generated, or 3·24d. per unit sold, figures which are not unreasonably large for a station of the size of that at Belfast. Finally, as regards a comparison of capital costs of generating machinery, the Belfast generating plant cost £15. 7s. per kilowatt, or 13s. 1½d. per 8 c p. lamp capacity. These figures are well below the average, and tend to show that the capital cost of a gas-driven station need not exceed that of one of equal capacity driven by steam.

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One practical result, if not more than one, has followed the reading of Capt. H. Riall Sankey's Paper on "The Thermal Efficiency of Steam Engines," a short abstract of which appeared in *The Electrician*, Vol. XXXVI., p. 796, for the Council of the Institution of Civil Engineers has appointed a committee, to consider the question of arriving at a definition of a standard or standards of thermal efficiency for steam engines. This committee will include Capt. Sankey, together with Profs. A. B. W. Kennedy, T. H. Beare, J. A. Ewing, and Messrs. Bryan Donkin, Macfarlane Gray, M. Longridge and W. H. Maw. Modern steam-engine theorists have on several occasions evinced dissatisfaction with the old-fashioned standard of efficiency afforded by the Carnot cycle. And even the less ancient cycle used by Clausius in his steam engine researches has been voted unsuited to modern requirements. It will be remembered that the main purpose Capt. Sankey had in view, in bringing his Paper before the Civil Engineers, was to present for discussion an ingenious modification of the Clausius standard, which would answer the purpose of the practical theorist, if we may coin the phrase. Doubtless our readers will also remember that in his recent "James Forrest" lecture, which we reprinted and commented upon last week, Prof. Kennedy stated that he does not in the least share "that great objection to the Carnot cycle which I know fills the breasts of some of my friends." We may look upon Prof. Kennedy as filling his place on the committee as counsel for Carnot and the *status quo ante*.

The first and most obvious thing which any committee would have to do that set itself to evolve a standard of steam-engine efficiency, would be to decide which are the unavoidable and which the merely contingent or avoidable losses in the steam engine. A list might be drawn up of all the items of possible loss of energy in steam engines, and these should be classified under the two heads indicated. Whatever mechanism, imaginary or real, was selected for the standard engine, it should comply with the condition that it should divide between the avoidable and the unavoidable losses. When, indeed, we are comparing any heat engine with a non-heat engine, it is quite fair to debit the former with the unavoidable as well as the avoidable losses. But when it is a case of comparing steam engines, or any other kind of heat engines, among themselves, a standard may reasonably be selected that will hold a just balance between what is actually done and what might really and actually have been done. The inevitably necessary losses in such a case should be put out of court.

The Paper on "Steel Steam Pipes and Fittings," which was read by Mr. Samuel McCarthy before the Institution of Mechanical Engineers at the beginning of this month, and which we commence to reprint this week, is in many ways interesting to electrical engineers. To begin with, it gives some account of the Benardos process of electric welding as applied to the welding of steam flanges, joints, &c. Several electric supply stations in this country are fitted with steam and exhaust mains which have been welded at the flanges and joints in this manner. The author of the Paper, who is connected with the electric welding department at Messrs. Lloyd and Lloyd's works, brings a great deal of technical experience in this matter to bear upon his subject. But, apart from the electrical side of this Paper, there is much useful information regarding the use of steam pipes that should be welcomed by central station engineers. Some of the most serious difficulties in practice arise from the faulty and uneconomical design or the unskilful use of steam mains. It is only quite recently that at a meeting of the Northern Society of Electrical Engineers several central station engineers complained that it was impossible to shut down their steam mains in the daytime, since the joints failed when steam was turned on if they did so. The practice of keeping the entire system of mains under steam all day long is a terribly expensive evil. It may be a necessary evil at the present time, but it may be well to take to heart the advice of Mr. Fawcus, to learn as quickly as possible how to be able to shut down the steam mains daily without risk. There is a fortune for the inventor of a pipe joint that will withstand the great stresses arising from the change in temperature.

To return to electric welding. The practice adopted by Messrs. Lloyd and Lloyd and, we infer from the Paper, by other pipe makers, is to gas or roll weld the longitudinal seams, and to use the electric process only for the flanges and circumferential joints. Electric welding is too expensive for the seams, we are told, though it is not too costly to enable it to compete with other processes as regards the other work. This limitation is to be regretted, since it entails the use of two or even three different kinds of welding apparatus at the same works. Nor do we believe that the limitation arises from anything but a failure to properly adapt the electric process to the different kind of operation which longitudinal seam welding entails. It can hardly be that there are such inherent difficulties in electric seam welding that competition with gas welding is altogether out of the question. When effectively done, electric welding makes a joint which is as tough, elastic and strong as the solid metal, and should place tubes on an equal footing with the excellent, though rather costly, seamless tubes so much admired by Mr. Platt.

No one will grudge the birthday honours bestowed upon so distinguished an explorer as Sir Clements Markham, so accomplished an educationist as Sir Joshua Fitch, or so renowned an astronomer as Sir David Gill; their names illuminate the otherwise dreary list of politicians, colonial judges and heroes (military or naval) who figure along with the successful contractor and the plodding civil servant. But where are the honours bestowed either on art or on science? We have lately seen honours and decorations—including the dignity of baron—bestowed upon Prof. Röntgen. Let us rejoice at the enlightenment of foreign governments. But why does our own British Government ignore the merits of the man without whom Röntgen would never have made his discovery? The inventor of the radiometer, the discoverer of thallium, the pioneer in spectroscopy, the patient investigator of the phenomena of high vacua—Mr. Crookes, has done more for science than most men of his generation. It is certainly

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strange, too, that the inventor of the printing telegraph and of the microphone, whose work has been recognised by so many foreign governments, should also remain without recognition in his native land. But prophets always were without honour(s) in their own country.

**Sir John Pender.**—Sir John Pender's health continues to show some improvement. He was able to walk out, and also to take carriage exercise in the early part of this week.

**New Use for Carborundum.**—It is reported that a new use for carborundum is found in the manufacture of filaments for incandescent lamps.

**A Large Gas Engine.**—The Paris Otto Gas Engine Company, says the *Gas World*, is getting a 1,000 H.P. gas engine ready for the next Exhibition (1900). Fuel gas will be used

**The Kelvin Jubilee.**—Prof. Sir G. G. Stokes, Prof. A. R. Forsyth, and Prof. J. J. Thomson are, says *Nature*, to represent Cambridge University at the celebration in Glasgow of Lord Kelvin's jubilee next month.

**The Wiring Question.**—On Wednesday, May 27th, at 8 p.m., Mr. Frederick Bathurst will lecture to the Electrical Trades Union at the Club Union Buildings, Clerkenwell-road, E.C., on "The Wiring Question."

**Obituary.**—We have to announce the death, at the early age of 27 years, of William Horace Cadiot, son of Mr. E. H. Cadiot, of Paris. Mr. Cadiot was electrical engineer at the electricity station of Jacmel (Hayti).

**The Toronto Meeting of the British Association.**—The Council of the British Association have resolved to nominate Sir John Evans, K.C.B., Treasurer of the Royal Society, for the presidency at the meeting which will be held next year in Toronto.

**The Dublin-Dalkey Tramway.**—On Saturday last the electric tramway from Dublin to Dalkey was formally inaugurated. Cars have been running over portions of this line for some time past. A full illustrated description of this interesting tramway system appeared in *The Electrician*, Vol. XXXVI., page 382.

**Cable Interruptions and Repair :—**

| | Date of Interruption | | Date of Repair. |
|---|---|---|---|
| Puerto Plata—Martinique..... | Dec. 19, 1895 | ... | — |
| Ceara- Maranham ..... | April 28, 1896 | ... | — |
| San Thomé—Loanda ..... | May 2, 1896 | ... | May 21, 1896. |
| Monte Alegre—Santarem..... | May 5, 1896 | ... | — |

**Fatal Accident at Bedford Electric Supply Station.**—On Friday last, at one of the sub-stations of the Bedford electric supply system, a young mechanic, while engaged in removing a fuse-box from a transformer, received a shock and was killed on the spot. Another labourer, who assisted, was also knocked down, but recovered shortly afterwards. The system employed at Bedford is high-tension alternate current at 2,000 volts, with transformer sub-stations. At the inquest it was stated that a Board of Trade inquiry would be held.

**A Monster Belt.**—What is stated to be the largest belt ever made in America is in process of manufacture at the Chicago Belting Company's works. The dimensions of the completed belt are as follows :—Length, 150ft.; width, 7ft.; weight, 30cwt.; thickness, $\frac{7}{8}$in. In its construction the selected portions of 450 oak-tanned hides, picked from over 5,000 skins, were used. The destination of this belt is the engine room of the Louisiana Electric Light Company at New Orleans, where it will be attached to the 28ft. driving wheel of the great Allis-Corliss engine.

**Royal Society.**—At the meeting of the Royal Society yesterday the following Papers were down for reading :—"On the Changes Produced in Magnetised Iron and Steel by cooling the Temperature of Liquid Air," by Prof. J. Dewar, F.R.S., and Dr. J. A. Fleming, F.R.S.; "Helium and Argon, Part III., Experiments which have yielded Negative Results," by Prof. Ramsay, F.R.S., and Dr. Collie, and "On the Amount of Argon and Helium contained in the Gas from the Bath Springs," by Lord Rayleigh, Sec. R.S.

**Electric Lighting in Theatres.**—The first of a series of three volumes has recently been issued of a work on "Modern Opera Houses and Theatres," by Edwin O. Sachs and E. A. E. Woodrow. This treatise comprises a large number of examples selected from European theatres, with reference to design and construction, and with supplementary sections dealing with the *technique* of theatre lighting, danger from fires and protective legislation. The first volume contains some hundred large and artistically-drawn plates, and the complete work will comprise 220 plates. The plans and detailed drawings are made to a uniform set of scales.

**Electrical Communication with Lighthouses.**—In consequence of difficulties which are still encountered, in certain circumstances, in maintaining electrical communication with light vessels, the Royal Commission on Electrical Communication with Lighthouses and Light Vessels have decided to postpone publication of their final report. An interim report has just been issued, in which the Commissioners state that, so far as lighthouses are concerned, the cables laid on their recommendation have worked satisfactorily, while as regards the cables to light vessels the results have been disappointing. Experiments are being undertaken to remove the causes of failure.

**Errata.**—In Mr. F. C. Raphael's article on "The Localisation of Faults in Electric Mains," on page 71, column 2, line 10 from the bottom, *et seq.*, for "the fault resistance of the negative main is 5,000 ohms, and that of the *negative* main is high in comparison," read "the fault resistance of the negative main is 5,000 ohms, and that of the *positive* main is high in comparison."—In the report in our last issue of the Paper of "The True Resistance of the Electric Arc," read before the Physical Society by Messrs. Frith and Rodgers, and in column 2, line 42 from top, for "between 75 and 0" read "between 7·5 and 0." As a matter of fact, the critical frequency at which the resistance of the arc changes sign was stated by the authors to be, from *à priori* reasons, between 7·5 and 0, and was actually found by them to be 1·8 $\sim$ per second.

**The City and South London Railway.**—The Bill promoted to extend the time for the purchase of lands for the purposes of the City and South London Railway Act, 1893, and for the completion of the underground railway and other objects, came before a Select Committee of the House of Commons on Monday last. The main question before the Committee was the demolition of the Church of St. Mary Woolnoth, in King William-street, for the purpose of erecting a station. Mr. C. G. Mott, Chairman of the Company, said the church was not wanted. There were ten churches within a radius of 200 or 300 yards, two of them being actually in the same street as St. Mary's. Besides, St. Mary's had no congregation, and there were no peculiar associations connected with it. The Committee found the preamble of the Bill proved, subject to the insertion of a clause for the protection of St. Mary Woolnoth, and declaring that it shall be referred to the arbitrator to take into consideration the additional liability which will devolve on the Company in consequence of giving up their present rights.

**Applied Electro-Chemistry.**—Mr. Swinburne gave his fourth and last Cantor lecture on Monday last. The lecture was devoted to experiments on electric furnaces. Aluminium bronze was made before the audience by the Cowles process on a small scale. Calcium carbide was also made in a small furnace, and a little generator was shown giving off acetylene from the carbide and feeding a 40-candle burner. Furnaces were also shown in action reducing uranium oxide and fusing tungsten, which is an exceedingly refractory metal. Zirconia and lime were melted in small quantities by maintaining a current through them. A piece of carbon pencil is used to start the experiment, and when it is burned off the heated oxide and hot air carry the current, of course offering considerable resistance and generating great heat. The manufacture of phosphorus in the lecture room by means of the Readman process would have been odorous if the room had not been already reeking with acetylene. The lectures will be published in the Society of Arts *Journal* during the summer.

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**Burn-Out of Mains at Charing Cross.**—We happened to pass along Northumberland-avenue on Monday morning last, at about 9.30, when we noticed smoke escaping from some of the mid-road and side manholes. A fire engine was on the spot, and it soon became evident that the electric light and other cables in the spacious subway beneath the centre of the road were on fire. There have been already, we understand, two fires of a non-electrical nature in that subway; and, so far as we have been able to ascertain, there is nothing to show that the direct cause of Monday's fire was electrical. Whatever the cause damage was done to, and temporary interruption caused in, the cables of the Metropolitan Electric Supply Company, the Charing Cross and Strand Electricity Supply Corporation, the Post Office telegraphs and the telegraph wires of the District Messenger Company. There was no interruption of traffic, and the consequences of the outbreak were of a less serious nature than might have been expected from the smoke produced.

**Soda and Potash Works at Niagara.**—It is announced in the American technical press that the Walton Ferguson Chemical Company's plant at Niagara Falls will shortly be started. This plant is the latest one built on the land of the Niagara Falls Power Company. At present it consists of two buildings, one of which is 60 × 125ft., and the other 30 × 60ft. Both are two stories high and built of wood. This company will manufacture potash and soda electrically. All the electrical appliances, transformers, &c., will be located in the smaller building, while on the upper floor of the larger buildings will be placed the large porcelain-lined iron tanks designed to contain the crude material for the manufacture of potash and soda. These tanks will be about 100 in number. When the plant begins its work it will consume about 1,000 H.P. One ton a day will be the capacity of the present plant, and the rock salt for making soda will be obtained in Syracuse. From Germany will come the crude material for making potash. As yet the subway in which the cables carrying power to the aluminium and carborundum works have not been extended so far as the carbide or soda plants, but they soon will be, and until they are, the power will be conducted by cables carried above ground.

**Conversion of Emery into Corundum.**—An electric process of converting emery into corundum by means of the alternate-current arc has recently been patented, says the *Trade Journal Review*. As heat, and not decomposition, is aimed at, continuous currents would be unsuitable. The furnace is made of firebricks and stands on two bridges; the hollow underneath serves as receptacle for the fused mass, there being a small hole in the bottom of the furnace. This hole is covered with a glass plate. The electrodes (carbon rods) are approached to within 1in. to 2in., the space between being packed with lumps of carbon. The emery, the finest dust, of little use otherwise, is mixed with powdered coal, the amount depending upon the iron oxide in the emery; for 25 per cent. of oxide 5 per cent. of carbon is reckoned. The coal is soon burned by the oxygen of the iron oxide and the arc forms. The inner mass begins to melt, the glass plate gives way and a stream of fused corundum flows out. The hard outer crust is then broken with iron rods, and new material thus fed to the arc. This addition stops the flow, which starts again after 10 or 15 minutes. The baseplate is strewn with fine emery powder to protect it from the intense heat of the fused mass. The resulting corundum is almost free of water, of which the emery contains about 5 per cent.

**Convention of the Municipal Electrical Association.**—The following arrangements have been made for the first annual convention of the Municipal Electrical Association, which is to be held in London on June 10th, 11th, and 12th. The meetings will be held at the Royal United Service Institution, Whitehall. At the first meeting Mr. Arthur Wright will read his presidential address on "The Municipal Electrical Association and its Objects," and the following papers, by municipal electrical engineers, will be taken for discussion:—(1) "Electricity Supply at 220 Volts," by A. S. Barnard, of Hull; (2) "Alternating-Current Stations and High-Voltage Lamps," by Harold W. Couzens, of Taunton; (3) "The Control by Municipal Authorities of Consuming Devices and the Wiring Connecting them to the Mains," by C. H. Wordingham, of Manchester; (4) "Electricity Works Records," by A. B. Mountain, of Huddersfield. At the second meeting the following Papers will be taken:—(1) "The Cost of Electricity Supply," by Arthur Wright, of Brighton; (2) "Cable Specifications and Tests," by Joseph A. Jeckell, of South Shields; (3) "The Organisation of an Electricity Works Staff," by E. T. Ruthven-Murray, of Worcester. Mr. John Hesketh's Paper on "Electric Lighting and Traction" will be taken on the afternoon of the second day. At a meeting to be held in Brighton on the afternoon of the third day of the session, a Paper on "Extensions to Outlying Districts" will be read by A. H. Gibbings, of Bradford.

**Belgian Electrical Engineering.**—At the meeting of the Institution of Junior Engineers, on Friday, May 8th, "Notes on Belgian Electrical Engineering Practice" were read by Mr. A. Anstruther-Thomson and Mr. G. C. Allingham. The communication embodied particulars which had been collected by the authors during the Institution's summer meeting of last year. Belgian electrical practice was difficult to define exactly. It was usual to associate English practice with high-speed engines, direct-coupled to dynamos or alternators, and Continental with slow-speed engines driving multipolar dynamos; no rigid distinction existed, however. Belgian practice seemed strongly influenced by both the foregoing characteristics, and was, therefore, extremely interesting as showing a variety of types, and affording exceptional opportunities for comparison. The system of free publication of central station accounts to which in this country we were accustomed was not adopted in Belgium. Originally high-speed dynamos were driven from slow-speed engines by belts; to secure the advantages of direct-coupling, in England the engine speed was increased, whilst on the Continent the dynamo speed was diminished. After briefly touching on the term "load-factor," and its influence on central station practice, the preference shown on the Continent for continuous current and large batteries was pointed out. With regard to electricity for power purposes, there were no long-distance transmissions in Belgium, and hardly any multiphase plant, but the use of electromotors in workshops was steadily increasing. Several instances were given, notably the important installation at the Herstal Small Arms Factory. General conclusions appeared to show that in electrical practice Belgium occupied a position intermediate between England and the Continent.

**The Niagara Power Transmission to Buffalo.**—Our Niagara Falls correspondent writes us that the Niagara Falls Power Company has filed with the Board of Public Works of Buffalo the plans for the distribution of Niagara electric power in that city so far as the Company is prepared to place them on record. This action is in accordance with the franchise granted to the Company. In regard to one of the two proposed trunk lines, it is stated that this line will be composed of a pole line consisting of poles not more than 100ft. nor less than 50ft. apart. The conductors for the delivery of the 10,000 H.P. generated at Niagara will consist of not less than three nor more than nine copper cables, each about $\frac{6}{10}$in. in diameter, not less than 22ft. from the surface of the ground, and, at places of special crossing, of greater height. The conductors are to be carried upon porcelain insulators of special pattern. From this trunk line it is proposed to construct two lateral lines. These lines are to be underground, in conduits of cement or vitrified clay of the type known as the Powers tellmic duct or the H. B. Camp Company's duct. Each of the conduits is to be laid so that the top surface will be not less than 18in. below the street, and each will contain not less than 18 holes, each hole not less than 3in. in diameter. The conductors used in each of the conduits are to be cables of copper wire; each cable being completely covered with insulation of standard vulcanised rubber. These underground cables, from the main lines on the canal lands to the points of use, are to carry not more than 20,000 volts. The second trunk line may be erected upon the lands of the New York Central and Hudson River Railroad Company, known as the Belt line, and will consist of a pole line similar to that already described. The first trunk line will be run alongside the canal.

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## INCIDENTS OF CABLE LAYING ON THE AMAZON.

Before an appreciative audience at the Royal Institution last Friday, Mr. Alexander Siemens delivered an interesting lecture on "Cable Laying on the Amazon River," in which he recounted his experiences and adventures during the voyage of the cable-ship "Faraday" up the mighty Amazon last January and February. The lecture was interspersed with many anecdotes, which, since they show the humorous and adventurous side of the undertaking, we have reprinted for the delectation of our numerous readers who are interested in cable matters. The lecturer commenced with a description of the preliminary undertakings:—

When it had been decided to connect Belem the capital of the State of Pará, by means of a subfluvial cable, with Manaos, the capital of the State of Amazonas, a preliminary journey became necessary, during which landing places at the various stations had to be selected, some reaches of the river explored, as no reliable charts exist, and various other details ascertained in order to facilitate the laying of the cable. This preliminary survey took place in October of last year, during the hottest season, when the river was at its lowest; while the cable was laid during January and February of this year, when the rainy season had commenced and the river was rising. The difference in temperature between the two journeys was, on the average, not more than 5½°C. (10°F.), but a great advantage during the laying was the almost continuous presence of clouds, which mitigated the fierce heat of the sun and kept the temperature at a very pleasant level.

In regard to the unreliability of the charts just mentioned, the lecturer told us at a later stage that in an adjoining room we should find maps showing the course of the cable up the river, and that in these maps we should see that the cable-ship "Faraday" had contrived to lay the cable right across several islands! It was, however, he said, the maps and not the cable-ship that had gone wrong. Some idea of the magnitude of this river cable scheme may be gathered from the following details as to the size of the Amazon:—

A glance at the map of South America explains without much comment how immense the volume of water must be which is collected from an area measuring more than 2½ million square miles, for the most part covered with dense forests. With several other large rivers the Amazon shares the fate that its name changes several times during its long course, and that at various times different affluents have been considered to be the true source of the main stream. Most geographers, however, regard the Marañon as the principal river, a branch of which, called Tunguragua, rises in Lake Lauricocha in Peru in 10° 30′ S. lat., and 76° 10′ W. long.; although the Ucayale, where it unites with the Marañon at Nauta (4° S. lat., 73° W. long.), is quite as important as the Marañon. If the greatest distance from the mouth is to decide the question, then the source of the Apurimac, an affluent of the Ucayale, can lay claim to being the origin of the Amazon, rising in Peru in 16° S. lat., and 72° W. long.

From the Lake Lauricocha the main direction of the Tunguragua and the Marañon is to the N.N.W. until the river turns eastward, and shortly after passing Jaen breaks through the Andes, entering the plains of the Amazon valley by the Falls of Manseriche, a short distance west of Borja. Its further course is a little north of east until it pours its yellow waters into the Atlantic under the Equator, between the Cabo do Norte and the Cabo Maguari, which are 158 miles apart. This distance is just about equal to the distance from Land's End to Cape Clear in Ireland, or from Brighton to Falmouth. Even west of the island of Caviana, which lies in the mouth of the river, together with the island of Mexiana and several smaller ones, the width of the main stream is over 50 miles, equal to the distance from Portland Bill to the Cap de la Hague. The part of the Amazon flowing north of the island of Marajó may therefore be compared in width to the English Channel, but in depth and volume of water it far surpasses it. It is a disputed question whether the water flowing south of Marajó, commonly called the Pará river, should be considered as part of the Amazon or not. A network of natural canals, "the narrows," connects the two waterways west of Marajó, but the influence of the tide makes it difficult to decide whether part of the water of the Amazon finds its way south of Marajó or not. Along the whole course of the Amazon, commencing at the foot of the Andes, a similar network of islands and canals is formed on both sides of the river, as the whole country is almost level, and is consequently inundated during the rainy season for hundreds of miles by the rivers flowing through it. The most notable exception to this general state of things occurs at Obidos, where the whole volume of water is compressed into one channel a little over a mile wide and said to be about forty fathoms in average depth. A sounding taken opposite Obidos about a third of the distance across the river showed a depth of 58 fathoms measured by a steel wire and Lord Kelvin's sounding machine.

With such uncertain charts, and in the face of such rapid currents as were found to occur in many parts of the river, special sounding apparatus had to be used in order to ascertain where there was deep enough channel for the cable steamer:—

As the current of the river averages three knots in the main channel, it is not easy to take soundings by an ordinary lead line and even with the steel wire an extra heavy weight (33lb.) has to be employed, or the results are not reliable. Besides the wire sounding machine a submarine sentinel was used on the preliminary voyage, wherever serious doubts existed about a channel through which the cable was to be laid. This apparatus consists of a small winch from which a wire leads into the water and drags at a short distance behind a piece of wood, shaped like an angle iron, in a nearly upright position. The wire is not attached directly to the piece of wood but to a string kite fashion, and the wood is fitted with an iron foot which on coming in contact with the bottom of the water releases one end of the kite string, so that the wood remains attached to the winch wire with one end only. The consequence is that the strain on the wire is suddenly reduced to a very small amount, and the piece of wood appears on the surface of the river. It depends on the quantity of wire paid out how deep the kite or the sentinel floats, and its action is quite reliable, so that it is unnecessary to take soundings by the line or by wire while the sentinel is being dragged by the ship. Usually the sentinel was set at five fathoms, and when it struck a bar the ship was stopped and a series of soundings taken to ascertain the exact depth of water and the extent of the shallow place.

A further difficulty in sounding originated from the soft nature of the soil, which for the greater part of the Amazon valley is alluvial clay, and allows the lead to sink into it for several feet. In the narrows there appears, however, a bank of hard clay, called tabatinga, which unfortunately blocks nearly all the branches of the narrows and creates bars all along the course of the Tajipuru, the main westerly waterway connecting to the Gurupa branch of the main river. Occasionally the same hard clay forms shallows in the main river, but as a rule the section of all the channels resembles the letter U, *i.e.*, the sides are very steep and the bottom flat. In this respect, as in many others, the Amazon differs entirely from the Indian rivers, which build up their beds above the surrounding country, occasionally breaking through their natural banks and seeking a new bed. The Amazon, on the other hand, carries with it only the light clay sediment which forms the soil of the whole valley, and the inducement for the main stream to alter its course is therefore very small, and long straight reaches are the result.

Under these circumstances the largest vessels can ascend the river nearly to the foot of the Andes. But the constantly changing sandbanks at the mouth of the Amazon proper make this approach of the river dangerous, and the State of Pará is for obvious reasons not over-anxious to have the deep channels properly buoyed and surveyed. This forces all the shipping to enter the Pará river and to pass the narrows if the Amazon is the goal of the journey. In doing the latter the choice for large ships lies between one of the channels (called furos) with a bar, where it joins the Tajipuru, and a furo, the Macajubim, which has plenty of water, but which winds about in such a serpentine fashion that only ships with twin screws can pass it unassisted. These difficulties are, however, much diminished during the rainy season, when the river rises to such an extent as to drive all the inhabitants of its banks into the towns which have been built wherever a natural eminence secured the inhabitants against the flood.

At Pará the cable steamer could not approach close enough to the shore to land the cable, so the shore ends were laid with the help of a barge and a tug. This method was also adopted at some of the other stations, as, for example, the sections from Pará to Pinheiro, and from thence to Mosqueiro. The section across the Pará river to Souré was laid by the cable steamer "Faraday."

At Souré the ss. "Faraday" was anchored at a convenient distance from the shore, so that the shore end might be landed direct from the ship, and as long as the tide was rising this plan appeared excellent. By the receding tide, however, a whirlpool was formed with the ship lying right across the centre, and *when it had been turned 17 times in one hour* the captain was tired of it, and moved the ship to a safer anchorage.

Another section of the cable, forming a branch from Pará to Cametá is laid in the river Tocantins. The upper reaches of this long river above Cametá are navigable, but are cut off from direct telegraphic communication on account of some rapids not far above Cametá.

Laying the main cable up the Amazon river from Pará to Manoas, and the branches up the numerous important tributaries, afforded occasion for many exciting incidents, out of which, however, the "Faraday" and everyone one on board emerged with safety. We may here remark that the "Faraday" had the distinction of being the first European steamer to navigate some parts of the Amazon; in fact, neither the pilots nor the inhabitants knew of any foreign vessel having previously touched at some of the ports.

The first station on the main cable is Breves, the centre of the rubber trade of the islands of the lower Amazon, situate in the centre of "the narrows." Between Pará and Breves is only one shallow passage, near the lighthouse of Gujabal, and the pilot managed to run the ship aground there. Luckily it was low, tide and with the rising tide the ship could be turned. At Breves the ship was anchored close to the shore and its stern secured to a tree by a rope, so that the tide could not cause it to swing. Under these circumstances the landing of the shore ends was an easy matter and soon finished. The ship then resumed its way into the narrow furos, described above, and the night did not put a stop to its progress, as the outlines of the forest were clearly visible against the sky and the water everywhere more than seven fathoms deep.

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While the speed of the ship was kept at about six knots, the pilot ordered the quartermaster to put the helm a-starboard, as he wished to increase the distance between ship and shore. The quartermaster was, however, confused, and put the helm hard a-port, with the result that the bows went into the forest until the branches of the trees touched the fore-yard. To appreciate the situation it should be mentioned that the fore-masts stands 74ft. abaft the bows, and that the fore-yard is 69ft. above the water level. Luckily, the soft ground, the elasticity of the forest trees and the steepness of the banks rendered this accident quite harmless, and on reversing the engines the ship at once came off, so that the laying could be resumed.

Mr. Siemens had told us that where the charts seemed to show the cable laid across river islands it was the charts and not the "Faraday" that had erred. But in this instance it would appear as though the steamer had attempted to rival the charts, and was desirous of creating a precedent in the art of cable laying. Nor was this the only instance where the peculiar difficulties of steaming up the Amazon made the "Faraday" evince a strong desire to get out of the water. The neighbourhood of the assault on the forest was the scene of further adventures:—

Not far from this spot the Aturia furo branches off, through which th cable had to be laid, but which was impassable for the ss. "Faraday" on account of a two-fathom bar at the Tajipuru end of the furo. As a splice had to be made with some cable on a barge from which it was to be paid out through the Aturia furo, the "Faraday" had to be anchored, and the right hand shore was approached so as to leave room for the ship to swing round when the tide turned. At the critical moment, when the anchor was to be lowered, somebody blundered and turned the electric light out, leaving the anchor winch and its surroundings in darkness. By the time this mistake had been rectified the ship was dangerously near the shore, and even the anchor could not sufficiently check its advance, so that it ran again ashore, stopping within about 5ft. of a house, much to the alarm of the inhabitants.

This manœuvre fixed the ship in a most convenient position, so that it was left there until the splice had been finished and the tug "Cochrane," with the barge, had started laying the cable in the Aturia furo. Again, there was no difficulty in backing the ship off the bank; but the furo proved to be too narrow to turn the ship, which had to return to Breves, or rather a few miles beyond, to the mouth of the Boiuassu, in order to enter the furo grande and the Tajipuru in a roundabout way. As the ship was drawing over 24ft., and the bar at the end of the Boiuassu had only 23ft. of water at high-tide, the result was easily foreseen; but the ship remained on the bar for nine days, by which time sufficient cable had been transferred to the barge and to the ss. "Malvern" to enable the ship to continue her journey.

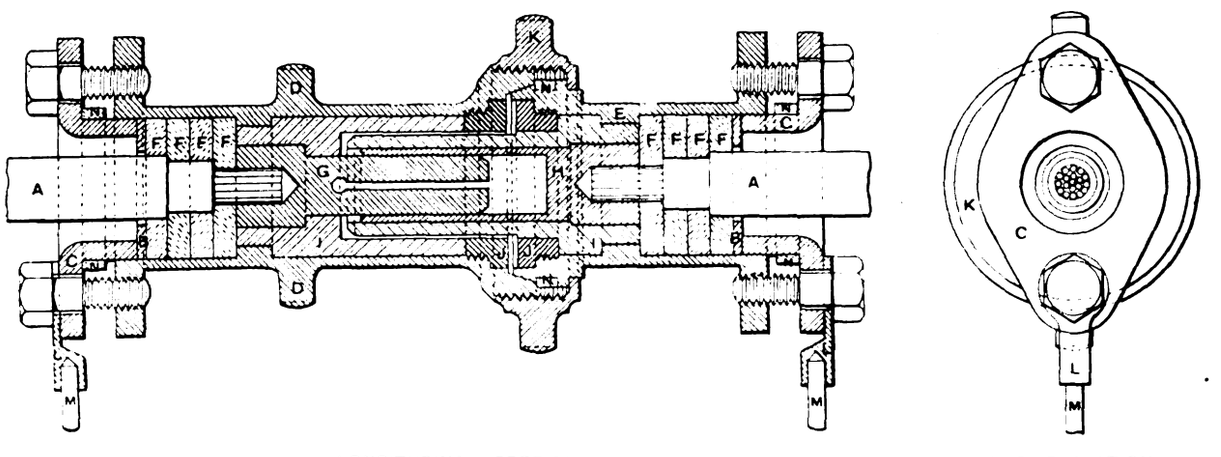
Great demonstrations of joy were frequently made at the landing of the shore ends at the various stations. The streets were decorated with flags, all the inhabitants turned out *en fête*, and the municipal authorities assembled in their best cotton garments to do honour to the important occasion. At one place a native band with native instruments of music went on board a native vessel and circumnavigated the "Faraday" to "express joy." Here is another good story, which will serve to illustrate the jubilations over the advent of the cable which were frequently made:—

In Gurupá, the second station of the main line, the inhabitants expressed their joy at being put in communication with the rest of the world by actively helping in the land of the first shore end. A young lady in white, niece of the Mayor, borrowed a handkerchief from one of our engineers, daintily laid hold of the end of the cable and triumphantly carried it into the station. Here a ball was started and the happy couples waltzed round the cable end to show their appreciation. Meantime the tug began pulling on the barge from which the cable was to be paid out, and just as these vessels began to feel the current, which runs rather strong there, something jambed, the cable would not run out and the tug could not hold the barge against the current. Barge tug and cable drifted down stream, the end gradually disappearing out of the station: This *contretemps* luckily did not disturb the dancers, who continued their rejoicings until the end had been brought back.

During the lecture a number of photographic views of the beautiful scenery to be met with in the Amazon valley were thrown upon the screen, also views of the ss. "Faraday"; and in the adjoining library, as well as on the lecture table, various collections illustrating the indiarubber industry, the flora and fauna of the district, and the habits of the people, were exhibited.

## A HIGH-PRESSURE CABLE COUPLING.

The accompanying illustration shows a longitudinal section and end elevation of a form of coupling for high-pressure electric light and power cables, invented by Mr. Leonard Penson. The outer casings, D and E, are of gunmetal with porcelain or ebonite linings, I, secured by nuts of vulcanised fibre, J J, at the parts where the terminals, G and H, are placed. In order to ensure a water-tight union between the two outer casings, these are ground to a cone, which is held securely in place by the coupling-nut K. A rubber washer, N, is placed between the flanges around the coned coupling to further ensure a water-tight and elastic fit, the washer taking its seating before the cone has been forced home. In making the joint the terminals are first withdrawn and the ends of the cable conductors sweated into place, as shown in the illustration. After this has been done the terminals are replaced, and the series of rubber washers, F F, are closed upon the cables by tightening up the end glands, C, by means of the studs shown.




LONGITUDINAL SECTION END ELEVATION

Penson's High-Pressure Cable Coupling; Half Full Size. A A, Cables. B B, Brass Washers. C C, Glands. D, Outer Casing. E, Outer Casing F, Rubber Washers. G, Terminal Plug. H, Terminal Plug. I I, Ebonite or Porcelain Insulation. J J, Black Fibre Nuts. K, Coupling Nut. L, Terminal for earth connection. M, Earth Connection. N, Rubber Rings.

An earth connection, M, is made at each end of the coupling by a joint to one of the studs on each end gland, the earth connection being made by a short length of flexible conductor.

The couplings are carried in the pavement or road boxes by cast-iron supports or bridge pieces, fixed across the surface boxes. These supports are provided with terminals, to which the ends of the earthing conductors are secured. To ensure safety in making the coupling the outer casings are covered with ebonite caps, thus preventing accidental contact with the live ends. And to prevent a cross connection one coupling is coloured red, while the fellow to it in the same box is black.

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When this form of coupling has to be adapted to concentric cable it requires to be somewhat modified. In such a case a length of ordinary cable about 3ft. 6in. long is jointed on to the inner conductor, and after the outer conductor has been cut back, a length of cable of the same length is T'd on to it, the whole joint being vulcanised in the usual manner.

Handy, safe, and cheap connecting pieces for both high and low-pressure covered cables are a great desideratum, especially where it may be necessary to make quick and frequent temporary disconnections. The Penson cable coupling, just described, promises to be as useful in these respects as the "Simplex" coupling for low-pressure mains, which Mr. Penson designed some time ago, and which has been used on several public supply systems. We understand that both these forms of couplings are manufactured by Mr. A. C. Hands, of London.

## A PRODUCER-GAS-ENGINE ELECTRICAL PLANT.*

BY ALBION T. SNELL.

The electrical plant at Messrs. R. Maclaren's iron foundry in Glasgow presents several points of interest, on account of the use of large gas engines with producer gas plant. The following information has been supplied by the contractors for the whole of the work, Messrs. Mavor and Coulson, of Glasgow.

*Scheme.*

The object of the plant is to displace some old and inefficient isolated engines supplied with power from a battery of three old Lancashire boilers through long ranges of steam piping. It is intended ultimately to put down three Tangye gas engines, each capable of running continuously at 120 B.H.P., and of giving 150 for a short period. These engines are to be supplied with producer gas derived from two gas generators, each of which is to be large enough to run two of the engines. At present one gas generator and one gas engine are installed.

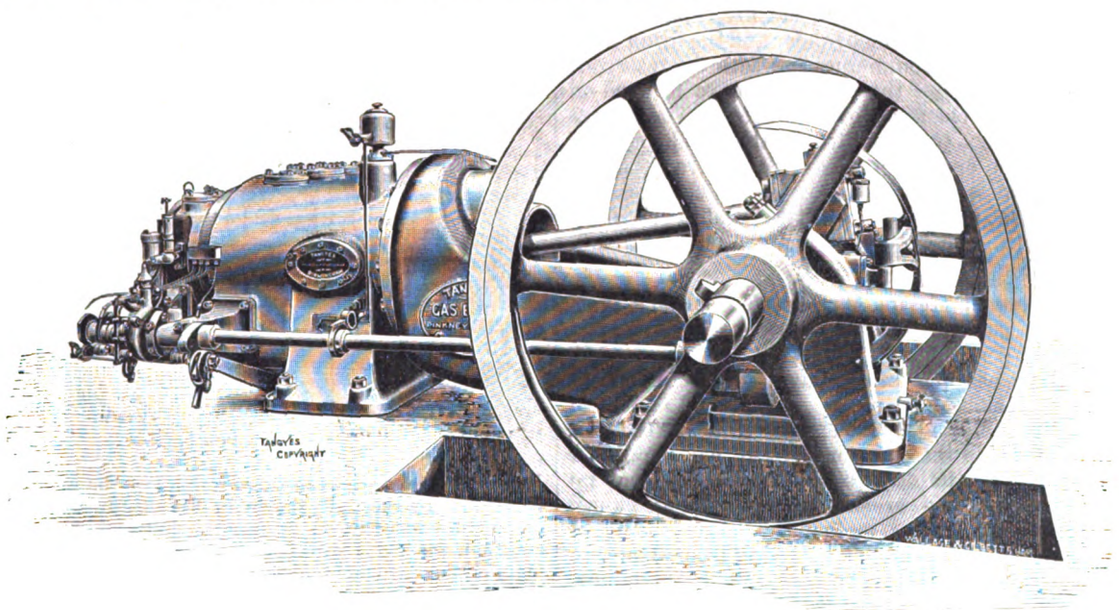
The first engine drives a 67-kilowatt dynamo by belting, a set of hydraulic pumps also by belting and by ropes, a line shaft from which are driven by two belts two heavy loam mills. Although the latter are situated only a short distance from the power-house, experience with electric motors in other parts of the works has led Messrs. MacLaren to regret that they have not adopted motors for the mills. The hydraulic pressure pumps serve an hydraulic accumulator supplying the cranes fixed throughout the foundry. The pumps are fitted with fast and loose pullies with striking gear controlled automatically from the accumulator.

The dynamo drives various motors and also supplies power for lighting the yard and shops by "Jandus" arc lamps and incandescent lamps.

*Power Station.*

This comprises at present the gas producer plant, one gas engine and one dynamo.

The gas producer plant is made under Pinkney's patents by Messrs. Tangyes. It is of very simple form, and consists of a generator, a small vertical steam boiler for blowing air over the fuel, galvanised-iron cooler, hydraulic box, coke scrubber and a gas receiver of 15ft. diameter, having a storage capacity sufficient for two of the engines. The coke scrubber receives the gas after it has passed through the cooler. On the top of the scrubber is a star-shaped pipe with a number of holes in each arm through which are forced jets of water, which wash and cool the gas before it enters the receiver. The generator has a special form of hopper, more lofty than the usual type. This is kept full to the top, and the coal is arranged to fall regularly down to the fusion zone, and is thus heated gradually to the desired temperature. It is claimed by the makers that this gradual heating of the fuel entails less attention to the firing than with producers in which the fuel must be kept at a fixed level, and also that a more uniform quality of gas is realised. The superheater, for heating the steam before it passes into the blower, instead of being placed inside the boiler passes through the inside of the gas delivery pipe. Part of the heat, which would be otherwise wasted, is thus usefully employed.



120-B.H.P. Single Cylinder Gas Engine, by Messrs. Tangyes.

The plant is designed for the addition of a second producer and cooler without material alteration to the existing arrangements.

*Gas Engine.*

The gas engine is one of Tangye's single cylinder engines with Otto cycle. The cylinder is 24in. in diameter by 30in. stroke, and the piston speed is 750ft. per minute, corresponding to 150 revolutions of the crank-shaft. There are two flywheels, each 9ft. in diameter by 15in., face turned for belt driving. They weigh three tons each. These are comparatively light for the size of engine, but are found to be sufficient owing to the peculiar form of the combustion chamber, which tends to reduce the shock upon the crank pin, and to make the pressure uniform throughout the power stroke.

This chamber is horned shaped, and the charge is fired from the small end, and gradually expanding into the large end gives a gradual rise of pressure, and thus avoids a heavy initial shock. The steady running of the lamps which are

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coupled to the dynamo driven off the engine is a proof of the even running of the engine. In addition to the flywheels, there is a multiple grooved wheel for a rope drive, mounted upon a main shaft and coupled to the engine shaft through an Edmiston friction clutch. The crank shaft is 9in. in diameter, and is extended to bearings in wall boxes on either side of the engine. When working with a charge compressed to 80lb. per square inch, the initial pressure is about 240lb. per square inch, and the mean pressure about 70lb.

The usual water circulating system is employed, cold water entering the cylinder jacket below and leaving at the top. The tank is placed above the engine, and forms the roof of the engine house. This method of cooling the cylinder causes an unequal expansion of the top and bottom of the cylinder which though not of serious importance in small engines is likely to cause trouble in large ones. To obviate this Messrs. Tangye arrange the cylinder in a special way which it is claimed maintains it truly circular under all conditions of working. The exhaust is made through two valves, a large and a small one. The small one is opened first, and relieves the maximum pressure, and then the large one is opened by the same cam. The exhaust box is water jacketed. The exhaust is delivered into two silencers in parallel, and from them is led by two pipes into the atmosphere at the top of the engine house. The silence of the exhaust is claimed as one of the features of the engine. The starting arrangement consists of a "baby" gas engine coupled direct to a small pressure pump, which forces a charge of air and gas into a reserv ir, from which it is discharged into the combustion chamber of the engine at any desired pressure. When starting the engine crank is placed in the usual position, at which the ignition valve is kept tight upon its seating, and thereby cutting off connection between the cylinder and the firing tube. The cylinder is then put in communication with the reservoir, the pressure in which causes the piston to move forward on the power stroke and to open the ignition valve. The charge then presses into the hot tube and fires in the usual way. It is possible to start the engine in this way with from half to three-quarter load on it without taking off the compression. The governor is of the centrifugal ball type, and is driven by scroll gear fixed to the side of the cam shaft.

*Dynamo.*

The dynamo is one of Messrs. Mavor and Coulson's type, made under Sayers' patents. It has an output of 67 kilowatts at 600 revolutions per minute, giving 610 amperes at 110 volts. It has three bearings and a heavy cast-steel flywheel, mounted on an extension of the shaft. The special feature of this machine is that the lead is fixed; and although the load varies largely, it is found that the commutator has acquired a fine dark purple skin on its surface, thus indicating that no sparking takes place. The brushes are of copper gauze. This dynamo runs a number of motors, the largest being of 25 B.H.P. capacity, and the remainder varying from 3 H.P. to 10 H.P. It also supplies current to large Sunbeam lamps, small incandescent lamps, and "Jandus" arc lamps, connected singly across the 110-volt mains.

*Motors.*

The largest of the motors has a capacity of 25 B.H.P., and drives the mechanics' shop. It is of the open type, and is belted to the shafting by a belt.

The other motors vary in capacity from 10 B.H.P. to 3 B.H.P., and are distributed about the works. They are all of the enclosed type, on account of the dust and dirt incidental to foundry work. They run elevators, machine tools, &c. In most cases they are coupled to the machines by belting.

The efficiency of the 3 H.P. motors is stated by the makers at 87 per cent., and that of the 10 H.P. motors at 90 per cent. The particulars of one of the latter sized motors with figures of test were given in *The Electrician* for January 10th last, on pages 341—343.

*Method of Distribution.*

The whole of the wiring is carried out on Messrs. Mavor and Coulson's concentric system with lead-covered outers, the outer being earthed. The switch boxes, resistance boxes and terminal boxes are all made of cast iron, with dust and damp-proof covers. The system admirably meets the exceptional conditions to be encountered in an iron foundry.

The mains from the dynamo are lead to a main switch and distribution board, upon which are mounted switches, fuses and ammeters for the various lighting and motor circuits. Each of the large motors has a separate single-pole switch and fuse and an ammeter.

*Working.*

It is found that the gas engine developes power at the rate of 1 B.H.P. per pound of anthracite coal, and allowing for losses in the dynamo, cables and motors, power is generated and distributed to the motor shafts for 1·25lb. of anthracite per horse-power hour.

The experience gained with the present plant is so satisfactory that Messrs. MacLaren contemplate at an early date the erection of a duplicate one to displace a further batch of isolated engines in the same foundry.

## EXPERIMENTAL TESTS ON THE INFLUENCE OF THE SHAPE OF THE APPLIED POTENTIAL DIFFERENCE WAVE ON THE IRON LOSSES OF TRANSFORMERS.*

BY STANLEY BEETON, C. PERCY TAYLOR AND J. MARK BARR.

*(Concluded from page 79.)*

EFFECTS OF THE INJECTOR.

As this Paper is essentially one dealing with transformer tests, we do not propose to discuss at any length the effects obtained by the use of the injector, but it may be useful to consider one typical case of injected resistance, and one of capacity. The effect of injecting rather a long resistance, when the current is *not in phase* with the

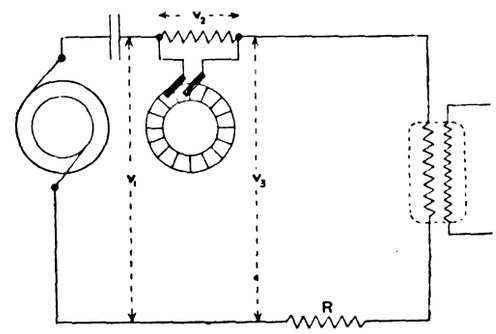


FIG. 5.

P.D. maintained between the terminals of the transformer is well illustrated by the wave shown in Fig. 3. In this test a resistance of 36 ohms was thrown in over the first part of the wave; but, in addition, we had a capacity of 96 microfarads *permanently* in the main circuit, which brought the current into phase with the P.D. between the terminals of the alternator. By bringing the current into phase with the P.D. we mean that the zero readings of the two waves occurred at the same point, but the waves, of course, possessed very different shapes.

The distinguishing feature of this wave is the curious sort of hump which occurs just at the beginning. The explanation of this is not hard to find. It will be observed that during the interval in which the current is opposite in sign to the P.D. the ordinates of the latter curve tend to increase, but directly the current-wave crosses the zero line the P.D. begins to decrease. Consider for a moment the instantaneous P.D.'s between the terminals (1) of the machine and condenser, (2) of the injector, (3) of the transformer and resistance R, represented by $v_1$, $v_2$, $v_3$ (Fig. 5) respectively, during the interval just alluded to. Since the current is in the opposite direction to the terminal P.D. of the transformer, we have:

$$v_1 = v_3 - v_2;$$
$$v_3 = v_1 + v_2;$$

that is to say, for this short interval the P.D. across the transformer equals the sum of the P.D.'s of the machine and the injector. This, then, fully accounts for the presence of the *hump*.

The effects obtained by the injection of capacity will be best explained by a reference to Fig. 6 and Fig. 7. In the latter we have shown (curve A) a P.D. wave at the terminals of the trans-

* Paper read before the Institution of Electrical Engineers.

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former and non-inductive resistance R (Fig. 6). This was obtained by adding, at each point, the drop in pressure due to this resistance to a curve obtained at the terminals of the transformer, and shown in Fig. 4 G. The interval during which the condenser (60 microfarads) was in circuit is also shown in Fig. 7, and the curve of P.D. between its terminals (*i.e.*, the brushes $b_1$, $b_2$, Fig. 1.), marked B, was obtained by integrating the current-wave during this interval.

By combining these two waves we get the P.D. between the terminals of the alternator, shown in curve C. Since the condenser P.D. is obtained by integration, its maximum necessarily occurs when the current crosses the zero line. This maximum value is directly proportional to the area of the current curve from the point of injection to its zero point, and inversely proportional to the capacity of the condensers injected.

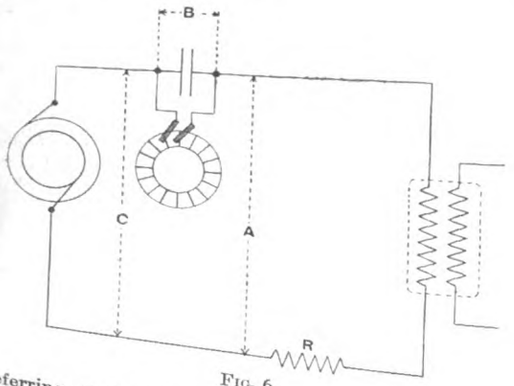


FIG. 6.

On referring to Fig. 7, we note that, since the current is large when the condenser is thrown into circuit, the curve B rises very rapidly, and therefore the curve A turns down very rapidly away from curve C, and crosses the zero line where B and C cross each other. The maximum point of the condenser P.D. curve, of course, occurs at the same time as the maximum *difference* between curves A and C, and thus, when the curve B turns down, A bends over and begins to approach C, which it crosses when B crosses the zero line. Soon after this the condenser is short-circuited, and thus B follows the zero line and A is again coincident with the alternator P.D. curve C. This coincidence lasts as long as the condenser is cut out of circuit by the "injector." The points marked

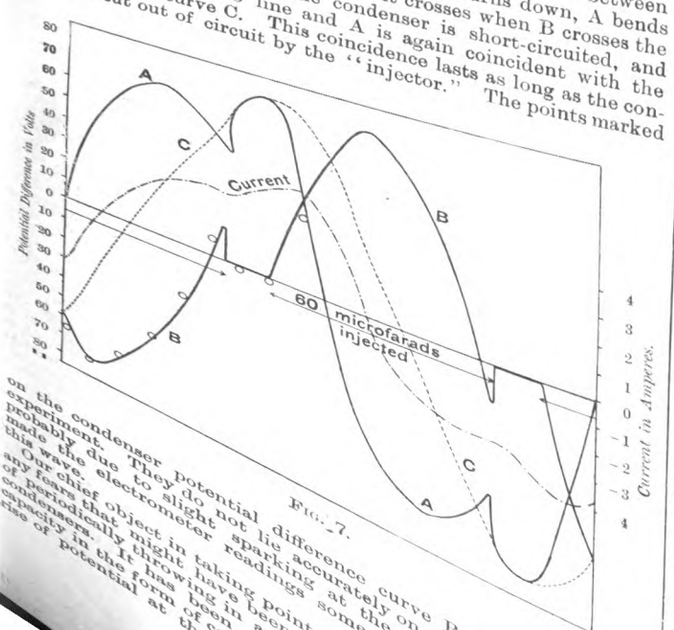


FIG. 7.

on the condenser potential difference curve B were obtained by experiment. They do not lie accurately on the curve, but this is probably due to slight sparking at the injector brushes, which made the electrometer readings somewhat unsteady when taking this wave.

Our chief object in taking points on this curve was to set at rest any fears that might have been entertained as to the advisability of periodically throwing in and removing from a circuit a bank of condensers. It has been shown that when a circuit possessing capacity in the form of condensers is broken there may be a sudden rise of potential at the terminals of the latter. No such rise of P.D. was observed in our experiments, and this was due to the fact that the condenser circuit was *never really broken*, for the capacity was removed from the circuit by being short-circuited.

### DISCUSSION OF RESULTS.

Our great aim at the time of carrying out these experiments was to find some definite law connecting the iron loss in the transformer with the shape of the applied P.D. wave. In no work published on the subject at that time could we find any results or conclusions which could form the basis of a connected theory regarding this question. None of the investigations on this subject had justified any conclusion which could materially help in judging of the exact, or even relative, value of wave forms not actually tried. The conclusions that we came to were—

1. That if the R.M.S. value of the applied P.D. is constant, and the area of the P.D. wave is constant, then, whatever be the shape of this wave, the total iron loss cannot vary.

2. That if the R.M.S. value of the applied P.D. is constant, but the area of the P.D. wave varies, then, whatever be the shape of this wave, the total iron loss will vary by an amount which is only dependent upon the area of the P.D. wave.

We feel fully justified in coming to these conclusions, for, as we have shown above, the hysteresis loss depends only on the area of the P.D. wave, and we have proved experimentally that the eddy-

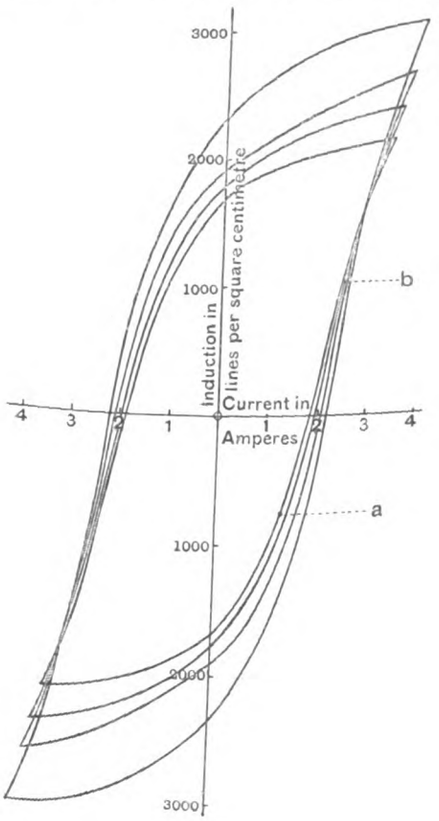


FIG. 8.

current loss is constant for a given effective P.D. This we refer to again below. The results calculated from our tests will be found in as concise a form as possible in Table I.

*Hysteresis Tests.*—In order to get a complete theory regarding the iron losses, it was essential that we should separate those due to hysteresis and to eddy-currents. To determine the former loss, then, hysteresis tests were made on the transformer itself by a method independently suggested and used by Prof. Ewing* and Dr. Hopkinson. We found this method most satisfactory. The two 12-turn coils of the transformer were used, one as the magnetising and the other as the test coil. A large resistance was put in series with the magnetising coil to reduce the time constant of the circuit.

The magnetising current was measured by means of a standard Weston ammeter, while in series with the test coil we had an Ayrton and Mather narrow-coil ballistic galvanometer, which was standardised with one of Hibbert's magnetic standards. In this way four complete B-H cycles, as shown in Fig. 8, were determined for the transformer. They were integrated with an Amsler polar planimeter, and the results obtained were plotted to show the relation between the maximum induction and power lost in hysteresis, at a frequency of 100 ∿. This curve is shown in Fig. 9. The hysteresis loss for each test was obtained by calculat-

* Paper on Magnetic Qualities of Iron, Royal Society, April, 1894.

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TABLE I.—*Results of Transformer Tests calculated from Curves.*

| Fig. | R.M.S. or Effective Values. | | Apparent Power in Watts. | Iron Losses in Watts. | | | Power-Factor. | Maximum Induction in Lines per Sq. Cm. |
|---|---|---|---|---|---|---|---|---|
| | P.D. in Volts. | Current in Amperes. | | Total. | Hysteresis. | Eddy-Currents. | | |
| 3 A | 49·5 | 2·42 | 120·0 | 92·5 | 60·5 | 32·0 | 0·77 | 2,330 |
| 3 B | 49·8 | 2·75 | 137·0 | 95·5 | 63·0 | 32·5 | 0·70 | 2,410 |
| 3 C | 48·5 | 2·81 | 136·0 | 93·5 | 65·0 | 28·5 | 0·69 | 2,490 |
| 3 D | 48·9 | 2·95 | 144·5 | 97·5 | 66·0 | 31·5 | 0·67 | 2,520 |
| 4 E | 49·2 | 3·03 | 149·0 | 103·0 | 71·0 | 32·0 | 0·69 | 2,680 |
| 4 F | 48·1 | 2·92 | 140·5 | 104·5 | 74·0 | 30·5 | 0·75 | 2,750 |
| 4 G | 49·5 | 2·80 | 138·5 | 111·0 | 76·5 | 34·5 | 0·80 | 2,800 |
| 4 H | 48·1 | 2·85 | 137·0 | 106·0 | 76·0 | 30·0 | 0·77 | 2,790 |

TABLE II.—*Results of Tests Corrected for a Common Effective P.D. of 50 Volts.*

| Fig. | R.M.S. or Effective P.D. in Volts. | Maximum Induction in Lines per Sq. Cm. | Iron Losses in Watts. | | |
|---|---|---|---|---|---|
| | | | Hysteresis. | Eddy-Currents. | Total. |
| 3 A | 50 | 2,350 | 61·0 | 32·5 | 93·5 |
| 3 B | 50 | 2,420 | 63·0 | 32·5 | 95·5 |
| 3 C | 50 | 2,560 | 67·0 | 30·0 | 97·0 |
| 3 D | 50 | 2,570 | 67·5 | 33·0 | 100·5 |
| 4 E | 50 | 2,720 | 73·0 | 33·0 | 106·0 |
| 4 F | 50 | 2,850 | 79·0 | 33·0 | 112·0 |
| 4 G | 50 | 2,830 | 78·0 | 35·0 | 113·0 |
| 4 H | 50 | 2,900 | 82·0 | 32·5 | 114·5 |

ing the maximum induction as previously shown, and referring to this curve, and the eddy-current loss by subtracting this from the total.

*Variation of Applied P.D.*—It will be observed, on reference to Table I., that the effective values of the applied potential difference are not all the same: they vary between 48 and 50 volts.

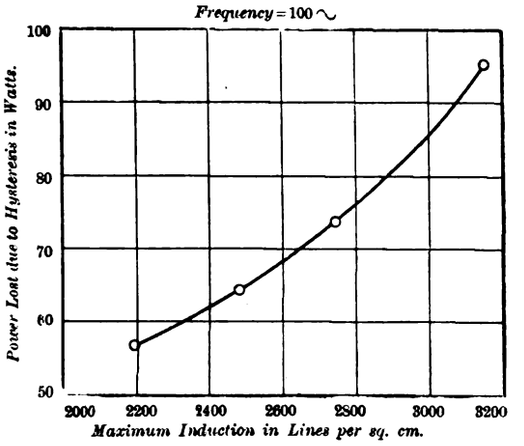


FIG. 9.—Curve showing the Relation between the Maximum Induction and Power Lost in Hysteresis in a 3-kilowatt Mordey Transformer.

This is due to the fact that they are not instrument readings, but are calculated from the curves by means of the first moment planimeter. The method of using this instrument to give the R.M.S. value of a curve was described in the articles referred to elsewhere.* It was due originally to Mr. Turner, one of the demonstrators in the mathematical department of the Central Technical College. We have given preference to this method of obtaining the effective value of both P.D. and current mainly for two reasons, viz.: Firstly, far greater accuracy is attainable by this method. This is easily understood when it is remembered that, by increasing the number of water cells used in conjunction with the electrometer, this instrument could be made as sensitive as we wanted, whereas the sensibility of the voltmeter was fixed. Secondly, by calculating *all* results from the curves of P.D. and current, any small errors which arise from inaccurate readings or drawing appear in them all, and these are made of far less relative importance. The voltmeter V (Fig. 1) was therefore only used to keep the effective value of the P.D. constant throughout each test, and it was not specially calibrated. This method of calculating the results has, however, introduced some difficulty in drawing conclusions from our experiments, as the small variations in effective P.D. must be taken into consideration. The difficulty of arriving at the true effect of this variation arises mainly from

* *The Electrician*, July 1895, Vol. XXXV., p. 290.

the fact that the eddy-current loss has been obtained by taking the difference of two much larger quantities, and thus the probable error is a large percentage of the whole range of variation. After a careful study of columns 2 and 7 of Table I., we came to the conclusion that within the limits of accuracy attainable by our experiments—*i.e.*, about ½ per cent.—the eddy-current loss is proportional to the square of the applied P.D. This leads at once to the further conclusion that *the eddy-current loss is independent of the wave form of P.D. so long as its R.M.S. value is constant.*

In order that this variation of applied P.D. should not obscure the true meaning of our results, we have calculated by known laws the difference in the iron losses produced by the difference in the value of the applied P.D. from 50 volts, and thus found the iron losses for each wave-shape corresponding to an applied P.D. of 50 volts. The methods of correction employed were as follows:—The effect of variations in the R.M.S. value of the P.D. is most marked in the case of the eddy-current loss, so that we will deal with this first. We have, then, here corrected the eddy-current loss to a value corresponding to a common effective applied P.D. of 50 volts. In doing this, since each test is corrected separately, we only assume that, *so long as the wave shape of P.D. is constant*, the eddy-current loss varies as the square of the effective volts.

From Table II. we see that, with the exception of the tests shown in Fig. 3 C and Fig. 4 G the eddy-current loss is practically constant, the variation of half a watt meaning only ½ per cent. in the determination of the total loss. Again, for the correction of the hysteresis loss we need only consider laws which hold so long as the wave form is constant. Under these circumstances the area of the P.D. wave varies directly as the R.M.S. value. Now the

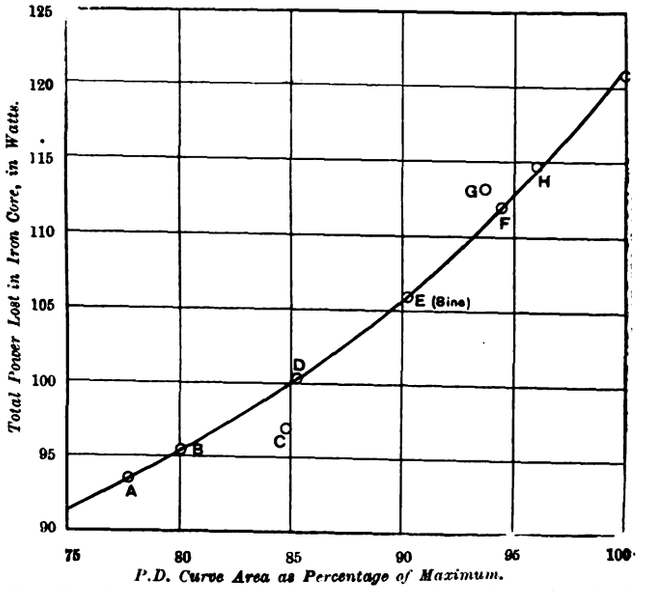


FIG. 10.—Curve showing Relation between the Total Power Lost in the Iron Core of a Transformer, and the Area of the Applied Potential Difference Wave expressed as Percentage of the Maximum Area possible with a R.M.S. value of 50 volts.

The letters A to H refer to the Curves given in Figs. 3 and 4.

area gives us at once the maximum induction, and the corrected hysteresis loss is then got by a further reference to Fig. 9. The values thus obtained are given in column 4 of Table II. The corrected total loss is now determined by the addition of the eddy-current and hysteresis losses, from which we obtain the curve given in Fig. 10.

*The Relation of the Iron Losses to the Area of the P.D. Wave.*

In Fig. 10 we have shown the relation between the total power lost in the transformer and the area of the P.D. wave expressed as a percentage of the maximum area possible with the given R.M.S. value of 50 volts.* This maximum area occurs with the rectangular shape shown in Fig 11.

Such a rectangular wave would give the greatest possible value of maximum induction—in this case 3,020 lines per sq. cm. On reference to Fig. 9, it will be found that the loss due to hysteresis corresponding to this value of maximum induction would be 88 watts; adding to this the constant loss due to eddy-currents—namely, 33 watts—the total power wasted in the iron comes out at 121 watts. This value must, of course, constitute the top limit of the curve shown in Fig. 10, since this wave-shape has the largest area possible with the given effective value. It will be noticed that

* It may be of interest to point out here that the ratio of the area of the P.D. wave to its maximum possible value is the reciprocal of the ratio more recently called by Dr. Fleming the "form factor."

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we have gone fairly close to the limit in this direction in our experiments. The process of fixing the limit in the other direction consists of finding the shape of P.D. wave which will have the *smallest* area for the given effective value.

Now it will be obvious that before the area of a wave of constant R.M.S. value can be very much diminished *the maximum ordinate must of necessity be increased.* We cannot, therefore, diminish to any great extent the hysteresis loss without necessitating higher insulation. If, on account of this difficulty, the maximum ordinate of the P.D. wave must have a definite limit (*e.g.*, maximum value not to exceed twice the effective value), the shape giving the least iron loss will be that shown in Fig. 12.

This is again rectangular, which may seem curious, but the essential point is to get as wide a peak as possible, and thus, as it were, confine the wave to one part of the period. This wave

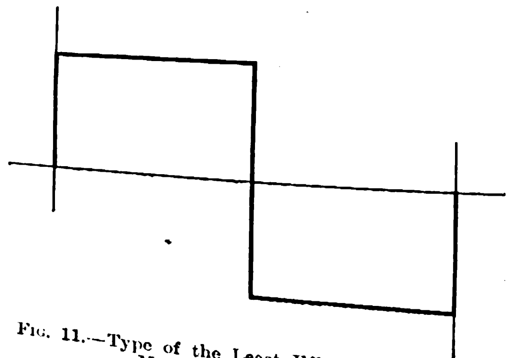

Fig. 11.—Type of the Least Efficient Wave of P.D. Maximum Value = Effective Value.

has been drawn to the same scale as the one given in Fig. 11. The area of the curve shown in Fig. 12 will be found to be exactly 50 per cent. of the possible maximum (Fig. 11); in fact, with waves of this type having a constant R.M.S. value, the area (and, therefore, the maximum induction) is inversely proportional to the maximum ordinate. This gives us a measure of the minimum possible hysteresis loss with different allowable P.D. maxima. It is evident that, *unless* the maximum ordinate of the wave is limited, its area can be infinitely reduced while its R.M.S. value remains constant.

*Advantages of Peaked Waves of P.D.*—Our lowest iron loss is that given by the P.D. curve shown in Fig. 3 A. This is due to the fact that it approaches most closely to the form shown in Fig. 12, thus giving the least area, and, consequently, the smallest

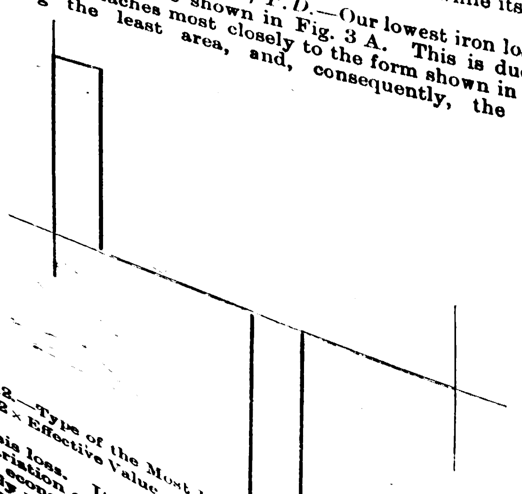

Fig. 12.—Type of the Most Efficient Wave of P.D. when the Maximum Value = 2 × Effective Value. (Same Scale and Effective Value as in Fig. 11.)

hysteresis loss. It will be observed from Table II. that there is a total variation of 22½ per cent. in the total iron losses. The consequent economy of using peaked waves of P.D. of course becomes especially noticeable at low loads, but even at *full* load the saving thus effected is by no means insignificant. For let us assume that the efficiency of a transformer worked off the P.D. wave shown in Fig. 4. H is 95 per cent. at full load, then, if the iron loss is (say) 2½ per cent. of the maximum output, we would increase the efficiency of the transformer to over 95½ per cent. by using the P.D. wave shown in Fig. 3 A.

Under circumstances of cheap power production this saving may not be of extreme importance, but in systems of distribution or transmission of power where large transformers are used, the efficiency of transformation is not the only question to be considered. One of the chief difficulties in designing large transformers is the providing of adequate means for keeping them cool, and any means by which the necessity for special cooling arrangements can be materially reduced will be sure to commend itself to those who have to deal with large transformers.

### No-Load Current.

We have not been able to arrive at any satisfactory explanation of the variation of the no-load current with the shape of the applied P.D. wave. The curve given in Fig. 13, however, is interesting as showing that the maximum current occurs with the sine wave of P.D. The power-factor for this wave, Fig. 4, E is also the smallest (Table I.). This is a distinct point against the use of sine waves of P.D. with transformers, especially in cases where many transformers have to be kept magnetised on light secondary load at the end of long mains; in cases such as these the mains losses—which vary as the square of the current—form a very appreciable item of the whole loss. The difference between the R.M.S. currents in cases A and E, for instance, is 25 per cent., so that the mains losses in case E would be more than 50 per cent. greater than in A.

In order to arrive at a satisfactory explanation of the shapes of the current waves, they must be considered as built up of two components—a hysteresis component and an eddy-current component. We have split them up in this way in Fig. 3 and Fig. 4, the hysteresis component was obtained from the induction curve by means of the B.H. curves in Fig. 8, and the eddy-current by taking the difference between this and the total current curve.

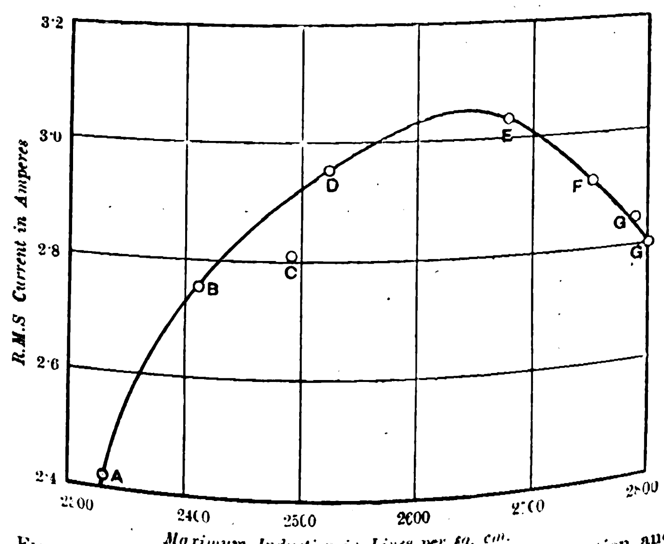


Fig. 13.—Curve showing Relation between Maximum Induction and R.M.S. Current in a 3-kilowatt Mordey Transformer. (From Table I.).

It will be at once apparent that the peculiarities of the current-curves are due almost entirely to the eddy-current component; the hysteresis parts are all very similar in shape. The roundness of the curves, especially noticeable in curves B, C and D, is entirely due to the eddy-currents, the hysteresis component being in all cases comparatively flat on both sides. The eddy-current components have been obtained by a somewhat complex method, and a discussion on the details of each one is therefore hardly justifiable; but as a class they exhibit some very interesting features, the most notable of which is that the curves are very nearly in phase with the P.D. waves. Speaking generally, the curves also have shapes similar to the P.D. waves. This is a clear indication of the fact that the eddy-currents may be considered as equivalent to one current flowing in a supposed secondary circuit. It follows from this that the eddy currents have the effect of bringing the total primary current-curve more nearly into phase with the P.D. wave, and thus tend to increase the power factor. It will be noticed that in all the curves, with the exception of IV. E., Plate 3, the eddy current component leads slightly in front of the P.D. wave; it is, however, so slight that it needs some corroboration from other experiments. The only explanation possible seems to be that the plates of the core, being separated by insulating paper, form a condenser, thus causing a small capacity-current as well as the ordinary eddy-currents.

### Notes on Investigation by Dr. Roessler.*

The conclusions at which we arrived in August were partly anticipated, we found, by Dr. Roessler in a Paper read in Germany

* See *The Electrician*, November and December, 1895, Vol. XXXVI. pp. 124-222.



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in July, 1895, but not published in England until November. Dr. Roessler, however, since he could only experiment with two wave-forms of applied P.D., could not prove by experiments the results which he obtained theoretically. We gather from an article in *The Electrician* on January, 10, 1896, that Dr. Fleming did not at that time consider it *proved* that the hysteresis loss in a transformer depended only on the form-factor of the applied P.D. wave—or on its area, which comes to the same thing. Dr. Roessler's system of measurement differs very materially from ours. To obtain the power given to the transformer Dr. Roessler employed the usual form of dynamometer-wattmeter, with its necessary corrections, and this gave rise to some rather complex calculations with the different currents. Dr. Roessler treats the question very largely from a mathemetical standpoint, and introduces a correcting factor into his formulæ for each typical wave-shape; but he does not appear to have fully appreciated the fact that the whole question of hysteresis loss is wrapped up in the *area of the applied P.D. wave*, independently of the R.M.S. value. In this paper we have shown that it is this *area* alone which determines the hysteresis loss of a transformer.

Dr. Roessler makes some interesting comments on the equation,

$$E\,p_1 = J_1\,\omega_1 + 0{\cdot}4\,\pi\,\frac{n_1^2}{l}\,S\,\frac{d\,B}{d\,H}\,\frac{d\,J_1}{d\,t},^{*}$$

in which $E\,p_1$ = primary P.D., J = primary current (both *instantaneous* values), $n$ = primary turns, and $l$ and S are respectively the length and cross-section of the path of the lines in the iron. The following sentence occurs:—"If . . . the alternator gives a very pointed potential curve, and very high maximum value, the maximum value of $\frac{d\,B}{d\,H}\,\frac{d\,J_1}{d\,t}$ must be very great. *But* $\frac{d\,B}{d\,H}$ *is independent of the alternate-current curve*" [the italics are ours], "and only depends on the hysteresis curve; hence the value of $\frac{d\,J_1}{d\,t}$, which is simultaneous with the maximum value of the potential curve, must be greater with pointed curves than with flat." This is not necessarily so, and the reason is this—that the value of $\frac{d\,B}{d\,H}$ *is* dependent on the form of the P.D. curve in so much as it is dependent on the point on the hysteresis cycle at which we are working, and this again on the part of the period at which the maximum value of P.D. occurs. Compare Figs. 3A and 3B. In A, when the P.D. is at its maximum, the induction curve has not crossed the zero line, and we are working at the point marked "*a*," Fig 8; but when the P.D. is a maximum in B we are working at the point "*b*," Fig. 8: the value of $\frac{d\,B}{d\,H}$ at *b* is 70 per cent. greater than at *a*, and this is why the current-curve is so steep at the time of maximum P.D. in A and comparatively flat in B, although the maximum P.D.'s in these two only differ by 10 per cent. The steepness of the curve in A is also partly due to the eddy-currents.

In conclusion we wish to thank both Prof. Ayrton and Mr. Mather for their kindness and help throughout these experiments; and we are especially grateful to Prof. Ayrton for the assistance he has rendered us in the preparation of this Paper.

### Appendix.

Before deciding on the method described in this Paper for obtaining potential difference waves of any desired shapes, we considered the practicability of using a series of alternators coupled on one shaft. By this means various component harmonics differing in phase, amplitude, and frequency could be produced and combined to give any desired wave-shape. This idea of combining harmonics to obtain prescribed results has been known for some time. Lord Kelvin used it in his famous tide-predictor, and it was afterwards employed by Profs. Ayrton and Perry in 1877 in their apparatus described in a Paper on "The Music of Colour and Visible Motion."† Although this method would have been in some ways very convenient, we were obliged to dismiss it as too expensive. It is also difficult to get waves of very great irregularity by this method. Dr. Fleming, in reference to this method,‡ remarked that three such alternators, giving frequencies in the ratio 1, 3, 5, would be sufficient for the majority of curves met with in practice. We were anxious, however, to experiment with waves *not* actually met with in practice, since our aim was not so much to find out which alternator now on the market was the best, but rather to give some information, if possible, which might be a guide in the future design of alternators for use on transformers.

On considering the question more fully, we also find that the first three odd harmonics given by the series of alternators just mentioned would not, in many cases of not very distorted waves, give a close approximation to the true shape; thus we find that, in order to get a peak in one part of a wave, it is necessary to cause the rest of the period to consist of a series of irregular undulations. We cannot, in fact, by this method alter one part of the wave without getting into difficulties with the rest of it. This point is brought out very clearly in Fig. 14. Here we show a wave which we have produced by our method of "injection,"* and also

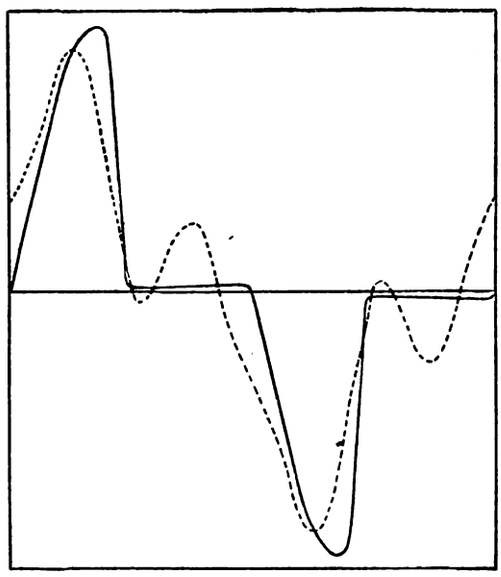

Fig. 14.—The Continuous Line Curve shows Wave actually produced with Injector. The Dotted Line Curve shows Wave that would be roduced by Combing the first three Odd Harmonics.

the wave given by the combination of its first three odd harmonics (dotted curve). It will be noticed that, though this wave approaches the desired shape at the peaked part, it is far from it during the rest of the period. The harmonics for this wave were obtained with one of Coradi's harmonic analysers, by the courtesy

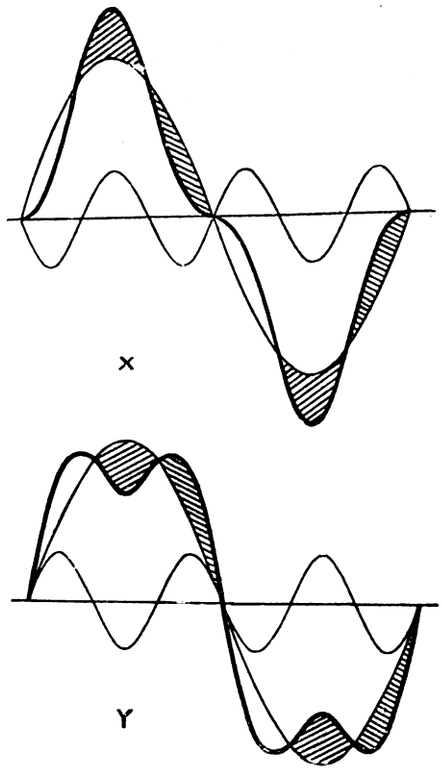


Fig. 15.—X = Third Harmonic in Anti-phase. Y = Third Harmonic in Co-phase.

of Prof. Henrici. It is here that our method has one of its chief advantages. If we want a peak or a depression in one part of our wave, we make it, and leave the rest in peace.

* *The Electrician*, November 29th, 1895, Vol. LXXXVI., p. 153.
† Physical Society, November 23, 1878.
‡ *The Electrician*, June, 1895, Vol. XXXV., p. 304.

* This wave, and the method of obtaining it, was given in *The Electrician*, June, 1895, Vol. XXXV., p. 289.

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The injector method is also one which may be adopted at very little cost. It may be argued that the condensers are expensive, but they are not *necessary*, as a great variety of waves can be got by injecting resistance, and using more than one pair of brushes ($b_1$ $b_2$, Fig. 1.), and so getting more than one injection on each half-wave. It should also be remembered that, when using condensers, the greatest effect is got with the least capacity. The effect of higher harmonics on the area of a P.D. wave (and consequently on the maximum induction) cannot be stated generally. But it may be of interest to indicate the general principles on which it rests. To do this a simple case may be taken as an example. It is only necessary to consider odd harmonics, as even ones make the waves unsymmetrical about the time line.

Consider the case of a third harmonic superimposed on a fundamental sine wave as shown in Fig. 15. The amplitude of the harmonic is here three-tenths of that of the fundamental.* The two extreme cases are shown, namely, those with the harmonic in co- and anti-phase. The effective value of the resultant is the same in each case (viz , very nearly 4 per cent. greater than that of the fundamental), but in $x$ the area of the semi-wave is *diminished* by that of a half-period of the harmonic, and in $z$ it is is *increased* by the same amount; this is the maximum effect possible, since, whatever the relative phases be, two of the half-periods of the harmonic cancel as regards area. The area of the wave may therefore be *diminished or increased* by 10 per cent. by the addition of the harmonic.

The area of a sine wave of the same effective value as the resultants will be 4 per cent. greater than that of the original fundamental. Thus, by building up a wave of two harmonics such as here chosen, we may get resultants of constant effective value having areas from 6 per cent. greater to 13·5 per cent. less than that of the sine wave of that effective value. It will be apparent from this reasoning that the effect of harmonics is entirely dependent on their phase relatively to the fundamental, and that attempts such as were made at the time of the "Sine Wave Controversy" to state generally the effect of harmonics in the P.D. wave on the iron loss of a transformer are quite futile.

## MAGNETIC DATA AND TESTING OF IRON AND STEEL.

At the ordinary meeting of the Institution of Civil Engineers on Tuesday, May 19th, Sir Benjamin Baker in the chair, two communications dealing with the magnetic properties of iron and steel were considered.

The first Paper was entitled "The Magnetic Testing of Iron and Steel," by Prof. J. A. Ewing, F.R.S. The author referred to the practical importance which now attached to the magnetic testing of iron and steel in relation to the manufacture of dynamos and transformers. From being a mere laboratory experiment, interesting only to students of physics, it had passed into the rank of an engineering operation. Iron makers now supplied material greatly superior, from the magnetic point of view, to that which could be obtained even two or three years ago. In dynamo construction the introduction of permeable steel castings for the field-magnets had given greater latitude as to form without loss of efficiency, the best steel castings being indeed somewhat better magnetically than most forged iron. In stampings of sheet metal for transformers the main consideration was absence of hysteresis, and so great had been the advance in this respect that iron was now readily obtainable with only half the amount of hysteresis which was considered possible a few years ago. This had brought about a notable increase in the efficiency of alternate-current distribution by reducing the large element of loss which occurred through the hysteresis of transformer cores during the hours of light load as well as of heavy load. The author recalled the conventions according to which the magnetic quality of iron was expressed. The most usual test was one to determine the relation of the magnetic induction to the magnetising force, the ratio of B to H being the permeability. To enable H to be determined with accuracy the specimen was arranged as a closed ring, or as an ellipsoid, or as a bar or bars rendered practically endless by the use of a yoke. Ballistic methods of testing were described, and it was shown how in the use of a yoke the proper correction might be experimentally found, to deduce the true magnetising force by allowing for the magnetic resistance of the yoke itself. For this purpose the author used a pair of bars joined by two short yokes at their ends, the yokes being shifted so as to include either the whole length or half the length of the bars in the magnetic circuit. Reference was made to various forms of apparatus designed to measure the magnetic induction by observing the force required to separate surfaces in the magnetised piece, and a form used by the author was described in which a yoke piece was simultaneously drawn away from polar extensions at both ends of the bar. A novel apparatus was shown in detail for measuring permeability by comparing the magnetising force required to produce a given induction with the force required to produce equal induction in a standard bar. This apparatus,* which the author terms a magnetic bridge from its analogy to the Wheatstone bridge for the measurement of resistance, reduced the operation of testing to a comparison between the specimen and a bar the magnetic quality of which had been determined once for all by the instrument maker. The two bars were connected by end yokes, and by varying the number of turns in the magnetising coil on one of them the yokes were brought to the same magnetic potential. The relative number of turns on the two thus gave the relative magnetising forces required to produce the same induction in both. A simple form of magnetic detector showed when the two yokes were brought to the same potential. The manipulation consisted in varying the number of turns acting on one bar by means of dial switches, while the magnetising current was from time to time reversed. This permeability tester was intended for workshop use, and might take its place alongside of the author's hysteresis tester, which was also described. The methods of directly measuring hysteresis were briefly referred to.

A number of representative examples were given of permeability tests of forged wrought-iron, forged steel and cast steel for dynamo magnets; also of hysteresis tests of transformer plate rolled from Swedish wrought iron and from ingot metal. The results were shown by means of numerical tables and also in curves.

The second Paper, on "Magnetic Data of Iron and Steel," was by Mr. H. F. Parshall, Assoc. M.Inst.C.E. Magnetic tests of iron and steel might be conducted to determine such properties as permeability, maximum magnetisation, residual magnetism, and permanent magnetism, and the relation they bore to tempering, annealing, internal stresses, composition, and processes of manufacture. The loss of energy through hysteresis might be determined either magnetically, by determining the area of the loop formed by plotting the flux densities as ordinates, and magnetic force as abcissas, or mechanically by suitable power-measuring apparatus. A study of the magnetic results and of the chemical analysis showed a more or less intimate relationship according to the degree with which the modifying physical conditions might be controlled. In general, a greater degree of purity was an indication of high permeability, but as the different qualities of iron and steel merged into each other by insensible degrees, owing to variations in the processes of manufacture, chemical analysis might be taken only as an approximate indication of the magnetic properties. Carbon was the most important element entering into the composition of commercial iron, and, within the limits that chemical analysis might serve as an indication of the physical structure, the permeability was inversely as the amount of carbon present. The limitation as to the state of physical structure was greatly affected by the state of the carbon, that was, whether free or combined; in cast iron as well as in steel, the effect of graphite was second to that of the carbide commonly known as fixed or combined carbon.

Beyond a certain degree of purity, as in wrought iron and carbon steels, the treatment as to annealing and tempering became of first importance. The magnetic properties of some of the alloys of iron, nickel, or manganese were such as to show that the physical structure was the ultimate determining factor. The hysteresis loss was in general inversely as the degree of purity; but in comparatively pure irons it was determined principally by its treatment as to annealing, heating, and mechanical straining.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, May 22nd.**

PHYSICAL SOCIETY.

*5 p.m.* Meeting at Burlington House. Adjourned discussion on Messrs. Frith and Rodgers' Paper: "On the True Resistance of the Electric Arc." The following Papers will be read: (1) "On Dielectrics," by R. Appleyard; (2) "The Field of an Elliptical Current," by J. Viriamu Jones; (3) "An Instrument to measure Frequency," by A. Campbell.

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Students' Meeting at 25, Great George-street, S.W. Paper to be read: "The X-Ray Photography," by H. S. Tyson-Wolff.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Hysteresis," by Prof. J. A. Ewing, F.R.S.

**THURSDAY, May 28th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Paper to be read: "The Utilisation of Water Power, especially with a small Fall, with some examples of Plants for the Generation of Electrical Energy," by Sept. Stoiger.

* Unless the ratio of the maximum of the fundamental to the maximum of the harmonic is greater than the ratio of their wave-lengths, the curve will dip below the zero line at the ends of the half-period, in cases such as shown in $x$, Fig. 15.

* [For an illustrated description of this instrument see *The Electrician*, May 8, 1896, p. 41.—ED. *E.*]



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## WAVE-FORMS AND IRON LOSSES.

Those who have watched the progress of alternate-current theory during the past few years will have observed, and probably have been pleased to see, that greater importance has been attached to actual physical research and less to abstract mathematical deductions. In the early days of this branch of electro-technical science we were commonly treated to a pound of abstract analysis, based upon FOURIER'S theorem, to every short ounce of actual experiment. True enough, tests were made, and the efficiencies of the various forms of alternate-current apparatus were measured and served up in tabular form. But these departures from pure abstractions were more in the nature of engineering metering than physical measurement, and in most cases they served only to intensify the gap between the so-called theory and what was found to occur in actual work. Sine waves and simple harmonic functions were the mathematical bricks and mortar of the theorist of that day, and if our results in practice did not resemble the structure which was reared of these materials, so much the worse, we were told, for our results in practice.

In those days of guessing by equation, alternate-current waves of complicated form were known and recognised by theorists; but the acquaintance was of a distant and frigid nature, and warm affection was reserved alone for the pure and genuine sine. Within the very heart of the alternator, it was true, all sorts of complicated waves might occur; but when the terminals were reached most of the harmonics would have suffered extinction; while by the time the energy had filtered through a system of transformers, not one single harmonic would have been able to survive the ordeal of self-induction, and nothing but a "true sine wave" would appear at the distant secondary end. FOURIER'S theorem showed it;

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and at the magic of that name everyone bowed in acquiescence; and no one took the trouble to find whether the wave was or was not really a simple sine.

Gradually, however, the hardy vitality of a complicated wave-form came to be recognised, and it was found to be one of the most difficult, not one of the easiest things, to effect an appreciable change in a wave-form impressed upon a circuit by an alternator or set of alternators. Transformers, Dr. Fleming has recently told us, copy every minor ripple and tiny harmonic with the greatest accuracy and faithfulness. The conditions under which the form of a supply-system wave becomes simplified occur not commonly but rarely, in general practice. So that the important question arose: What are the relative commercial values of the different forms of waves that are met with in practice? We believe that this question was first raised in America, where the practical engineer, bombarded by a superabundance of equation-woven "theory," had grown tired of it all and had struck out for himself on practical lines. Unfortunately a section of American engineers still laboured under the-thrall of misapplied mathematics; and when these found that alternators of various kinds did not have their waves twisted into true sines, they obeyed the dictates of the theorists and tried to build their alternators to generate waves of this simple form. Whatever may be said for the simple sine wave purely in relation to line-drop over long-distance transmission circuits, there was nothing at that time and there is nothing now to show that the pure and simple sine is the most efficient and best form for alternators in general. In fact, it is demonstrably not the best form. We were therefore led to raise a protest against this obviously hasty and unwarranted inference from "theory" in our issue of July 6, 1894.

Awakened thus to the importance of the question of alternator wave-form, electrical engineers on both sides of the Atlantic busily engaged themselves in solving the many problems that it suggested. After the war of words had ceased which immediately followed our criticism of the American practice just referred to, a great deal of experimental work was commenced, some of the results of which have only just been published in the admirable Paper that Messrs. Beeton, Taylor and Barr read last Thursday week before the Institution of Electrical Engineers. We commenced a reprint of this contribution to the literature of the subject in our last issue and complete it this week. But we are anticipating the order of events somewhat, and must return to an earlier stage, when, on July 6, 1895, a Paper on "The Behaviour of Transformers under the Influence of Alternating Currents of Different Wave-Forms" was read by Dr. G. Rössler at the Münich meeting of the Verband Deutscher Electrotechniker We give the actual date of this meeting in order that Dr. Rössler's important work may be properly acknowledged and that a legitimate place may be assigned to it in the history of the subject. A translation of this valuable Paper was commenced in our columns on November 22, 1895.

The researches of Dr. Rössler, and the later researches of Dr. Fleming and others, were carried on by the aid of a number of actual alternators giving different types of waves. It will be evident that though by this means it would be possible to determine in which direction a general improvement of wave form might be effected, the limited number and the limitations in form of the available waves would make it impossible to deduce any general quantitative law. A valuable step in advance was made when it occurred to the authors of the Paper just read before the Institution of Electrical Engineers, to produce artificial and carefully selected distortions in the wave of a single alternator, by "injecting" resistance and capacity into the circuit at definite parts of the wave and for definite intervals. The perfect control thus acquired over the wave-form experimented upon enabled a quantitative series of results to be determined, from which not only the best form of wave but the degree of its superiority over any other form could be accurately ascertained.

The discussion on Messrs. Beeton, Taylor and Barr's Paper revealed that electrical engineers in this country are not wholly alive to the importance of the question at issue, and are divided as to its practical value. Dr. Fleming, whose own work on the subject has been neither small nor unimportant, was the first to speak. He paid a tribute to the ingenuity of the authors' method of producing their wave-forms, but pointed out that transformer design is more than a matter of minimising iron loss, and reminded his hearers that a peaked form of wave produces, for a given voltmeter reading, a greater stress on the insulation of the circuit than less efficient forms. Dr. Rössler has observed this too, but has qualified his observation by the remark that "with a suitable form of wave of this type one could remove most of the objections based on the higher insulation required, without otherwise affecting the properties of these (peaked) waves." Mr. Evershed followed with some arithmetic. From Mr. Evershed, who is an avowed opponent of pure theory, one naturally expected to get practical arithmetic. He told us that the iron losses in a transformer amounted to only 2·5 per cent., and that 10 per cent. of this was nothing, or nothing worth making a fuss about, and not worth the trouble of saving; and that when it was saved it was only the cost of the coal and the oil that was really saved. Mr. Evershed's figures disappointed us, because they were not practical, but were based on assumptions that do not correspond to practice. A transformer doubtless may be designed that, when always kept on full load and under laboratory conditions, will have an iron loss not greater than 2·5 per cent. But when that same excellent transformer is put into active commission on a supply network, it will have to work at very much lower loads, while all the time wasting in its iron exactly the same amount of power as before. At one-tenth of its best load, this transformer would waste no less than 25 per cent. of the energy supplied to it. The contention cannot be upheld that on any transformer system, however carefully banked, the transformers can be run all day and night long on their best load; while on the vast majority of systems, where no banking regulation is even attempted, the average load throughout the year cannot be anything but a small fraction of the most efficient load. Mr. Evershed's estimate of a total transformer capacity of 4 million units, for a system delivering 3 million units per annum to the consumers, is very far below the actual mark, as will be seen when we say that it represents a transformer load factor of 75 per cent. for the entire year. The statistics of alternate current supply systems speak for themselves, and quite justify our contention that to effect a 10 per cent. reduction in transformer losses is a matter of more than academic interest. Newcastle with its 40 per cent. loss in distribution, Sheffield with its 30 per cent. loss, or even Bedford—the most favourable example we can cite—with more than 10 per cent. of distribution loss, shows that there is economy of a very valuable magnitude yet to be effected in this direction. We are not contending that all this loss takes place in the transformers, nor that more than a small percentage of it could be saved by means of a better wave-form. What we do assert is that the saving to be effected is much greater than Mr. Evershed would have us believe, and sufficiently large to merit the attention of practical engineers.

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In quite another respect, also, do we differ from Mr. EVERSHED. Doubtless it is true, as Dr. FLEMING has observed, that all engineering design is a matter of compromise. But it is equally true that the best design arises from the most intelligent of all possible compromises; and a design is most intelligent when the engineer is in possession of the greatest number of facts about what he intends to do. He cannot design intelligently and work in the dark at the same time, and even partial darkness is injurious to good work. Now, the suggestion that any element of design is trivial and insignificant amounts to a statement that it can be ignored. And if one such supposed trifle may be ignored so may many others. If we can afford to be careless about alternator wave-form, because, as Mr. EVERSHED asserts, it makes a difference of only £42 per annum in the working expenses, we can also afford to be careless about the length of a shaft bearing, or the choice of a lubricating oil, or the selection of station ammeters and voltmeters. The Scotch say, "many a mickle makes a muckle," and there is a sound principle of engineering design in the old-fashioned English proverb that "if we take care of the pence, the pounds will take care of themselves." Besides, how, unless we investigate the matter in the way Mr. BEETON and his colleagues have done, can we be sure that the most efficient type of wave-form is not given by the cheapest design of alternator? Those who scoff at the matter tacitly assume that it must be the dearest.

## REVIEWS.

**The Magnetic Circuit in Theory and Practice.** By Dr. H. DU BOIS. Translated by Dr. Atkinson. (London: Longmans, Green and Co. 1896.)

The accomplished translator of Ganot has done another service to English students of science—this time to a later generation—by putting within their easier reach Dr. du Bois' treatise on the magnetic circuit, originally published in German two years ago. The translation has had the advantage of the author's own revision, and is enriched by a number of notes, in which he has made brief reference to some of the most recent developments of his subject. Though here and there a trace of the German idiom survives, Dr. Atkinson has done his work well, and has left Dr. du Bois' English friends comparatively little reason for regretting that the author did not select English, instead of German, as his original medium of expression, out of the many European languages of which he is master.

Amongst modern advances in the science of magnetism the conception of the magnetic circuit has taken a leading place. Compared with older methods of attacking magnetic problems it offers an alternative which is always interesting, and often in the highest degree fruitful. Many cases, and especially cases such as arise in dynamo design, admit of satisfactory treatment by aid of this idea, when they are too complex for solution in any other way.

Its utility is so great and its range of application so wide, that there would have been matter of surprise if it had not received the cordial welcome which electricians have, in fact, given it. Small wonder, indeed, that in the warmth of their reception some of them perhaps allowed their enthusiasm to get the better of their judgment. Most remarkable opinions were expressed as to the influence of the new ideas in displacing the old ones. The conception of magnetic poles, the law of inverse squares, and so on, were to be completely shelved. We were gravely told that it was impossible now to gauge how much the progress of electrical science had been "impeded and retarded" by the weight of the great names of Coulomb and Poisson and Laplace. The notion of the magnetic circuit was for electrical engineers the pearl of great price; to gain it they were to sell all they had formerly held dear. "Having this, they need no laws of inverse squares of distances, no magnetic moments, none of the elaborate expressions for surface distribution of magnetism, none of the ancient paraphernalia of the last century." It was almost the language of the revivalist preacher; but the new gospel of the magnetic circuit fortunately had enough real strength and vitality to survive even such excesses on the part of its more ardent proselytes.

Dr. du Bois gives no countenance whatever to any such extravagant views. He is studiously careful to assign to the notion of the magnetic circuit its proper place both in magnetic theory and in the application of theory. He recognises at once its value and its limitations, and we nowhere find him playing the part of the child who shows its devotion to a new toy by throwing the old ones into the dust-bin.

One of the most interesting chapters of his book is that which gives a historical survey of the development of this important conception. The analogy of magnetic systems to circuits of other kinds is in fact so old that if all the "ancient paraphernalia of the last century" were swept away the foundations of this analogy would perish with them. Dr. du Bois traces it as far back as Euler. In the hands of Faraday, of Kelvin, and of Maxwell it took clearer shape, Maxwell's contribution dealing especially with the analogy to the electric circuit, and Lord Kelvin with the analogy to the conduction of heat and the flow of fluid through porous material. It was this hydro-kinetic analogy that led Lord Kelvin to introduce the word permeability, now so familiar to everyone who has to speak of the magnetic quality of iron. Coming to more recent developments, Dr. du Bois refers to the writings of Rowland, Bosanquet and W. von Siemens, to the practical work of Elphinstone and Vincent and of Kapp, all of which may be said to have prepared the way for the great Paper in which J. and E. Hopkinson gave definite scientific expression to ideas which had up to then been too general to be very useful, or too vague to be very convincing. It is not too much to say that this Paper was to most students of magnetism the first evidence that the idea of the magnetic circuit could in certain cases be sufficiently divested of arbitrary assumptions to be logically conclusive, and at the same time be applied to practical problems with admirable effect. It is essentially from the standpoint supplied by this Paper that Dr. du Bois has written his book.

He writes with the fullest knowledge of his subject, both in its mathematical and its experimental aspect. The treatment is conspicuously thorough and exact. Dr. du Bois assumes some knowledge of the magnetic qualities of materials, that is to say, he is content to refer students to other works where such results have been fully stated. The book is not one for beginners in magnetism; it is a critical and philosophical study of a large part of magnetic theory and of a large group of methods in magnetic investigation. The field is one in which Dr. du Bois is himself well known as an original worker. Amongst the experiments and experimental methods that are described a considerable number are the author's own. If anything, he has given these a less prominent place than they deserve; but in dealing with the work of other investigators his book shows, in every chapter, how wide has been his reading and how careful and sympathetic his appreciation of the experiments of his contemporaries. There is a wealth of reference to the work of others throughout the volume that is not very often found in English text books, for we are apt, most of us, to go our own way without looking much to the right or left, and scarcely ever glancing behind.

It would be impossible without unduly extending this notice to give even a summary of the large field of which the work treats. The first five chapters deal with mathematic theory, tempered of course by experiment; then come applications, history, and accounts of experimental methods. No existing text book or treatise covers the same ground. The book is in all respects one to be commended to the attention of those who wish to obtain a real grasp of magnetic science. The present writer may perhaps be allowed to express a hope that those who have found a certain volume on magnetic induction serviceable to them will enlarge their knowledge by reading Dr. du Bois.

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English readers may perhaps regret that the "magnetic force" with which they are familiar is called by Dr. du Bois the "magnetic intensity," or more generally the "intensity" alone. We find such phrases as "lines of intensity" and "the direction of the intensity." Dr. du Bois is perfectly consistent in his nomenclature, and it is not likely that any confusion will be caused. But these things are matters of taste and habit, and (especially in view of the usage which gives to the quantity **I** the name of intensity of magnetisation) we should have preferred to see the name magnetic force retained for **H**.

This, however, is a small point, in no way diminishing the obligation under which Dr. du Bois has put students of physical science and electro-technics. He has given them a systematic and authoritative account of modern ideas in magnetism. J. A. E.

## STEEL STEAM PIPES AND FITTINGS, AND BERNARDOS ARC WELDING IN CONNECTION THEREWITH.*

BY SAMUEL M'CARTHY.

The constantly increasing use of steam at high pressures, both for marine and land engines, renders the employment of the most suitable and reliable steam pipes a matter of the utmost importance and interest to engineers; and it is somewhat surprising that the subject does not appear to have been brought before this Institution for consideration and discussion during so long a period.

*Cast-iron and Copper Pipes.*—Cast iron, which has the advantage of being seamless, and which can be moulded into any desired shape, is heavy, cumbrous, frequently porous, and always liable to fracture by a blow. The necessarily great thickness of cast-iron steam-pipes, and the rigidity of the bends, also add greatly to the difficulties of arranging for expansion. Hence the use of this material for pressures over 50lb. or 60lb. per square inch is becoming more and more rare. Copper, which for so long a period was almost exclusively adopted in the navy, and also to a great extent in the mercantile marine, for steam and feed-pipes, has, in consequence of numerous disastrous failures, become of late years greatly discredited. The cause of its failure need not be entered into here, nasmuch as the subject was fully dealt with in the Paper on steam-pipes which was read by Mr. J. T. Milton before the Institution of Naval Architects in April, 1895 (*Transactions*, Vol. XXXVI. p. 191).

*Wrought-Iron and Steel Pipes.*—Cast-iron and copper having failed to afford the necessary security and confidence in connection with steam at high pressures, there arose a great demand for welded wrought-iron or steel pipes, which was promptly met by the leading tube-makers, who lost no time in procuring the requisite machinery for their manufacture. With regard to the respective merits of iron and steel for this purpose, as for many others, there has always been a great difference of opinion among engineers; and the controversy is not yet at an end, but invites renewed experiment and useful discussion. In the early days of the manufacture of large welded steam-pipes, iron was most frequently preferred; and doubtless the preference was then wise, and was justified by experience, inasmuch as at that time the manufacture of steel plates had not reached the degree of perfection to which it has since attained. Not only were the steel plates often laminated and blistered, but it was difficult to procure mild steel of a suitable quality for welding. Happily these troubles have to a great extent disappeared; and an abundance of excellent mild steel can be obtained, which can be welded as readily as iron.

*Corrosion.*—One of the principal objections raised by the opponents of steel has been that it is more subject to corrosion than iron; and doubtless this would be a grave defect if shown by experience to prevail. This matter was dealt with at great length in the Paper on the comparative endurance of iron and mild steel when exposed to corrosive influences, which was read by Mr. David Phillips before the Institution of Civil Engineers in March, 1881 (*Proceedings*, Vol. LXV. p. 73). As the result of numerous experiments, he came to the conclusion that steel, in the form either of boiler tubes or of plates, was greatly inferior to iron in power to resist corrosion; but in the lengthened discussion which followed the speakers were almost unanimous in their dissent from this conclusion. At all events, whatever may be the result as regards boiler tubes, there is every reason to believe that welded steel steam-pipes are free from any risk in this respect. Recently the author has had an opportunity of examining several lengths of 7in. steam-pipes and bends, made of steel, at the City of London electric lighting station at Bankside, which have been constantly at work at a pressure of 160lb. for over three years, and which exhibit not the slightest appearance of pitting, scoring, or corrosion in any form. Although only an isolated case, this affords pretty strong evidence so far as it goes; and the author has never heard of a single complaint as regards corrosion of steel, steam-pipes in connection with the large quantities which have been supplied. In erecting ranges of steam-pipes, great care should be taken to ensure efficient drainage; for should there be any point in the range where the condensed water is allowed to lodge, corrosion will no doubt take place sooner or later at that part, whether the pipes are made of wrought iron or of steel.

*Thickness of Metal.*—As to the comparative thickness of steel and iron pipes, it might naturally be expected that the former would be made lighter in proportion to the greater tensile strength of steel. Theoretically this should be so; but in practice it is carried out to only a limited extent. Not only is a large margin required for safety, but the exigencies of manufacture necessitate a certain thickness of plate to ensure making a sound weld; and this thickness cannot be reduced without risk. For instance, a common size of steam-pipe, 10in. bore, is most conveniently made of $\frac{1}{4}$in. plate, which would be amply strong enough for iron, and is consequently excessive for steel; but the reduction of $\frac{1}{16}$in. in the thickness would affect the cost and the weight so slightly, that it is thought best to err on the safe side. For larger sizes, of 12in. to 18in. bore, it is found practicable to make steel pipes somewhat lighter in proportion to iron. In this connection it is interesting to note that the Admiralty are now using steel for all sizes of steam-pipes over 2in. bore. Above 9in. bore they still adhere to the practice of having a butt strap or cover strip riveted along the line of weld, which the author believes to be worse than useless, as the numerous rivet-holes necessarily tend to weaken the pipe. It is also probable that the presence of the cover strip, in connection with the expansion of the pipe both circumferentially and longitudinally, has the effect of setting up a tearing strain, which may result in leakage at the rivets. The addition of the butt strap also adds greatly to the cost of the pipes. In a recent specification for steam-pipes the Admiralty fix $\frac{5}{8}$ths of an inch as the uniform thickness for all pipes from 6in. to 14in. diameter of bore, the tensile strength of the steel not to exceed 25 tons, and not to be less than 23 tons per square inch. In the following Table I. are given the thicknesses which are usually specified for steam pipes from 6in. up to 18in. bore, for pressures varying from 100lb. to 180lb. per square inch, also the corresponding hydraulic test pressures. In addition to the hydraulic test, the pipes are also tested with high-pressure steam. This is important, because they are thus tested under actual working conditions as regards temperature and consequent expansion; and any minute pin-hole which has not been revealed by the cold-water test is certain to be detected under steam.

**Table I.**—*Thicknesses of Steel Steam Pipes for varying pressures.*

| Diameter of bore. | Steam pressure, pounds per square inch. 100 | 120 | 150 | 180 |
|---|---|---|---|---|
| Inches. | Inch. | Inch. | Inch. | Inch. |
| 6 | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{4}$ |
| 7 | ... | ... | ... | ... |
| 8 | ... | ... | ... | ... |
| 9 | ... | ... | ... | $\frac{5}{16}$ |
| 10 | ... | ... | ... | ... |
| 11 | ... | ... | $\frac{5}{16}$ | ... |
| 12 | ... | $\frac{5}{16}$ | ... | ... |
| 13 | $\frac{5}{16}$ | ... | ... | ... |
| 14 | ... | ... | ... | $\frac{3}{8}$ |
| 15 | ... | ... | ... | ... |
| 16 | ... | ... | $\frac{3}{8}$ | ... |
| 17 | ... | ... | ... | ... |
| 18 | ... | ... | ... | ... |
| — | 200 | 240 | 300 | 360 |
| | Hydraulic test-pressure, pounds per square inch. | | | |

*Methods of Manufacture.*—It is frequently supposed that the electric arc is brought into operation for welding the longitudinal seam of the barrel of the pipe. As a matter of fact this is not the case. It can of course, be done, and has been done successfully in many instances: but as it was found from experience that no saving in cost was effected, and that nothing was gained either in speed or in efficiency by the use of electricity for this purpose, the straight seams are still welded in the ordinary manner, namely, either in the rolls or by gas and power.

*Roll Welding.*—In this process the iron or steel in the shape of strip is first scarfed along both edges in a planing machine, on the outer face along one edge, and on the inner face along the other; it is then heated in a muffle, and, by being drawn through skelping dies, is bent into tubular form or skelp, and is ready for the welding furnace. When the welding heat is reached the skelp is withdrawn from the furnace with tongs, as shown full size in Fig. 1, and the end is placed upon the head of a horizontal mandril fixed

* Paper read before the Institution of Mechanical Engineers.

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to a long rod, which is held between a pair of revolving rolls that are turned to suit the particular size of tube being made. The skelp being seized by the rolls is rapidly welded by the pressure exerted upon it between the two rolls on the outside and the mandril on the inside of the tube. In all cases the tube is drawn twice through the rolls at a welding heat, the process being the same each time. On finally leaving the welding rolls, the tube passes through a mangle or reeling machine, which straightens it; the ends are then cut off square, and it is ready for testing.

*Gas Welding.*—The strips, after being scarfed along their edges, are heated only cherry red in a muffle, and are then bent to the required diameter in the rolls. The pipe is next placed on a "beak," as shown half full-size in Figs. 2 and 3, and a jet of gas is brought to bear along the seam, whereby in a short time, varying according to the thickness of the plate, a length of about 6in. to 8in. is brought to a welding heat. A small quick-speed steam hammer, fixed above the work, then rapidly closes the seam, and completes the weld. The operation is repeated on the next length,

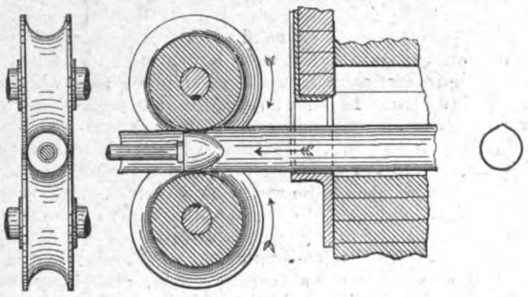

FIG. 1.—Roll Welding.

until the longitudinal seam is completed. The use of gas renders the process clean, and absolutely free from dust and other impurities; and the edges of the pipe, having been carefully freed from scale after leaving the heating furnace and rolls, a perfectly sound weld is obtained. At some works all sizes of pipes are made through the roll, while at others this method is followed only up to 8in. bore, and all the larger sizes are welded by gas.

*Bernardos Arc Welding.*—It is in the manufacture and attachment of flanges, branches, bends and T- pieces that the Bernardos system of welding by means of the electric arc plays such an

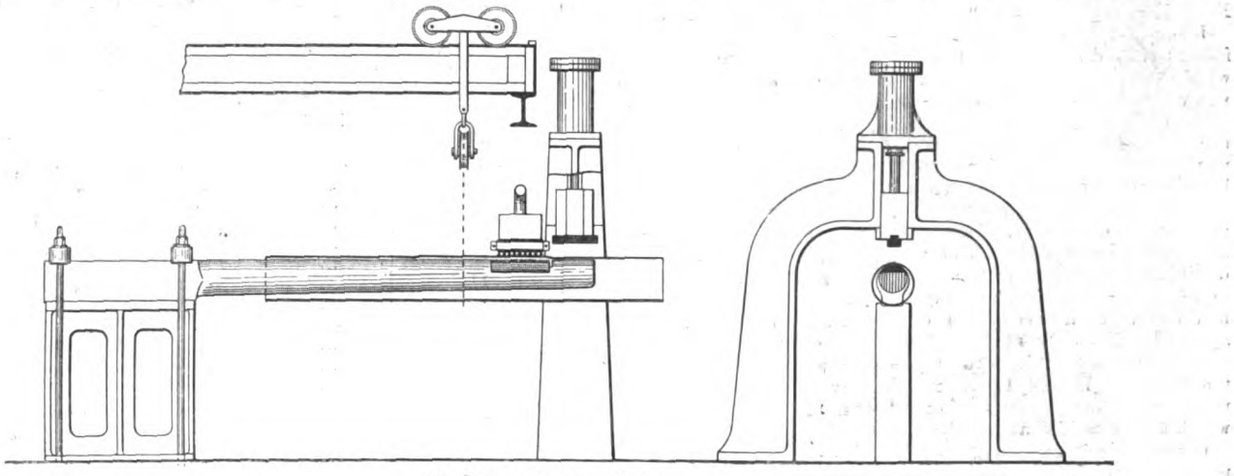

FIG. 2 and 3.—Gas Welding.

important part. This process has now been in constant operation for over five years at Messrs. Lloyd and Lloyd's Coombs Wood Works, near Halesowen, with which the author is connected, where during this period it has been employed chiefly on large steel pipes and connections, suitable for high-pressure steam. The process has been so fully and clearly described from time to time in the various technical and scientific journals that it is unnecessary to do more than briefly illustrate it here, before showing its special application in connection with the subject of the present Paper. The method of working is simple. Ordinary low-tension continuous-current lighting dynamos are used; to the terminals of these a battery of Bernados accumulators is connected, into which the current flows continuously. When the welding circuit is closed, the current flows from the dynamos and accumulators, and large resistances are used when necessary. In this way a large discharge is obtained, equal to about twice the capacity of the dynamos, and the load factor of the apparatus is high. For some purposes it is possible to work without the accumulators; but when this is done the efficiency of the apparatus is not so high, because during part of the working period no current whatever is passing, and the machinery is running light.

As illustrated by the diagram, Fig. 4, the plant is run on the parallel system, and between the terminals of the dynamos or battery as many welding arcs can be connected as may be desired,

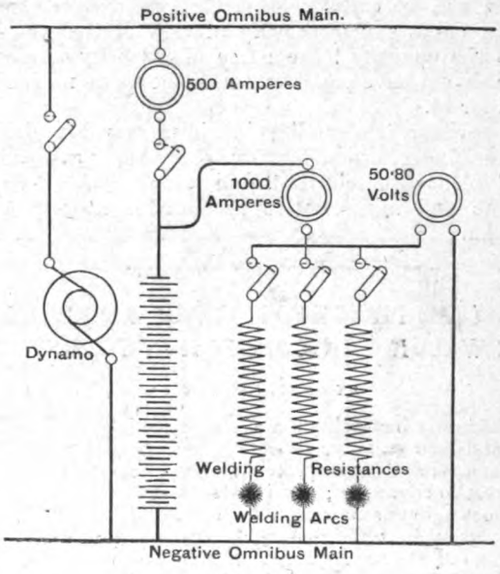


FIG. 4.

and every welder is able, independently of the others, to vary his own current to suit the work in hand at the moment. One terminal of the circuit is connected by means of a flexible cable to a carbon pencil in an insulated holder (Fig. 5), which is held by the workman; the other terminal is connected to the table on which the work lies, or to the work itself. When iron or steel is under treatment, itis usual to make the carbon the negative pole, and the iron or steel the positive pole; but for other metals the poles are sometimes reversed. In the appendix is given a summary of the results of experiments made by Messrs. David Kirkaldy and Son for Messrs. Lloyd and Lloyd, to ascertain the tensile strength of electric-welded bars of various brands and sizes; and also a comparison of these with fire-welded bars.

*Flanges.*—The method usually adopted for welding flanges to steam pipes is as follows (Figs. 6 to 11). The flange is stamped out under the steam hammer in such a way that a V-shaped groove is left on the inside edge, as shown double full size in Fig. 7, extending about three-fourths through the thickness of the metal. The flange is next shrunk upon the tube, with the flat face outwards or at the end of the tube, and is carefully set in the exact position required (Fig. 8). The welding consists in laying small pieces of steel in the V-shaped groove, and welding them in one by one by means of the electric arc, Fig. 8, the welds being freely hammered between each heat. The welder makes a complete circuit of the back of the flange, and fills it up sufficiently to make a fillet of about 1½in. radius, Fig. 9. In this way the flange is solidly welded to the tube at the back, and about three-fourths of the way through its thickness, Fig. 9; but the front or outer side

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s not yet welded. The tube is then up-ended, Fig. 10, and the outer side of the flange is welded to the tube, the only difference being that the heat of the arc is used to burn out a cavity all round the junction of the pipe and the flange, until the depth is reached at which the two have already been united ; this cavity is then welded up, Fig. 11, in the same way as the back of the flange, thus ensuring that the flarge is welded solid to the pipe right through.

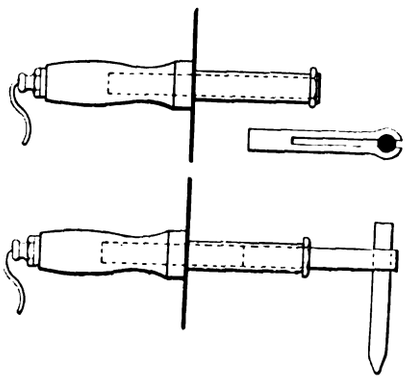
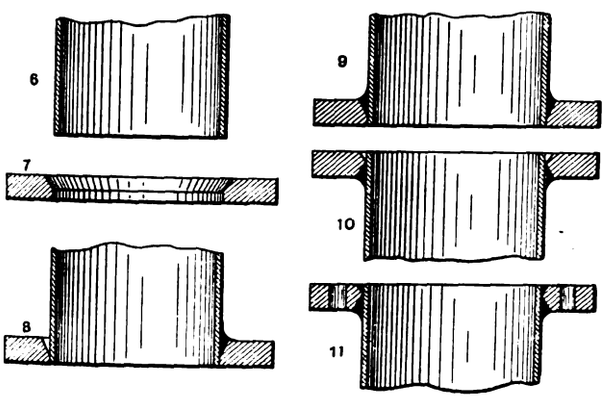


Fig. 5.—Electric Carbon Holder.

*Outlets, Branches and T-pieces.*—The welding in of outlets and branches into steam-tubes is done by much the same method as already described in the case of the flanges. The outlet, which consists of a piece of ordinary lap-welded tube, is cut off to the required length, and a hole is burnt by the arc in the tube, large enough for the outlet just to fit into. When fixed in the right




Figs. 6 to 11.—Flange Welding.

position the outlet is welded in, as in the case of the flange, by laying on small pieces of steel about 1in. long by $\frac{3}{4}$in. wide and $\frac{1}{4}$in. thick, and welding them in one by one, continuing the process all round the outlet, until a fillet is formed of about $1\frac{1}{2}$in. radius, but this varies slightly with the position of the outlet on the tube. A T-piece is made in a precisely similar way, a short piece of tube

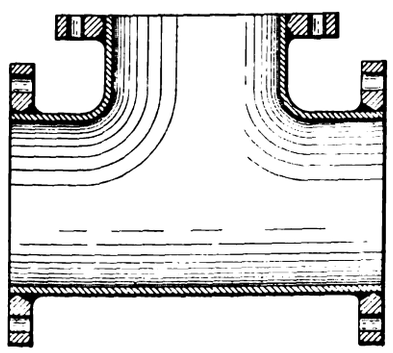


Fig. 12.—Tee-Piece.

being welded into a longer piece (Fig. 12) ; and a cross (Fig. 13) is made by welding two similar short pieces, one on either side of the main tube.

*Bends and Expansion Pipes.*—These are made by the same method as the outlets and T-pieces. In Fig. 14 is shown a form of expansion bend, of which a number are at work, and are found highly effective.

*Length and Size of Arc.*—One point in connection with electric-welded work, to which the author would call special attention, is the length and size of the arc which is used in the welding of various kinds of work. With a short arc, the carbon point is brought down too close to the steel ; and the result is inferior work, not only from the presence of the carbon, but also because the heat is concentrated upon so small a surface that the strains set up in cooling are considerable. The longer the arc, the softer and more diffused is the heat ; and any slight strain which may be set up can be got rid of by careful annealing. A long arc is therefore indispensable to the proper working of the system.

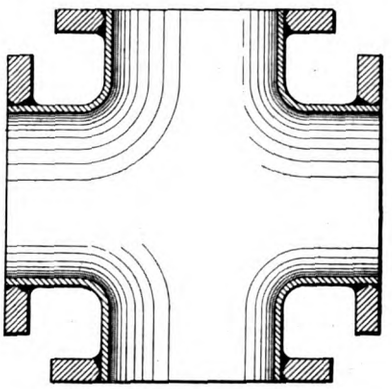


Fig. 13.—Cross-Piece.

*Strength of Electric-welded Flanges.*—An 8in. iron pipe $\frac{1}{4}$in. thick, with flanges electrically welded on, when tested to destruction at Lloyd's Proving House, Netherton, broke in the body of the pipe at over 88 tons, the welded part remaining intact ; and a similar pipe of steel broke in the welded part of the flange at over 101 tons. These tests were tensile only, and were carried out with the view of proving the absolute soundness and consequent strength of the flanges electrically welded on. For this purpose special tackle was made. A blank flange with an eye-bolt attached was secured to each flange of the pipe, and the chain of the testing machine was connected with the eye-bolts at each end, with the result given above.

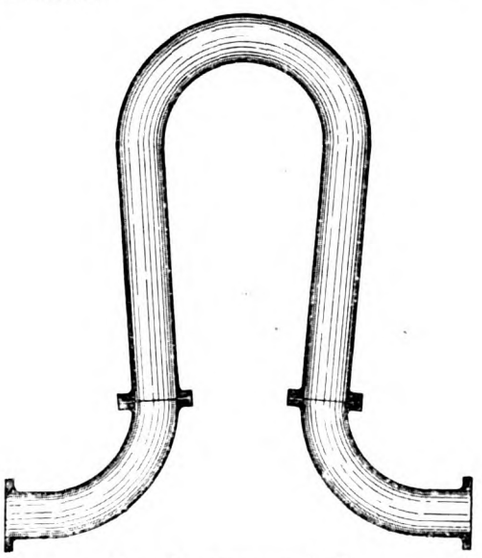


Fig. 14.—Expansion Bend.

*Other Applications of Arc Welding.*—All kinds of work of the above description can be readily and satisfactorily done by this process ; but its utility in large works does not stop here. Small flanges can be heated and welded upon tubes by spinning them in a lathe at a high speed, and allowing the arc to play on them, the weld being made by the pressure of two rollers, one inside and the other outside the tube. Defects in steel castings and in finished forgings can be repaired with the greatest ease ; and the fact that, when such repaired articles are faced or turned in the lathe, the turnings come away sound and whole, is a proof that the welding has been perfect, and that the metal has not been burnt or rendered brittle by the process.

Reverting to steam pipes with flanges and outlets electrically-welded on, these have been in constant request ever since the Benardos system was introduced into this country some five and



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a-half years ago by Mr. Henry Howard, and the electric welding department at Messrs. Lloyd and Lloyd's Coombs Wood Works has been kept going almost night and day. The principal demand has come from the various electric lighting works, for which the advantage and security were at once recognised of the solid welded flange, and also of the reduction in the number of joints by the outlets being welded to the tube. In many instances also the bend and the tube have been made in one piece, thus further reducing the joints. The City of London electric lighting station at Bankside has been almost entirely fitted with these pipes. They are also adopted at the Metropolitan electric lighting station at Amberley-road, the Kensington and Knightsbridge, the Bristol and the Nottingham electric lighting stations, and many others. Among users of these pipes and fittings in connection with high-pressure steam engines may be mentioned Messrs. Pearson and Sons, Blackwall Tunnel Works; Messrs. J. Musgrave and Sons, Bolton; Sir Titus Salt, Bart., Sons and Co., Saltaire; and many others.

*Joints.*—In connection with the cognate subject of joints, the author is enabled by the kindness of Mr. Frank Bailey to describe a simple form of joint in use at the City of London and the Metropolitan electric lighting stations, which in conjunction with the solid electrically welded flanges has given excellent results. As shown double full size in Fig. 15, the joint is made simply with a copper ring $\frac{1}{8}$in. thick, of which a specimen is exhibited. These rings are cut of the required thickness from a copper cylinder of the necessary size, and are carefully annealed. The great thickness of the solid welded flanges admits of their being screwed tightly together, without any possibility of springing; and an absolutely steam-tight and durable joint is thereby made, which gives no trouble whatever.

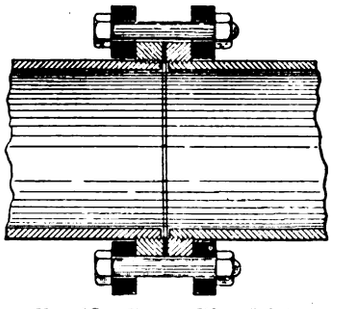

Fig. 15. Copper Ring Joint.

*Bolt Holes.*—Another great advantage of the solid welded flange is that it obviates any difficulty with the bolt holes. The frequent trouble and annoyance experienced with screwed flanges, from the bolt holes not coming fair opposite each other, are well known; and the objections to flanges riveted on steam pipes are too obvious to need any comment.

## Appendix.

In Table II. is given a summary of experiments to ascertain the tensile strength, contraction of area and extension of electrically-welded bars of Lowmoor iron, Parkgate steel, Farnley iron and Netherton crown best iron; ten bars were tested of each of the five sizes, named, and the mean results are here recorded of the ten welded and the ten solid bars of each size. All the welds were scarf, the length of scarf averaging 1$\frac{1}{4}$in. to 1$\frac{1}{2}$in. The results obtained from the welds of Lowmoor iron, Parkgate steel and Farnley iron are satisfactory; the principal features are absence of cinder or impurities from the faces of the scarf, and the maintenance a fair amount of ductily at the weld, the material not being abnormally affected by the heating. Where the welds have come out low, the appearance of the fracture points either to the metal having not been hot enough, or to the thin edge of the scarf having cooled before the weld was closed by hammering. In the welds of the Netherton iron there is a serious tendency to loss of ductility, the fractures showing crystalline. As, however, there are some good welds amongst them without these objections, it would appear as if the treatment, as regards the amount of heat, had not been adapted to the nature of the iron. In order to judge of the full merits and capabilities of the electric welding, due regard must be paid to the individual results as well as to the average. The mean results in Table II. are based upon the whole of the ten welds, as far as the ultimate stress and the ratio of weld to solid are concerned; but as regards the contraction of area and the extension, the results are the mean of the bars which broke through the weld, because necessarily, where the weld did not break, the contraction and the ultimate extension could not be obtained.

In Table III. is given a summary of experiments to ascertain the tensile strength, contraction of area, and extension of fire-welded bars, of different sizes of the foregoing brands, welded by engineers' smiths; and also a comparison with the electrically welded bars. The general average of the electrically-heated welds is seen to be 18$\frac{1}{2}$ per cent. better in figure of merit than that of the fire-heated welds. The welding of the fire-heated iron bars was well done, the difference being slight compared with the same sizes heated electrically; but turning to the steel, the fire-heated welds are more irregular or uncertain, some being good and others bad.

**Table II.**—*Mean Results of Tests of Electric-Welded Bars.*

| Brand. | Nominal size. | Fracture through solid or weld. | Ultimate tensile strength per sq. inch. T | Contraction of area at fracture. C. | Extension in 10in. | Tensile strength, ratio of weld to solid. |
|---|---|---|---|---|---|---|
| | Inches. | | Lb. Tons. | Per cent. | Per cent. | Per cent. |
| Lowmoor iron | 5 × $\frac{3}{16}$ | Solid | 58,417 = 26·1 | 42·3 | 19·5 | |
| | | Weld | 47,367 = 21·1 | 17·3 | 7·3 | 81·1 |
| | 2 × $\frac{1}{4}$ | Solid | 55,537 = 24·8 | 45·7 | 22·9 | |
| | | Weld | 48,429 = 21·6 | 20·9 | 8·1 | 8·72 |
| | 2 × $\frac{5}{16}$ | Solid | 53,237 = 23·8 | 46·0 | 24·1 | |
| | | Weld | 48,890 = 21·8 | 20·7 | 9·7 | 91·8 |
| | 2 × $\frac{3}{8}$ | Solid | 55,363 = 24·7 | 41·7 | 26·7 | |
| | | Weld | 49,517 = 22·1 | 16·7 | 9·0 | 89·4 |
| | 2 × $\frac{1}{2}$ | Solid | 47,872 = 21·4 | 46·9 | 31·3 | |
| | | Weld | 46,343 = 20·7 | 19·2 | 10·2 | 96·8 |
| Parkgate steel | 2 × $\frac{1}{8}$ | Solid | 67,846 = 30·3 | 57·1 | 22·3 | |
| | | Weld | 49,956 = 22·3 | 18·4 | 3·8 | 73·6 |
| | 2 × $\frac{3}{16}$ | Solid | 57,268 = 25·6 | 57·2 | 25·7 | |
| | | Weld | 46,482 = 20·8 | 16·0 | 4·2 | 81·2 |
| | 2 × $\frac{1}{4}$ | Solid | 56,730 = 25·3 | 57·4 | 27·0 | |
| | | Weld | 44,464 = 19·8 | 17·5 | 4·4 | 78·4 |
| | 2 × $\frac{5}{16}$ | Solid | 54,819 = 24·5 | 57·1 | 26·4 | |
| | | Weld | 46,405 = 20·7 | 17·1 | 6·1 | 84·7 |
| | 2 × $\frac{3}{8}$ | Solid | 55,932 = 25·0 | 54·7 | 26·0 | |
| | | Weld | 45,044 = 20·1 | 15·5 | 6·3 | 80·5 |
| | 2 × $\frac{1}{2}$ | Solid | 54,486 = 24·3 | 61·2 | 31·5 | |
| | | Weld | 47,100 = 21·0 | 15·4 | 7·3 | 86·4 |
| Farnley iron | 2 × $\frac{1}{8}$ | Solid | 53,918 = 24·1 | 31·2 | 17·3 | |
| | | Weld | 46,281 = 20·7 | 6·5 | 4·4 | 85·8 |
| | 2 × $\frac{5}{16}$ | Solid | 59,207 = 26·4 | 37·4 | 18·1 | |
| | | Weld | 45,887 = 20·5 | 8·6 | 4·4 | 77·5 |
| | 2 × $\frac{1}{4}$ | Solid | 52,816 = 23·6 | 35·7 | 23·3 | |
| | | Weld | 48,365 = 21·6 | 17·6 | 6·5 | 91·6 |
| | 2 × $\frac{3}{8}$ | Solid | 49,005 = 21·9 | 49·4 | 27·5 | |
| | | Weld | 48,234 = 21·5 | 13·1 | 6·4 | 98·4 |
| | 2 × $\frac{1}{2}$ | Solid | 49,028 = 21·9 | 44·7 | 26·7 | |
| | | Weld | 42,343 = 18·9 | 10·5 | 4·6 | 86·4 |
| Netherton crown best iron. | 2 × $\frac{3}{16}$ | Solid | 51,892 = 23·2 | 23·5 | 11·2 | |
| | | Weld | 44,122 = 19·7 | 8·6 | 4·7 | 85·0 |
| | 2 × $\frac{1}{4}$ | Solid | 48,910 = 21·8 | 22·7 | 10·6 | |
| | | Weld | 44,935 = 20·1 | 10·8 | 4·5 | 92·0 |
| | 2 × $\frac{5}{16}$ | Solid | 56,298 = 25·1 | 23·7 | 18·0 | |
| | | Weld | 40,732 = 18·2 | 7·0 | 2·2 | 72·4 |
| | 2 × $\frac{3}{8}$ | Solid | 56,292 = 25·1 | 24·3 | 20·9 | |
| | | Weld | 41,064 = 18·3 | 5·8 | 2·5 | 72·9 |
| | 2 × $\frac{1}{2}$ | Solid | 53,485 = 23·9 | 29·5 | 23·2 | |
| | | Weld | 41,539 = 18·5 | 5·5 | 3·4 | 77·7 |

**Table III.**—*Mean Results of Tests of Fire-Welded Bars compared with Electric Welded.*

| Brand and size. F = Fire-welded. E = Electric-welded. | | Ultimate tensile strength per sq. in. T. | Contraction of area at fracture. C. | Extension in 10in. | Ratio of weld to solid. | Figure of merit. T × C. |
|---|---|---|---|---|---|---|
| Brand. | Inches. | Tons. | Per cent. | Per cent. | Per cent. | |
| Lowmoor iron | 2 × $\frac{3}{16}$ F | 20·3 | 15·2 | 7·3 | 77·9 | 308 |
| | E | 21·1 | 17·3 | 7·3 | 81·1 | 365 |
| Lowmoor iron | 2 × $\frac{5}{16}$ F | 21·5 | 22·3 | 11·3 | 90·7 | 479 |
| | E | 21·8 | 20·7 | 9·7 | 91·8 | 451 |
| Netherton best iron | 2 × $\frac{1}{4}$ F | 18·4 | 10·1 | 3·4 | 84·4 | 185 |
| | E | 20·1 | 10·8 | 4·5 | 92·0 | 217 |
| Parkgate steel | 2 × $\frac{1}{8}$ F | 20·9 | 9·3 | 1·9 | 69·1 | 194 |
| | E | 22·3 | 18·4 | 3·8 | 73·6 | 410 |
| Parkgate steel | 2 × $\frac{1}{2}$ F | 20·4 | 15·9 | 8·1 | 82·3 | 324 |
| | E | 21·0 | 15·4 | 7·3 | 86·4 | 323 |

$$118{\cdot}5 \text{ per cent.} = \frac{\text{Average of electric-welded bars} = 1{,}766}{\text{Average of fire-welded bars} = 1{,}490}$$

## DISCUSSION.

Mr. McCARTHY, before the discussion was started, called attention to the specimens of tubes exhibited. One piece of tube had been left unfinished purposely to show the process, and he thought the specimens would speak for themselves. They were of steel and all electrically welded precisely in the manner which had been described in the Paper, and on the diagrams on the wall. He would like to call attention to the importance of using the very best steel pipes.

Mr. SCHONHEYDER said he had not examined the specimens on the table, but it seemed to him that according to the process there must be a rough corner inside a bend where the weld has taken place, and not as shown on the drawings 12 and 13. He thought it was a disadvantage, but perhaps the author would explain that it is possible to expand them out and make the corners more as they usually are

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Mr. DRUITT HALPIN said he would like to call attention to a point in connection with Fig. 15. He showed a drawing of a joint made by the late Mr. Willans, and thought it had great advantages over the joint shown. This consisted in a copper ring placed between the flanges, the pipes being bolted through the flanges. He had used a great many hundreds of these joints, and had only had one case of leakage.

Mr. HOWELL said as he had had a great deal of experience in welding tubes, it might not be out of place for him to say a few words on the subject. He had read the Paper, and the description of the electric welding. He should not call it welding at all, but electric *soldering*, because the metal which is set to be welded in is not really welded, but fused in. The effect of this, he said, was that there was a great liability of the steel at the root of the flange, in the immediate neighbourhood of the weld, becoming reduced in quality, and getting more brittle than the remainder of the tube. In 1892 he went into the question of welding, and took a piece of tube of a suitable length, and cut it into rings 2in. long, of which there were 28. The first ring was cut open in the weld, and the next ring was cut in the centre opposite the weld. They were taken in pairs along the whole length of the tube. This was done for the purpose of testing the strength of the weld in comparison with the solid portion of the tube side by side. Six out of the 14 did not break in the weld at all, but it would be useless for him to go into the whole of the tests. The tensile strength of the solid was 22·71 tons, and that of the weld 22·58, or very nearly as strong as the solid itself. Since he had received the advance copy of the Paper, he had hurriedly made a few tests similar to those mentioned in the Paper. The elongation was 18·8 per cent., and in the weld actually 21·50 per cent., showing that in this case the elongation was greater than it was in the solid, and he might say that this weld did not break at all, but the tube broke in the solid. From what he had learned from these experiments he did not think electric welding was as good as gas or roll welding. The great advantage with electric welding was that you could weld small pieces of tube, and this was very difficult to do with gas, because you could not easily get at them.

Mr. PLATT said he would like to ask Mr. McCarthy why he places the copper ring in a joint so that it is not flush with the inside of the pipe. He also wanted to know why pipes were welded at all when you could make perfect pipes out of the solid. There were seamless pipes being made in London up to 12in. diameter, 12ft. long and ¼in. thick, and they were being largely used by the Admiralty, and he thought it a very much safer job than any welded pipe could be. Some members might doubt this, but they are making in London solid drawn steel pipes. The price, of course, was considerable; but if you want a good article you must pay for it. Some 30 years ago he used a considerable quantity of wrought-iron pipes with wrought-iron flanges, and found that a wrought-iron flange bored out conical a little and riveted on the pipe made a perfect joint, and he had no trouble at all with this joint.

Mr. TREMLETT CARTER said he did not agree that electric welding was *merely* a process of soldering or a process of the flux of metal. The electric current seems to carry the melted metal of one part of the weld into the metal on the other surface, so that the two are interlapped and not merely stuck together. This is very evident when we try to weld copper or brass to steel, a thing which it would be very difficult to do by the ordinary process. He said he would like to call attention to another point. He thought the author ought to have given some particulars of the relative cost of the different processes. In America, where the Thomson-Houston process is very largely used for all kinds of metal work, welding and forging work, the cost has always worked out very much cheaper than the ordinary mechanical and thermal processes. In this country he was not sure whether the cost is always cheaper. He knew it had worked out so in one or two cases in this country. He should like to know the cost of electric welding as compared with the cost of the furnace processes, and the saving of time and labour effected. The saving in time and labour which was effected by using the electric process was one of its most distinctive features.

The PRESIDENT said we must all admit that the Paper was a very able one, and the question of having a reliable steam pipe was a very important one, and perhaps Mr. McCarthy, in reply to the various questions, would say something about Mr. Howell's remarks.

Mr. McCARTHY, in his reply, said he thanked Mr. Schonheyder for calling attention to a little error which had been made in the drawings, and if he would look at the samples he would see that there is a corner inside. Of course, the corners were nothing like so round as shown on the drawings. With regard to what Mr. Howell said about electric welding not being welding at all, but electric soldering, that had been stated a good many times. Call it fusing if you like. But he was prepared to show that it is a perfectly sound process. It was very interesting to hear what Mr. Howell said about the tube, but he did not think it had any bearing on the Paper at all, unless it was to show that the welded part of the tube was stronger than the other part. With regard to corrosion, it will affect pipes, whether in iron or steel or anything else, but taking the ordinary run of steel, he should say, from his experience, that there is no corrosion. With regard to the 12in. solid drawn pipes, he said he should like to know something about the cost of these. He has to thank Mr. Robinson for the very interesting particulars he had given with regard to the 4in. lapwelded tubes. Mr. Robinson had, no doubt, very good reason for recommending that the joints should be narrower, and he would mention that to Mr. Bailey when he saw him. With regard to screwed joints, he was not going to preach against them, because there were a lot of them on the table, but his idea in bringing this Paper forward in connection with moderately high steam pressures, was to bring forward what he believed to be the very best, and that was electric welded tubes. With regard to Mr. Carter's inquiry about the comparative cost, he was sorry that he was not in a position to give it. It was rather a delicate matter.

## TESTS OF A 10-CAR ELECTRIC RAILROAD.*

BY JOHN F. VAUGHAN.

The electric street railway from which these figures were taken consists in a newly built line of single track, ten miles long, running north and south across an open and somewhat hilly country, and an eleven-mile loop, several years old, leaving the main line near the south end and meeting it again about two miles from the north end. A short spin leaves the line near the south end.

The power for this road is derived from a station about three-quarters of a mile south of the south end, occasioning about 25 volts drop before the track is reached, although the station regulation is good. The data may be tabulated as follows:

| | | |
|---|---|---|
| Miles of track | | 22½ |
| Number of cars in service | | 10 |
| Car mileage per day | | 1,750 |
| Average speed (including stops) | miles | 9½ |
| Average current per car (during run) | amperes | 20 |
| Watt-hours per car mile (at station) | | 1.500 |
| Watt-hours per car mile (by wattmeter on car) | | 1,090 |
| Station potential | volts | 560 |
| Average potential on line | volts | 448 |
| Maximum drop on line | per cent. | 49 |
| Average feeder losses (calculated) | „ | 14 |
| Average ground losses (measured) | „ | 15 |
| Line efficiency (at present) | „ | 71 |
| Line efficiency (with good bonding) should be | „ | 82 |
| Maximum observed station load (clear cold weather) | amperes | 450 |

The bonding on the old line is destroyed in many places, showing over 50 per cent. of the total line resistance in places. The line leakage varied from 2 to 8 amperes, according to the weather. The heaters added, on an average, 8 amperes per car.

A striking example of the effect of the position of the station on the economy of distribution is seen by comparing the above figures with those obtained on the assumption that half the power be taken, as is proposed, from a lighting station between the proper centre of distribution and the north end of the line. With the two stations and the same feeder system:

| | | |
|---|---|---|
| The maximum drop on line | 22 volts = 3 per cent. | |
| Average potential on line | volts | 546 |
| Average feeder losses | per cent. | 3·1 |
| Probable line efficiency | per cent. | 96 |

## ON THE INFLUENCE OF LIGHT UPON THE CHARACTER OF THE INFLUENCE MACHINE DISCHARGE.†

BY J. ELSTER AND H. GEITEL.

Some years ago we described in these *Annals*‡ the arrangement of a photo-electric experiment in which the brushes and sparks of a Holtz machine passing between a sphere as positive and a plate as negative electrodes were made to disappear by the illumination of the cathode by light of short wave length. The arrangement is very simple. A hollow plate of zinc is placed upon the negative pole rod of the machine, its front surface being amalgamated by rubbing a mercury drop on it with a piece of linen dipped in sulphuric acid, then rinsed with water and dried with tissue paper. If now the knob of the other pole rod is withdrawn until strong zigzag sparks pass, or till, on removing the condensers, a brush streams against the zinc plate with a crackling noise, and a piece of magnesium wire is lighted in the neighbourhood, the stream is extinguished as soon as bright light impinges upon the negative pole surface, reappearing as soon as the light vanishes. The experiment, striking enough owing to the sudden silence observed, appears even more remarkable if we consider that in this case the illumination of the cathode effects the reverse of what might be expected after other experiments. Instead of a facilitation of the discharge, we have, in fact, an apparent impediment to it.

As we showed on that occasion, this influence of light is made even more conspicuous by introducing parallel to the spark gap to be illuminated another gap between brass knobs, adjusted so that in the dark the former is just preferred by the discharge. Under the influence of the magnesium light upon the zinc cathode the discharge then leaves the former path and passes by the latter. If we are also to apply the term "resistance of a gas stratum," to a spark discharge, this phenomenon may be shortly expressed by saying that the illumination of the cathode of amalgamated zinc increases the resistance of the spark gap.

The paradoxical result thus brought out led us to resume the investigation of this phenomenon. The following is a report upon our results.

The first supposition suggested by a comparison with other photo-electric processes is that, under the influence of light, the visible and

* From the *Electrical Engineer* of New York.

† *Wied. Ann.*, No. 3 of 1896, pp. 401-407.

‡ *Wied. Ann.*, 1890, 39, p. 332.



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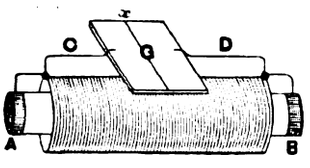
audible discharge is replaced by a silent one. The absence of any noise of streaming indicates that this form of discharge either takes place in a continuous manner, or that the alternations owing to high frequency or small amplitude no longer give rise to audible notes.

In order, first of all, to assist the ear to perceive the more pronounced discontinuities, we introduced into the circuit of the machine a telephone of the kind used by E. Wiedemann and Ebert for similar experiments. As was to be expected, the telephone was silent during illumination, and only after its cessation did the strong note accompanying the restored brush discharge set in. But still the discharge might have been discontinuous, if its frequency exceeded the limits of audibility or the resonance capacity of the telephone diaphragm.

To discover discontinuities of current of very small period, we employed the arrangement shown in the figure. An ebonite tube about 6cm. long is provided at both ends with metal tips A and B, and may be slipped with friction along a pole rod of the machine. An insulated copper wire 0·2mm. thick is wound to the extent of several hundred turns upon the tube in several layers separated by oiled silk, and the ends of the coil are attached to A and B. From these points two wires, C and D, lead to a small silvered glass strip G, the metallic coating of which is divided into two separate portions by the diamond cut $x$, as in Righi's resonators. The contact between the silver and the wires C and D is made secure by a small piece of gold leaf. If, now, the tube is mounted at A upon the pole-rod in such a manner that it only projects slightly into the interior, and the knob is mounted upon B by means of a suitable cylindrical piece of metal, every continuous discharge will take place through the wire coil, and the gap in the silver coating remains dark. But as soon as discontinuities or current surgings take place, the self-induction of the coil increases to such an extent that sparks appear at $x$.

After the little apparatus is arranged on the positive-pole rod, the zinc cathode is illuminated with magnesium light, and the machine is worked. As long as the light lasts, no sparks appear at $x$; but they appear at once, together with the sparks and brushes at the anode knob, as soon as the illumination is interrupted. The




gap $x$ is widened by corrosion to such an extent that the sensitiveness of the vibration indicator is much diminished. It is, therefore, necessary to insert a freshly-prepared Righi plate before each experiment.

The experimental result would, therefore, not be in the way of the supposition that under the influence of light the discharge of the machine passes into a continuous one. We may, at all events, conclude that the duration or the amplitude of the alternations are so small that they escape observation, even by the means specified. But are we to suppose that this new form of discharge consists solely in the photo-electric transference of negative electricity from the zinc cathode to the anode? This supposition appears questionable if we consider how small are the quantities of electricity transferred in air under atmospheric pressure in this manner. It may therefore be expected that the photo-electric dissipation taking place at the cathode also changes the form of the discharge at the anode, so that a practically continuous discharge takes the place of the sparks and brushes. Such a discharge can among known types only be represented by the glow discharge.

Since the magnesium light must only impinge upon the cathode surface, a possible glow process at the anode might perhaps be directly observed with suitable screens against the brilliant light. And in fact, on screening the eye and observing the anode sphere, also in the shadow, against a black background, it is seen that as soon as the zinc cathode is illuminated the brushes and sparks are replaced by a violet glow. The glow is the stronger the smaller the anode knob. Sometimes it remains for some time after illumination has ceased.

The experiment is facilitated by employing, instead of the magnesium, a flame of carbon bisulphide blown with oxygen. It is known that this is very rich in short-wave rays, and it does not blind the eye. It is, therefore, possible to observe conveniently the change in the form of discharge when the rays are allowed to reach the zinc surface; but the flame must be used with good ventilation arrangements, otherwise the sulphurous acid formed will soon stop the activity of the machine.

It is further remarkable that the change in the character of the discharge only occurs when the anode is actually hit by the electrified gaseous particles streaming from the cathode. If during illumination a perforated glass plate or a sheet of paraffined paper provided with a small hole is introduced between the anode and the cathode, brushes and sparks are at once formed at the anode. But a wire net put to earth and introduced between anode and cathode does not interfere with the photo-electric glow light. It must therefore be assumed that the electrified gas particles proceeding from the cathode go through the meshes of the net without quite parting with their charges. This result is quite in accordance with older experiments of W. Giese and later ones of Lord Kelvin. About the experimental arrangement we must remark that the wire net must be mounted in a metallic ring without any external projections from which brushes might issue to the neighbouring terminals of the machine.

An analogy is easily suggested with the process employed by Holtz* in order to produce and maintain a glow discharge. According to this investigator, the glow between the anode sphere and the cathode surface may be brought about by covering the latter with a layer of silk or several layers of tissue paper. This covering, we may suppose, has the effect of starting the discharge at the electrode at many points simultaneously, and thus distributing it over a large surface; but the very same must take place when the zinc cathode is illuminated by ultra-violet light.

The increase in the resistance of the air-space cannot be deemed surprising after the change in the character of discharge caused by the light is made plain. It is, indeed, not to be expected that under similar circumstances the various kinds of discharges transfer equal quantities of electricity. But in order to leave no further doubt on the question we made two further experiments apart from the introduction of a spark gap in parallel. We introduced an insulated Lane unit jar between the machine and the amalgamated zinc plate, while the positive terminal knob was placed opposite the latter at the distance of several centimetres. When the machine was worked and the condensers removed, a brush discharg eappeared at the gap, which disappeared in the light. At the same time, the machine being worked at a uniform rate, the discharge of the unit jar in equal times could be counted in the light and in darkness. It was observed that they took place somewhat more slowly during the illumination of the cathode, *i.e.*, that in the light during glow discharge, less electricity passed through the air-space, than in darkness through the brush discharge. From this it further follows, that in the light the difference of potential of the electrodes must increase. We showed this to be the case directly by means of a small cork pendulum mounted upon the electrodes with the aid of a rod ending in a sphere. During illumination of the cathode this gave a slight increase of potential, accompanied by a disappearance of the brush, more pronounced at the negative than at the positive pole.

Thus the glow of the anode produced by light gives less transference of electricity than the brush discharge in the dark. The question occurs at once whether, as indicated above, this only implies a difference between the two forms of discharge independent of light. The decision is made difficult by the circumstance that, without charging the electrodes or using light, the forms of discharge cannot be transformed the one into the other. But we may take it as probable that the question must be answered in the affirmative. For if the anode is a sharp point, which results in a glow discharge occurring in the dark, no difference in the resistance of the air gap is brought about by illumination. From this we conclude than an increase of resistance does not take place independent of the form of discharge. We had already in our previous communication mentioned that an existing glow discharge is not affected by light.

The chief results of the experiments described may be summarised as follows:—

The brushes and sparks of a Holtz machine passing between a cathode plate of amalgamated zinc and an anode sphere of any metal are replaced by a glow discharge when the cathode is illuminated by short-wave light. This glow discharge, during illumination, transfers a smaller quantity of electricity than do the brushes and sparks in the dark.

Wolfenbüttel, January, 1896.

## BOOKS RECEIVED.

"Notes on Motor Carriages." By J. H. Knight. (London: Hazell, Watson and Viney.) 1896.

"Anuario de la Mineria, Metalurgia y Electricidad de Espana." By Don Roman Oriol. (Madrid: Establecimiento Tipografico de E. Teodoro.)

"The Old Light and the New." By Wm. Ackroyd. (London: Chapman and Hall, Limited.)

"Der Drehstrom Seine Erzeugung und Anwendung in der Praxis." By Josef Krämer. (Jena: Hermann Costenoble, 1896). 15s.

* Carl's Report, 17, p. 402, 1880.

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## AN INTERESTING ELECTRIC LIGHT PLANT IN COLORADO.*

The electric lighting plant of the Citizen's Electric Light Company at Leadville, in Colorado (10,000ft. above the sea level), is thoroughly representative of the latest modern practice in electric lighting. It is one of the first in America in which the principle of direct connection has been exclusively adopted, and one of the first also operating a very extensive public arc lighting system from incandescent circuits.

*Boilers and Engines.*—The station occupies a fireproof brick building with iron trussed roof. The boilers are three in number, 60 by 16ft., horizontal tubulars of 85 H.P., and are designed for a working pressure of 140lb. Space is left in the boiler room for an additional battery of three boilers. The smokestack is of steel, 4ft. 8in. in diameter and 90ft. high, set up on four iron columns. Two sets of duplex pumps, each pump of sufficient capacity to operate six boilers, and one feed water heater complete in boiler-room equipment. The three 85 H.P. Lake Erie engines are vertical cross-compound, with cylinders 7½in. by 13in. by 14in. Directly connected to each of the engine is a 50-kilowatt General Electric generator running at 275 revolutions per minute. The third engine has two 25-kilowatt generators of similar type, one on each end of the shaft, running at 300 revolutions. These generators are compound-wound 125-volt multipolar machines, with ironclad armature. During the first two months of the operation of the plant the overload on these dynamos daily ran up to from 25 to 40 per cent. without appreciably heating, while since December, 1895, according to the manager of the station, there has not been a night that all the dynamos have not carried an overload of from 10 to 20 per cent. without experiencing any difficulty.

*Switchboard.*—The switchboard is of the panel type, 13ft. long by 5ft. high. It is placed well away from the wall to give free access to the back. The conductors are brought to it under the floor and the switches and circuits are so arranged that any dynamo may be operated in conjunction with any other one or more, and on either side of the three-wire system. Two sets of feeders run from the board, and in the event of breakdown on one set the other may be called into requisition.

*Distribution.*—The plant is operated on the three-wire system, current being supplied to both arc and incandescent lights and motors. One engine, with the two 25 kilowatt dynamos, is designed to carry the night load from 2 to 5 a.m., the others being cut in as the demand for current requires. By having the generating units thus properly proportioned to the load and capable of being started and stopped at will, great economy of operation is gained, which would not be obtainable by the employment of one or two larger engines. Actual tests on the units installed at this plant showed over 82 per cent., delivered at the dynamo terminals.

The district covered by this system is a little over a mile square, and the lamps at present connected amount to an equivalent of 4,000 of 18 c.p. There are about 120 arc lamps of the new Thomson type, which have given excellent satisfaction. The circuits throughout the city are divided into sections, each of which is protected by proper safety devices, so that any trouble occurring on a section will affect that section only.

The main supply circuit consists of an endless circuit, making a complete enclosure. From this circuit are run the branch circuits supplying consumers east and west. This main circuit is fed at four symmetrical points by the two sets of feeders previously mentioned. The mains consist of three No. 0000 wires. The branches vary in size from No. 4 to No. 0000 wires, with a No. 000 for the neutral. The other feeder consists of five No. 0000 wires.

Since the first month of the operation of this plant the station has been running above its capacity, and business has been turned away. The installation of the fourth dynamo relieved the station but temporarily. The Company started by supplying current at a flat rate, intending gradually to introduce meters. The majority of consumers now have meters, and the load is gradually falling off, although the income is about the same; this shows the advantages of operating on the meter basis.

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**A Telegraphic Girdle Round the Earth.**—A telegraphic message was despatched from the Electrical Exhibition now being held at New York, and, after making a double circuit of the globe, it returned to its starting-place, the time occupied being 50 minutes. President Chandler, of the Postal Telegraph Department, sent off the message, and Mr. Edison, sitting at the same table, received it.

* Abstract from the *Electrical Engineer* of New York.

## LONDON COUNTY COUNCIL.

At Tuesday's meeting the report of the Highways Committee containing the proposals of the Tramway Syndicate to lease the whole of the tramways from the Council and substitute electric traction, and the further proposals of the North Metropolitan Tramway Company to sell their undertaking to and subsequently lease them from the Council, came up for discussion.

Earl RUSSELL (in the absence of the Chairman of the Committee) formally moved the adoption of the report. He said he did so on the understanding that a sort of undertaking had been given that the merits of the question should not be discussed that day. An amendment had been moved to the recommendation of the Committee regarding the proposals of the Tramway Syndicate, and the Highways Committee thought it desirable that the discussion should take place on that as apart from the merits of the proposal of the North Metropolitan Tramway Company.

Mr. HOARE (Chairman of the Finance Committee), moved as an amendment "That the Syndicate's proposal be referred to the Finance Committee with instructions to consider and report as to their financial bearing." He said if the amendment was agreed to the Committee would confine themselves strictly to the bearing of the scheme on the financial position of the Council.

Ultimately, however, a motion to adjourn the discussion was agreed to.

The Bridges Committee brought up their proposal to construct a tunnel under the Thames from Millwall to Greenwich, referred to in our last issue, but the discussion of the subject was postponed.

The Works Committee recommended that the rate of pay for electric wiremen be increased from 8d to 9d. to 8½d. to 9½d. per hour, and this was agreed to.

The Chairman of the Highways Committee was asked by Mr. EMDEN when a report would be submitted in reference to the Council constructing subways; and by Mr. THOMPSON if there was anything to report with reference to the fire which took place in the subway at Northumberland-avenue the previous day.

EARL RUSSELL, in reply, said that nothing had been done with regard to subways at present. With respect to the fire in Northumberland-avenue, he was informed that it arose owing to some accident to the two electric wires in the Council subway. The wires became fused.

The consent of the Council was given to the making, by the Post Office, of a 1½in. pipe connection with the telegraph wires in Northumberland-avenue subway.

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## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May 8, 1896.*

**The National Electrical Exposition.**—At eight o'clock on the evening of Monday, May 4th, the National Electrical Exposition was opened in this city amid great enthusiasm. Governor Morton, of New York State, touched a golden key which turned on the current and set all the machinery in motion, at the same time turning on a blaze of light from thousands of lamps scattered throughout the hall. He stood in a framework of vacuum tubes, which also became illuminated at the moment he touched the key. The vacuum tubes were those of Mr. Macfarlan-Moore used in his system of "etheric" lighting, which has already been fully described in the electrical journals. Current from Niagara supplied the power for the illumination of miniature lamps used on the model of the Niagara Falls power plant. There were 8,000 people present during the opening evening, and since that time the Exposition has been very largely attended day and night. As has already been stated, the exhibition will continue through the month of May. The exhibits are very complete and well arranged, and everything in the electrical line is shown to the best advantage. The various historical exhibits attract much attention, and the working exhibits afford an excellent opportunity for the study of the different machines.

**The Nineteenth Convention of the National Electric Light Association.**—This Association met in the Exposition Building on May 5th, and the Convention continued for three days, adjourning on Thursday evening. It was a very successful meeting and was largely attended by the representatives of central stations throughout the country. While some excellent Papers were read, the standard was perhaps a little below the average. One of the most interesting Papers read was that on "The Commercial Value of Acetylene Gas," by Mr. L. A. Ferguson. Mr. Ferguson gave some figures on the cost of production of calcium carbide from which acetylene gas is produced. He also showed the cost per kilowatt hour, and that it would be

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cheaper for central stations to utilize their energy in the daytime at lower rates than to use it for the production of calcium carbide. He stated the central station men need have no fear of acetylene gas, as under the most favourable conditions the cost of production of the gas is so much higher than that of electricity that there was no danger of acetylene encroaching on the electric light field or affecting the dividends of central stations. Mr. John F. Kelly read a Paper entitled, "The Evolution of the Inductor Alternator," and Mr. W. L. R. Emmet read one giving the results accomplished in distribution of light and power by alternating currents. "Steam Boilers, their Equipment and Management," was the title of an excellent Paper by Mr. Albert A. Cary. Other Papers of equal importance were read and well received. The social features of the convention were many. On the evening of May 5, Mr. Max Osterburg gave a lecture on "The Röntgen Ray," and on the next evening Mr. D. Macfarlan-Moore gave one on the subject of "The Light of the Future," which title he applies to his system of vacuum lighting. On Thursday night a large party, by invitation, visited the works of the Crocker-Wheeler Electric Company, at Ampere, N.J. A special train was chartered, and the crowd was so large that ten cars were required to carry the visitors. The works were thoroughly inspected.

**Honour to a Canadian.**—In connection with the Electric Light Association Convention it will be interesting to English people to know that a Canadian was elected as President for the ensuing year. This gentleman is Mr. Frederic Nicholls, who is closely indentified with electrical interests in Toronto, Canada.

## CORRESPONDENCE.

### ALTERNATING ARCS AND WAVE-FORMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With great interest I have read your editorial in the issue of May 1, 1896, on Mr. Frith's Paper on "Alternating Arcs." It seems to me, however, that the historical sketch given by you therein is rather incomplete.

In 1890, in a Paper read before the American Institute of Electrical Engineers by Messrs. Tobey and Walbridge, and published in the *Transactions* of 1890, p. 367, it was shown that the Stanley arc machine, when feeding a non-inductive or an inductive circuit, *i.e.* series incandescent lamps or a solenoid, gives practically sine waves of current and of E.M.F. If, however, alternating arcs, from 1 to 40, were inserted into the circuit, the E.M.F. wave changed to the most exaggerated form of a flat-topped wave—that is, a sharp double peak with deep hollow between (*see* illustrations *Transactions* American Institute of Electrical Engineers, and *Electrotechnische Zeitschrift*, 1892, p. 567), while the current remained practically a sine wave. A very satisfactory explanation of this phenomenon was given in the discussion by Prof. Pupin, in the periodically varying resistance of the arc, which is extremely high at or near the zero value of current, low near the maximum value.

The above mentioned machine was designed for series arc lighting by constant alternating current, thus of very high internal reaction, and therefore the current wave remained fairly sinusoidal while the E.M.F. wave changed. Inversely, with a machine of very low internal reaction, the E.M.F. wave would remain practically unchanged, and the current wave be distorted to single peakedness, that is, to the shape undesirable for arc lighting. An interesting result of this distortion was observed for the first time in the above-mentioned Paper, consisting in the appearance of a discrepancy between volt-amperes and watts, that is, of a power factor in the alternating arc without a displacement of phase, as discussed in *Electrotechnische Zeitschrift*, 1892, pp. 460 and 567.

Thus to conclude, it cannot be said that the alternating arc modifies the wave shape so as to be the best suitable, but rather that it introduces a discrepancy between the current wave and E.M.F. wave, resembling a very high apparent resistance of the arc at or near the zero value of current, and a low apparent resistance during high values of current, and thereby tending to distort the E.M.F. wave towards double peakedness and flat top, or the current wave towards single peakedness and flat zero, the former distortion being predominant in generator circuits of high internal reaction, the latter in circuits of low internal reaction.—Yours, &c.,

CHARLES PROTEUS STEINMETZ.

### THEORY OF THE SECONDARY BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been greatly interested by your Editorial Notes this week on the theory of secondary batteries, and with reference to them I should like to point out that you are not quite correct in the statements made in your third paragraph as to there being no "hydrate" theory in existence before 1892.

If you will refer to *The Electrician* for April 1, 1887, you will see that the "hydrate" theory is there described in a letter written with reference to Mr. Fitzgerald's tests of his lithanode plates. Since that date I have made a vast number of experiments on all types of lead batteries, but have never arrived at any result which would cause me to alter the views then expressed.—Yours, &c., H. W. BUTLER.

4, Great Winchester-street, London, May 19, 1896.

### PHOTOGRAPHY OF LIGHTNING FLASHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I enclose a photograph of a flash of lightning which I have just received from a friend in Buenos Ayres, who writes under date March 25, 1896, "I thought you might be interested in one of the enclosed photos, which I was lucky enough to get, of a splendid flash of lightning not long ago;

it might be of use to some scientific man." He, however, does not say whether the negative was taken with a hand camera or not, but I judge this was the case.

Can it be that each of these fine lines represents a distinct oscillation of the discharge? And is the ribbon appearance of three of them due to halation of the plate? It will be noticed that the apparent spiral striations of the broader bands are in alternate directions in each. Perhaps some of your readers can throw some light upon this.—Yours, &c.,

Bexley, Kent, W. G. LITTLE.
May 7, 1896.

### FUNDAMENTAL MAGNETIC UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have just seen a copy of your paper for April 24th, in which is printed my article on "Fundamental Magnetic Units."

I do not think it is hard to obtain a conception of the axis of a magnet without the use of "magnetic fluids." The direction of a uniform field is that which a *thin* magnet needle magnetised in the direction of its length assumes when freely suspended in the field. The axis of a magnet is that direction in the magnet which coincided with the direction of the field when it is freely suspended. Perhaps this looks a little like reasoning in a circle, but the conception of a thin magnet

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does not seem very hard to obtain; in the earth's field such a needle points north. I believe the terms "broadside on" and "end on" are used quite commonly to indicate the orientation of the deflecting magnet in the second and first position of Gauss. In any case, the meaning to be attached to these terms can be seen in the definition of unit magnetic moment, which immediately follows them in the article.

I presume that the most scientific way of attacking magnetism in accordance with modern views would be to study the polarisation of the whole of space, both within and outside the magnet. I fancy, however, that it would be hard to frame a definition of the unit of polarisation that would bring the new system of units into numerical harmony with those now in use. This is certainly one advantage of the unit magnetic moment.—Yours, &c., H. N. ALLEN.

Nebraska, Lincoln, U.S.A., May 8, 1896.

## ELECTRIC MINING PLANT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I note in your issue of March 27th that the *Financial News* of 24th of that month is quoted as having stated, on the authority of the directors of Moodie's Fortuna Gold Mining Company, that electric power has not proved suitable for running their battery. As engineer in charge of Moodie's transmission plant, I beg to inform you that the facts of the case have been by no means correctly represented. The consulting engineer to the Fortuna Company has expressed a most favourable opinion as to the suitability of electric motors for battery running, and has, in fact, as manager of a neighbouring mine, been able to declare a dividend by the use of power derived from the same source as that which supplied the Fortuna Company.—Yours, &c.,

Moodie's, Barberton, S.A.R., April 24, 1896. H. J. S. HEATHER.

## ELECTRIC TRANSMISSION AT ROMAGNANO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Our attention has been drawn to an article in your current issue taken from *l'Elettricista* of a few months back, describing the electrical transmission of power for the Vonwiller paper mill in Romagnano.

We would remark that the word "alternations" is likely to be misunderstood. The frequency employed in this installation is our normal one of about 12 complete periods per second (∿).

Further, in the remarks on the motors you give 7 per cent. as the drop of speed from synchronism at a load of 10 per cent. more than normal, whereas this is the total drop, which has to be shared between the turbine regulators and the motors, which latter have a drop of not more than 3 per cent. at this load.

As these points are of some importance a correction would oblige.—Yours, &c., BROWN, BOVERI AND CIE.

[We regret the occurrence of the error mentioned by Messrs. Brown, Boveri and Cie. in the article referred to. Our correspondents are, however, in error in attributing the source of the article to "*l'Elettricista* of a few months back." The article was sent to us by a foreign contributor, and would, of course, have been acknowledged in our usual manner had we taken it from the columns of a contemporary. —ED. *E.*].

## HORSELESS STREET BILL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As one of the earliest workers in the horseless carriage movement, and as the only person who has had the practical experience of running a horseless vehicle upwards of 5,000 miles through the traffic of London streets, I should be glad of this opportunity of expressing, on behalf of all those interested in this immense industry which is now looming on us, our grateful acknowledgment to the Right Hon. H. Chaplin, the Government and Lord Harris for the great attention and care—having due regard to all the interests involved—that has been taken by them in removing the obstacles that have hitherto stood in the way of horseless vehicle traffic. I do not think that this momentous epoch in this great question should be allowed to pass without also some acknowledgment of the services rendered in connection with this matter by one who has represented the London Chamber of Commerce, and has also been specially able to speak on behalf of the electrical section of the horseless carriage interest which will have most to do with street and town traffic, as opposed to country road work. I refer to Major S. Flood Page.—Yours, &c., RADCLIFFE WARD.

# PARLIAMENTARY INTELLIGENCE.

On Tuesday and Wednesday the Kidderminster and Stourport Electric Tramway Bill was under the consideration of a House of Commons Committee. The Bill sought for powers to construct and work an electric tramway four miles long between Kidderminster and Stourport, at an estimated cost of between £30,000 and £40,000. The point in which the Bill differed from its predecessors was in the fact that it was the first electric tramway venture which sought to cross the line of a railway company by means of a level crossing, and upon these grounds, amongst others, the Bill was opposed by the Great Western Railway Company only. Mr. Pollock, Q.C., on behalf of the opposition, contended that the passage of an electric line over their system by means of a level crossing would seriously interfere with the working of the Great Western Company's system. Earth currents would greatly inconvenience the working of their telegraphic system, and would be accompanied even with danger to the travelling public. Mr. Lewis Coward, Q.C., opposed this contention, and argued that the passing of an electric tram by means of a level crossing would be attended with no more inconvenience or danger than would be the disarrangement caused by an ordinary thunderstorm. Mr. Coward, however, did not strongly press this point, but urged that the Railway Company should, under the provisions of their original Act, erect a bridge at the point in dispute. The Council after considerable deliberation decided that the preamble of the Bill was proved, but required the insertion of a clause arranging for the construction of a bridge over the Railway Company's line in place of the proposed level crossing, £750, or about a quarter of the cost at the option of the Board of Trade, to be borne by the Tramway Company, who will also be called upon to bear the cost of such additions or alterations in the metallic circuits of the Railway Company as the Board of Trade may consider necessary to prevent interference with the signals and apparatus of the Company.

# TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition o "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Hand book is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged is quite up-to-date, and includes the new Board of Trade Regulations.**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated; price 12s. 6d. Will be ready first week in June.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

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"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

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TENDERS INVITED.—The Corporation of Leeds require tenders for an electrical installation sufficient for working by the overhead system on a double track of tramway seven miles in length. The work is divided into seven contracts, details of which will be found in our advertisement columns. Tenders have to be sent in to the Town Clerk, Town Hall, Leeds, not later than June 20th, and particulars, plans, &c., can be obtained from the City Engineer, Municipal Buildings, Leeds, or from Dr. John Hopkinson, F.R.S., 5, Victoria-street, Westminster, London, S.W.

——— The Hammersmith Vestry invite tenders for the erection of (*a*) an engine and boiler house, offices, &c., and (*b*) a chimney shaft 140ft. above footings. Tenders must be sent in to the surveyor (Mr. H. Mair), Vestry Offices, 57, Fulham Palace-road, Hammersmith, S.W., by the 27th inst.

——— The Aberdeen Town Council require tenders for supplying and erecting boilers, feed water heater, pumps and piping at the electricity works. Tenders to the Gas and Electricity Office, Town House, Aberdeen, by 10 a.m., 27th inst.

——— The Bradford Corporation invite tenders for the works required in the installation of electric lighting at Cliffe-road destructor works. Tenders must be sent to the Town Clerk, Town Hall, Bradford, by the 2nd prox.

——— The Oldham Corporation invite tenders for the supply of a jet condensing plant. Tenders to the Town Clerk, Oldham, by the 26th instant.

——— The Netherlands Minister of the Colonies invites applications for the supply of galvanised telegraph wire. Tenders to the Ministry, The Hague, by the 27th inst.

——— The State Small Arms Authorities at Spandau require tenders for the supply of 27,300 arc lamp carbons. Tenders to the Königliche Direktion der Gewehrfabrik, Spandau, Germany, by June 12th.

TENDERS ACCEPTED.—The Sunderland Town Council have accepted the tender of Messrs. John Hargreaves and Co., Rawtenstall, for the supply of an evaporative tubular surface condenser, with air and circulating pumps, for the electricity station.

——— The Lighting Committee of the Brighton Corporation have decided to recommend the acceptance of the tender of Messrs. Skeats and Co. for supplying 450 lanterns for incandescent electric lamps for £180.

——— The Portsea Guardians have accepted the tender of Mr. J. R. Penning, of Southsea, for wiring part of the workhouse for the electric light for £52. 10s. Tenders ranging from £44. 15s. to £113 were received.

——— It has been announced that the tender of the Brush Company has been accepted by the Hampstead Vestry for the supply of steam and exhaust pipes and feed water heater for their electricity supply station. We are asked to state that this is an error, the order having been placed with Wright's Patent Heater Condenser Company, of Westminster, London, the tender including the supply of Berryman heaters with special gear for cleansing, and the amount of the tender being £967.

——— The contract for the erection of the building for the Corporation Electricity Supply Works has been given to Messrs. Holme and King, of Liverpool, at £8,000, and the tender for erecting the chimney shaft has been let to Mr. Wm. Thickett, of Horbury, Wakefield, at £2,500.

SALE BY AUCTION.—Particulars will be found in our advertisement columns of the disposal by public auction by Messrs. Wheatley Kirk, Price and Goulty, on Tuesday, June 2nd next, of the entire contents of the late lighting station of the Reading Electric Supply Company (Limited), situated in Thorn-lane, Duke-street, Reading, Berks. The sale of this plant, &c., is taking place owing to the Company having completed their new central station. It will be seen that the sale includes two Babcock-Wilcox boilers, steam engines by Browett and Lindley, Alley and Maclellan, and Greenwood and Batley, Thomson-Houston dynamos, and a quantity of useful electric plant and apparatus, instruments, &c. Catalogues can be obtained from the auctioneers, or direct from the Reading Company.

BUSINESS FOR SALE.—From our advertisement columns it will be seen that private offers are invited for the business of electrical engineers and manufacturers lately carried on by Messrs. Morris Bros. (Limited), at Birmingham. Offers should be sent to the liquidator, Mr. E. J. Abbott, 9, Bennett's-hill, Birmingham.

APPOINTMENTS VACANT.—The Corporation of Lincoln, who intend to establish electricity supply works, invite applications for the position of electrical engineer. Salary £300 per annum. Applications must be sent in to Mr. H. K. Hebb, Clerk to the Urban Sanitary Authority and Deputy Town Clerk, by Saturday, June 6th. Some additional particulars are given in our advertisement columns.

——— The Municipal Technical Institute of the Borough of Salford invite applications for the post of (1) Chief Lecturer in Chemistry (salary £200); (2) Chief Lecturer in Dyeing (£150); (3) Art Master (£220); (4) an instrument maker (£2 per week). Some further information is given in our advertisement columns, and all particulars can be obtained of the secretary at the Institute, Peel Park, Salford.

——— There is a vacancy for an assistant electrical engineer at the Bolton Corporation electricity works. Applications to the Town Clerk, Town Hall, by Wednesday next, the 27th inst.

APPOINTMENT.—Mr. S. J. Ross has been appointed by the Hackney Vestry engineer and electrician at the public baths. The salary is £156 per annum.

DISSOLUTIONS OF PARTNERSHIP.—The partnership business of electricians hitherto carried on by Messrs. H. Patterson and G. J. Harford, under the style of Patterson and Harford, 49, Moorfields, Liverpool, has been dissolved. Debts by Mr. G. J. Patterson who continues the business under the old title.

——— Messrs. Edgar Isaac Everett and Charles William Brown, trading as electricians and engineers under the style of Everett and Brown, at 11, Albemarle-street, Clerkenwell, London, have dissolved partnership.

REMOVAL.—The London offices of the Chloride Electrical Storage Syndicate (Limited) have been removed from 16 to 39, Victoria-street, Westminster, S.W.

LIQUIDATIONS.—At a meeting of the proprietors of the Nalder and Harrison Construction Syndicate (Limited) on the 11th inst., it was decided to wind up the Syndicate voluntarily. This resolution was confirmed on the 27th ult., when Messrs. N. F. Nalder, J. A. McMullen, J. G. M. Hilton, and K. J. McMullen were appointed liquidators. As announced in our issue of the 8th inst., a new firm has been established to carry on the businesses of the Nalder and Harrison Construction Syndicate (Limited) and Messrs. Swinburne & Co. (Limited), under the style of Nalder and Hilton.

——— A meeting will be held at 137, West Regent-street, Glasgow, on June 17th, at noon, to receive an account of the winding up of Clark's Electric Launch Company (Limited).

THE GÜLCHER COMPANY'S AFFAIRS.—The creditors and contributories of this Company are notified that a meeting is to be held at 73, Lombard-street, London, at noon of the 26th inst. for the purpose of receiving from the voluntary liquidator an account of the Company's affairs in the winding up, and to consider an offer which has been made from the holders of Second Debentures. The report of the liquidator holds out no hope of any dividend for the holders of Ordinary or Preference shares or for the ordinary creditors, there being less than sufficient funds to discharge the ordinary costs of the liquidation.

WOODHOUSE AND RAWSON UNITED (LIMITED).—We have received a lengthy document from the directors of "The Manchester Electrical Works, Limited (successors to Woodhouse and Rawson)," which is in reality an invitation to the shareholders and creditors of the old firm to apply for shares in the new Company, described as having a capital of £50,000. Accompanying this document is a lengthy account of a meeting "of some of the principal shareholders of Woodhouse and Rawson United (Limited)," held in April last in response to a circular sent out by Lieut.-Col. N.

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Willoughby Wallace, who was voted to the chair on the occasion. Col. Wallace described himself as one of the original shareholders in the Woodhouse and Rawson concern, and as a number of his friends had, on his instigation, taken shares in that Company, he felt desirous that some of the assets should, if possible, be saved. Inquiries showed him (Col. Wallace) that a contract had been made by Mr. F. L. Rawson with Mr. Leslie, the Receiver, to purchase the Manchester works, and also the supply business carried on at 88, Queen Victoria-street, London, together with the industrial patents and the goodwill of the business. These are described as being the two departments of the old Company which paid, and Col. Wallace considers that it will be worth the while of shareholders and creditors to retain and carry on this branch of the business themselves, together with the "financial patents" which have (according to Col. Wallace) also been purchased by Mr. Rawson, and have been handed over to a concern called the "Industrial Inventions Development Company (Limited)." It appears that Mr. Rawson is quite willing to hand over his purchase to the shareholders at the "actual cost," and Col. Wallace considers it will be well to take advantage of the offer. The Manchester works are described as being well organised and equipped, and, in addition to their own plant, possess the best tools from the London works. Col. Wallace further pointed out that it was extraordinary that nothing had been done (since the expiry of the Edison patent) with the Woodhouse and Rawson incandescent lamp, which he considered should now be taken in hand and pushed vigorously. One of the proposed new directors of the Manchester Company had negotiated for its manufacture abroad, and it was anticipated that a ready demand would be created in England for large quantities of the lamps at a low price. It was proposed to retain the services of Mr. Bertram Thomas, the manager at the Manchester works of Woodhouse and Rawson United (Limited), and a special clause was to be inserted in the Articles of Association of the new company binding the Directors "to do no outside financial business, and to confine the Company's operations to industrial business"! Mr. Thomas, who was present at the meeting, is stated to have read a lengthy report, which had been prepared some time previously, and in which figures were given showing that a new company, working with the old Company's tools and making similar goods, would have reasonable chances of success. He recommended the preparation of a new catalogue and the appointment for London of a good agent, acquainted with the customers of the old Company. The meeting, it is stated, carried a resolution that Col. Wallace and Messrs. D. E. Cardinall (a Director of a large Manchester brewery), and W. Pirrie (of Pirrie, Hope and Co., Newcastle), should be elected as the first Directors, at a remuneration of £100 for the first year. The final resolution of the meeting was:—"That a Company be formed, with £50,000 capital, to take over the Manchester works and the supply business of Woodhouse and Rawson United, and that the shareholders and creditors of Woodhouse and Rawson United have the right of applying *pro ratâ* for the first issue of £10,000 of such capital, with a minimum of £10."

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from May 13th to May 19th, with the ports of destination:—

*Argentina*—Buenos Ayres, £100. *Australasia*—Adelaide, £15; King George's Sound, £799 (electric lighting apparatus); Launceston, £74; Melbourne, £171; Newcastle, £1,458 (electrical mining machinery); Sydney, £1,855 (including £1,050 telegraph cable). *Austria*—Trieste, £6. *Belgium*—Antwerp, £107. *Ceylon*—Colombo, £206. *Denmark*—Copenhagen, £58 (telegraph wire). *Holland*—Amsterdam, £50; Flushing, £43. *India*—Calcutta, £20. *Italy*—Spezia, £110. *Russia*—St. Petersburg, £1,342 (including £694 telegraph material). *South Africa*—Cape Town, £72; Delagoa Bay, £81; Durban, £63. *Sweden*—Gothenburg, £152 (telegraph material); Malmo, £5.

"LONDON."—Many of our readers will be interested in the "London Manual" for 1896-7, which is issued by the proprietors of *London*, 125, Fleet-street, E.C. Particulars are given of the constitution of the various local bodies which govern the metropolis, with their officials, and statistics regarding the committees and departments of these controlling bodies are included in the 260 pages of which the books consists. The published price is 1s.

SCOTLAND.—We last week referred to the Guide issued by Mr. MacBraine for the use of those intending to spend a holiday in Scotland. We have now to acknowledge the receipt of an extremely useful handbook, entitled "Mountain, Moor, and Loch," illustrated by pen and pencil on the route of the West Highland Railway. This is a second edition of the work, which contains 230 illustrations from original drawings made on the spot. Particulars of the principal show places on the West Highland Company's system are given, and the book should be in the hands of all who intend making Scotland their holiday resort for the coming season.

AMSTERDAM.—The British Consul at Amsterdam states that the Council of that town have come to an arrangement with the Telephone Company for the transfer of their undertaking on the expiry of their existing concession. The acquisition of the local tramways is also being considered, a vote in favour of purchase having already been passed by the Council, and just at present there appears to be a strong opinion in favour of the municipalisation of all public undertakings.

AYR.—The Town Council have received the sanction of the Secretary for Scotland for borrowing an additional sum of £5,000 for electric lighting purposes, bringing the total authorised up to £25,000.

BATH.—A special meeting of the Urban Sanitary Authority has been convened for to-day (Friday) to discuss the report of the Electric Lighting Committee recommending that application be made to the Local Government Board for permission to borrow £15,000 for the purchase of the City of Bath Electric Lighting and Engineering Company's undertaking, for providing capital for extensions of the mains and for defraying expenses incurred in obtaining a Provisional Order.

BURTON-ON-TRENT.—The infirmary is to be wired for the electric light. Current will be taken from the Corporation mains.

CALCUTTA.—A proposal for the establishment of electric light works in this city and for introducing electric traction on the tramways has been referred to the Indian Government. The question at issue is as to the employment of overhead wires.

CANTERBURY.—The City Council intend to erect a refuse destructor plant in conjunction with their electricity supply works, and have decided to borrow £20,000 for that purpose.

CHESTER.—The ceremony of laying the foundation stone of the electricity supply station was performed on Tuesday last by the Mayoress, Mrs. B. C. Roberts.

CHURCH LIGHTING.—St. Andrew's Presbyterian Church, Ealing, is now lighted electrically. The installation has proved successful and has given great satisfaction.

COLLIERY LIGHTING.—The electric light is to be employed in the workings and at the pitheads of the Hunter and Derwent Collieries at Medomsley, Durham.

EALING.—The electricity department of the District Council at present have orders on hand for an equivalent of 7,175 8 c.p. lamps, and 6,036 of these have been connected.

GLASGOW.—The Electric Lighting Sub-Committee have decided to send a deputation to Birmingham, Manchester and London for the purpose of inspecting and reporting on the systems of electric lighting employed in these cities.

GUILDFORD.—The Board of Trade have forwarded to the District Council a letter from the Guildford Electricity Supply Company, asking to be allowed to make an immediate start on the laying of the electric light mains. The Company state that 979 £5 shares have been allotted, and promises are in hand to take 100 more. The Council's consent will be given as soon as the Company submit a plan of the streets in which they propose to lay the mains.

ISLINGTON AND CITY ELECTRIC RAILWAY.—A House of Commons Select Committee has passed the preamble of the City and South London Railway Company's Bill for an extension of time until August, 1901, for constructing their line to Islington.

LEEDS.—The Yorkshire House-to-House Electricity Company have written to the Town Council offering to supply the necessary electrical energy for working the tramways.

LIVERPOOL.—Arrangements are being made for the completion of the purchase and transfer of the Liverpool Electric Supply Company's undertaking on July 1st.

LLANFAIRFECHAN (CARNARVON).—The new Convalescent Home, erected by Messrs. Heath, of Walsall, is to be lighted electrically.

MANCHESTER.—The accounts for the past year's working of the electricity department, which will shortly be submitted to the City Council, show a profit of over £11,000, against £5,500 for the previous year. It is stated that the demand for electric current has exceeded all anticipation, considerable extensions being in progress and further extensions are in contemplation. The capital expenditure to date is £175,000, and it was recently decided to borrow a further £100,000 for extensive additions to the station plant and mains. In December, 1893, there was an equivalent of 32,716 8 c.p. lamps connected; in December, 1894, and December, 1895, the figures were 60,298 and 93,200 respectively, while the number at the end of March last was over 103,000. The report states that fifty-one miles of single conductor have been laid, and in the course of the present summer mains will be laid in several additional streets. A reduction in the price of current (6d. per unit) is in contemplation.

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MITCHELSTOWN (CORK).—At a recent meeting of ratepayers, called to discuss (amongst other things) the question of the lighting of the town, on the suggestion of Dean O'Regan a committee was formed for the purpose of collecting information and reporting. Mr. Webber, a local landlord and owner of water-power in the neighbourhood, has offered to light the town electrically by 36 incandescents for £66. 13s. 4d. per annum, the contract to be for a term of 21 years. This offer will probably be accepted.

OXFORD.—Under the presidency of Sir Henry C. Mance, Chairman of the Oxford Electric Company, a successful demonstration f the new photography was given in the Examination Schools on Tuesday by Mr. J. Hardie McLean and Mr. E. L. Birkbeck.

PORTSMOUTH.—The Town Council propose to apply to the Local Government Board for sanction to borrow £6,000 for electric light extension purposes. Mains are to be laid in St. Ronan's-road at an estimated cost of £200.

POWER TRANSMISSION PLANTS IN THE RAND.—The *African Review* states that the Koesterfontein Company propose to establish an electrical power plant for the purpose of supplying power to the various West Rand properties, at an estimated outlay of £20,000. The necessary works will be erected on Steenkoppies, and water power will be utilised in the generation of current, which will be supplied to any mine within 20 miles to the east or south-east, this radius including all mines on the Botha's or Randfontein reefs. The Company anticipate, in addition to supplying energy to their own mines, to be able to dispose of 1,000 H P. at £40 per horse-power per annum.

ROYAL INSTITUTION LECTURE.—On the occasion of Prof. Ewing's lecture on "Hysteresis" to-night, Messrs. Gabriel and Angenault will show examples of their duplex and other lamps.

RUSSIAN PATENT LAW.—The Russian Government have drawn up a Bill amending the patent laws of that country, which at present only awaits Imperial sanction. Under the new law the term of a patent is fixed at 12 years, and is subject to a tax of 20 roubles for the first year and 30, 40, 60, 80, 100, 150, 200, 300, 400, 500 and 600 roubles respectively for each succeeding year. Though an application fee of 30 roubles must in all cases be paid, a suspension of the tax for the first two years is granted to indigent patentees, but if the payment is not then made the patent can be annulled. Protests, which have to be filed at the courts, will only be considered within the first two years. Supplementary patents must be filed within one year of the issue of the original patent, and a fee of 30 roubles is payable on application, and an additional 20 roubles becomes due immediately the supplementary application is granted. A patent can be annulled (1) after it has been in force 12 years, (2) through irregularity in the payment of the annual tax, (3) through not being applied for, or not furnishing proof at the proper time, and (4) through the protest of a third party. Infringers of a patent are liable to a criminal prosecution as well as for damages.

SALFORD.—A Local Government Board inquiry was held at Salford on Wednesday into the application of the Town Council for sanction to borrow, amongst other sums, £5,000 for electric lighting purposes. It was stated that in September, 1893, the Council applied for sanction to borrow £50,000, but only a sum of £32,000 was authorised. In June, 1895, a second application was made for powers to borrow £18,000, but in this case only £7,770 was sanctioned. The present loan was required to meet expenditure in excess of estimates to the extent of £3,587, and for certain extensions to the plant. The application was unopposed.

STAFFORD.—It was stated at the last meeting of the Town Council that as a result of five months' working of the electricity works there was a small balance on the credit side.

ST. PANCRAS (LONDON).—The Vestry have decided to abolish all meter rents from July 1st next. The Electricity Committee have handed over £1,000 out of the profits on last year's working to the general account. Property adjoining the dust destructor station has been acquired for £1,450 in order to obviate a threatened action for injunction.

SOUTHPORT.—At the last meeting of the Town Council, Councillor Hulme said, in referring to the recent resignation of the borough electrical engineer (Mr. Arthur Ellis) and to the appointment of Mr. C. D. Tate to fill the vacant position, that they were sorry at losing Mr. Ellis, as he had proved himself to be a most efficient public servant. One or two members protested against the proposal to make Mr. Tate's salary £230 per annum, as Mr. Ellis only received £204; but the proposal was ultimately agreed to.

SUNDERLAND.—At the last meeting of the Town Council, Alderman Bruce announced that the receipts from the sale of current, meter rents, &c., for the past year amounted to £2,166, and the deficiency was only £701, which included an extra three months' interest. The actual output had been 95,446 units, and the average price realised 5·13d. per unit. Expenses and management came to £1,490, while interest and sinking fund absorbed £1,377. The results of the first year's working had exceeded their anticipations, and they had already received notifications, now that the reduction in the price of current had taken place, of considerable extensions. The Electric Lighting Committee had made arrangements for the extension of the station building and for putting down additional plant before September, so as to be in a position to meet the increased winter demand.

TARIFF CHANGES.—Under the new (1896) Argentine Customs Law electric light machinery and apparatus (except service fixtures) imported into the country are subject to an *ad valorem* duty of 5 per cent.——The German Customs authorities have decided that electrical, physical and scientific instruments, galvanic batteries, &c., will in future be charged with the duties applicable to the materials of which they are made.

WEST HAM.—The borough electrical engineer (Mr. Risch) has prepared a report on the electric lighting question, in which it is recommended that the electricity supply station be erected in conjunction with the pumping station, and that all the boilers be placed in one building. For private lighting Mr. Risch recommends the adoption of the high tension alternate-current transformer system, current to be supplied to consumers from sub-stations on the three-wire system at a pressure of 100 volts. For public lighting Mr. Risch proposes to run the arc lamps in series off a constant current machine. Incandescent lamps will be fixed to the arc lamp pillars to enable incandescent to be substituted for arc lighting after midnight. The borough engineer (Mr. Lewis Angell) and the electrical engineer have been empowered by the Council to settle details as to the working of the electric lighting and sewage plants.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Publishe is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

April 21, 1896.

8,380. B. F. MERRITT and J. M. JOY. London. Improvements in printing telegraph instruments.*

8,382. J. DEVONSHIRE. London. Improvements in automatic circuit-breakers for use in electric tramcars or other electrically-propelled vehicles. (W. B. Potter, United States.) *

8,397. H. EDMUNDS. London. Improvements in electrical cut-outs.

8,398. H. EDMUNDS. London. Improvements in or connected with electrical resistances.

8,399. H. EDMUNDS. London. Improvements in apparatus for completing interrupting, and controlling electrical circuits.

8,410. J. C. GRAHAM. London. Improvements in the electro-deposition of metals, particularly applicable to the deposition on wires.

April 22, 1896.

8,428. J. B. VERITY. Birmingham. A new or improved electric switch.

8,458. W. TURVEY. London. Improvements in electrical recording instruments

8,483. SIEMENS BROS. AND CO. (LIMITED) and W. DIESELHORST. London. An improvement in joints for electrical cables.*

8,507. J. HINKS AND SON (LIMITED) and F. R. BAKER. London. Improvements in chandeliers, gaseliers, electroliers and other hanging lamps.

8,512. G. W. DOLMAN. London. Improvements in or connected with drain pipes, water or electric conduits, and the like.

8,514. J. A. TIMMIS. London. Improvements in electric glow lamps.

April 23, 1896.

8,541. W. WOODHEAD. Halifax. Improvements in electric lamps for miners, and in the method of lighting said electric lamps.

8,569. E. TYER. London. Improvements in apparatus for making electrical contact by passage of a railway train.

April 24, 1896.

8,630. J. CHANDLER. Liverpool. Improvements in magnetic motors.

8,647. F. TUDSBURY. Sheffield. Improvements in induction electrical machines.

8,659. F. W. SCHNEIDER. London. Improvements in paste-carrying plates for electric accumulators.*

8,660. F. W. SCHNEIDER. London. Improvements in the construction of cells for electric accumulators.*

8,666. THE BATTERY AND MOTOR COMPANY (LIMITED) and H. T. BARNETT. London. Improvements in and connected with battery electrodes.

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8,682. C. A. McEvoy. London. Improvements in hand grenades and in electrical firing apparatus applicable for firing the same.
8,684. F. L. Muirhead. London. Improvements relating to telephones.
8,695. W. Majert. London. Improvements in electrodes for accumulators.*

April 25, 1896.

8,743. H. A. Cutmore. London. Improvements in speaking-tube, telephone and the like receivers.

April 27, 1896.

8,802. C. Shore and C. Heap. Rochdale. Improvements in and relating to switchboards to be used for telephonic purposes.
8,810. J. Edmondson. Halifax. Improvements in dynamo electric machines.
8,815. G. Davis. London. Improvements in or connected with electric light switches.
8,819. J. W. Mitcherd. Merioneth. Railway pilotman's substitute apparatus, for working single line during failure of "tablet" or "electric" staff working.
8,846. H. Sandwith. London. Improved dynamo-electric machine.
8,853. H. Arzt. London. A new or improved construction or arrangement of generator of electricity.

April 28, 1896.

8,890. T. Meacock. Birmingham. Electricity and water supply for household and other purposes.
8,906. L. B. Atkinson and F. G. Treharne. Penarth. Improvements in the generation of electricity.
8,943. R. Williams. Chiswick. Improvements in the fixing of metal caps to incandescent electric lamp bulbs.
8,948. H. H. Lake. London. Improvements in electric signalling apparatus. (G. E. Painter, United States).*
8,964. O. Imray. London. Improvements in electrical furnaces. (D. Graham, Canada).
8,973. R. P. Strand, De B. Carritte and C. A. Stockton. London. Improvements in electrical organs.*

April 29, 1896.

8,999. A. M. Rosebrugh. Toronto. Duplex or multiplex telephony.
9,014. G. J. Baird. Glasgow. Improvements in electric temperature alarms.
9,030. W. W. Channon. London. An improved automatic electrical cut-out.
9,047. T. D. Farrall. London. Method of and apparatus for heating by electricity.
9,048. H. Tomlins and C. R. Gurr. London. Electrical fog signalling apparatus.
9,055. J. A. Timmis. London. Improvements in fire-proof cements and varnishes for electrical and other purposes.

May 1, 1896.

9,171. W. Fairweather. Glasgow. Improvements in underground conduits for electric railroad or street railway systems. (Munson, Roberts, Alston, Reid and Reid).*
9,233. H. A. Willey and S. Simpson. London. Improvements in prepayment-mechanism for gas, electricity, and other meters.
9,239. W. McMurtrie. London. Improvements in tools for stripping insulation from wires.*
9,257. C. Grahner. London. Improvements in and relating to electric arc Lamps.*
9,262. R. Pippette. London. Improvements in switch apparatus for use in distributing electricity for telephonic, telegraphic and other purposes.

May 2, 1896.

9,266. J. MacKenzie Urquhart and W. H. Dingle. London. Improvements in electric lighting fuses or cut-outs.
9,284. A. H. Walton. London. Improvements in automatic apparatus for switching gear of electrical transformers and other electrical circuits.
9,288. A. Marr. Manchester. Improvements in telephonic receivers.
9,289. W. E. Heys. Manchester. Improvements in and connected with the electro-deposition of copper. (E. Dumoulin, France).
9,332. A. Rinclake. London. Improvements in and connected with permanent electric ways.
9,362. W. B. Sayers. London. Improvements in dynamo electric machines.

May 4, 1896.

9,402. O. von Morstein. London. Improvement in electric gas lighting devices.*
9,447. A. G. Cooke. London. Improved reversible variable speed gear applicable for use in electrical regulation and other purposes*

May 5, 1896.

9,480. A. S. Krotz, W. P. Allen and O. S. Kelly. Manchester. Improvements in electrical contacting devices for subways or conduits.*
9,517. W. R. Sykes and F. T. Hollins. London. Improvements in electric locking and block signalling on railways.
9,528. H. H. Lake. London. Improvements in telegraphic relays and the like. (C. G. Burke, United States.)*
9,530. J. Devonshire. London. Improvements in sockets or holders for incandescent electric lamps. (H. C. Wirt, United States.)*
9,531. J. Devonshire. London. Improvements in dynamo-electric machines. (C. P. Steinmetz, United States.)*
9,534. J. Lavender. London. Improvements in electric switches for use with or without mechanical or electromagnetic brakes.
9,537. J. Lavender. London. Improvements in or relating to electro-mechanically propelled vehicles.
9,555. T. A. Clarke. Liverpool. Improvements in or connected with electric burglar and other alarms.
9,565. M. Schindler. London. Improvements in or connected with electric melting apparatus.

May 6, 1896.

9,619. S. P. Eastick and E. Sayer. London. Improvements in incandescent electric lamps.
9,637. A. Blahnik. London. Improvements in arc lamps.
9,650. E. Lanhoffer. London. Improvements in electro-motors and dynamos and in apparatus for use therewith.*

May 7, 1896.

9,667. W. Fox. Broughton. Electric arc lamps.
9,668. W. Fox. Broughton. Electric arc lamps and projectors.
9,681. H. L. P. Boot. Tunbridge Wells. An improved method of street lighting by glow lamps.
9,713. D. Foulis. Glasgow. A signal indicator for use on locomotives, and means for electrically operating the same.
9,758. F. Fanta. London. Improvements in floorcloths or carpets for the purpose of electrical distribution therein.

May 8, 1896.

9,806. H. Pieper, Fils. London. Improvements in apparatus or devices for starting and arresting electro-motors employed in driving wire-drawing or other similar machines.
9,817. E. Bach, H. S. Lewis and A. B. Saunders. London. Improved shade for use in connection with electric incandescent lamps and the like.*
9,820. M. Binswanger and F. G. Bell. London. Improvements in coupling boxes for electrical circuits.
9,832. J. E. Kingsbury. London. Improvements in telephone systems of exchange. (The Western Electric Company, United States.)
9,843. R. P. Wilson. London. Improvements relating to electric current meters.
9,853. E. S. Collicott. London. Improvements in and connected with electric belts and like appliances to be worn next the skin.*

May 9, 1896.

9,910. A. Schanschieff. London. Improvements in secondary batteries.
9,919. W. Friese-Greene. London. Improvements in and related to exhausted tubes for electrical and other purposes.
9,929. R. W. Lane. London. The self-returning electric bell indicator.

## SPECIFICATIONS PUBLISHED.

**Note.—All Specifications can now be obtained at the uniform price of 8d. each.**

1895.

962. Stendebach. Electric railways.
3,954. Berditschewsky and Freudenberg. Telephone systems.
6,391. Ballance and Fitzmaurice. Electric lighting.
7,152. Faber. Writing by telegraphy.
7,191. Fisher. Electric arc lamps.
7,712. Burton. Electric furnaces.
7,713. Burton. Electric furnaces.
7,910. Borland. Lighting up roundabouts, &c., by electricity.
8,583. Berry and Lipkowski. Railway electric signalling apparatus.
8,764. Wright. Distributing electricity.
8,876. Shrewsbury and others. Electric batteries.
9,180. Lunn. Raising and lowering arc lamps.
9,388. Crompton. Arc lamps.
9,546. Lachmann. Electric railways.
9,816. Robinson. Railway electric signalling apparatus.
10,313. Smith and Granville. Telegraphic or telephonic cables.
10,448. Falero and Lumley. Secondary batteries.
10,655. Binswanger and Angold. Arc lamps.
11,181. Edmunds. Electric switching apparatus.
11,355. Edmunds. Electric cables.
11,482. Taylor and Dearlove. Telegraph cable, &c., lines.
11,548. Kingsbury (Western Electric Company). Telephone systems.
11,549. Kingsbury (Western Electric Company). Telephone systems.
11,560. Aldridge. Electric mains or conductors.
11,659. Niblett. Secondary batteries.
11,700. Johnson and Steele. Alternating current machines.
11,892. Hepworth. Arc lamp.

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12,301. ATKINSON. Dynamos, motors and alternators.
12,311. SIEMENS BROS & Co., Ltd. (SIEMENS and HALSKE). Electric railways and tramways.
12,394. KOSANKE and OTHERS. Indicating telephonic communications.
12,719. ESTRADE. Incandescent electric lamps.
13,961. LAKE (Compagnie de l'Industrie Electrique of Geneva [Usine de Secheron]). Electric tramways and railways.
20,904. DEVONSHIRE (Potter). Controlling electric motors.
21,924. HUMMEL. Wattmeters.
23,852. BROMHEAD (Société Anonyme des Anciennes Salines). Electrolytic diaphragms.

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434. MCKENNA (Electric Selector and Signal Company). Electric switches.
1,006. ZINNER. Electric resistances.
1,687. RUDOLPH. Fastening electric conducting wires.
1,992. BAGNALL and ARNOLD. Arc lamps.
3,133. WIESNER and WITZEL. Electric clocks.
4,237. DEVONSHIRE (Thomson). Electric motors.
4,427. PARSHALL and OTHERS. Armatures for alternators, &c.
4,805. WETHERILL. Magnetic separation.
4,807. DEVONSHIRE (Thomson). Monocyclic electric generators.
4,808. DEVONSHIRE (Potter). Electric brakes for railway and tramway vehicles.
4,817. LAVENS. Arc Lamps.
4,844. ADAMS. Arc lamps.
5,098. BALDO. Electrolytic processes.
5,113. PITT (Hollingshead). Electro-plating bath.
5,295. SEAVERNS. Arc lamps.

# COMPANIES' MEETINGS AND REPORTS.

## West India and Panama Telegraph Company (Limited.)

The thirty-eighth ordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, on Wednesday, Mr. C. W. Earle presiding.

The SECRETARY (Mr. R. T. Brown) read the notice calling the meeting and the minutes of the last meeting, the report of the Directors and statement of accounts being taken as read,

The CHAIRMAN said: Gentlemen, we who are engaged in carrying on the business of the West India and Panama Telegraph Company are always very thankful for small mercies, and it is with some satisfaction that we note that the long-continued decrease in the traffic receipts that we have had to report at a good many meetings has at last taken a turn, there having been an increase of £1,083 as compared with the December half of 1894. It is quite true that that little benefit is wiped away almost entirely by the loss of the French subsidy from Guadeloupe. However, that was a contingency we foresaw with certainty in respect to the French Government and her colonies. It was a loss which we had no means of escaping from. The traffic receipts of this Company, considering the extent of its cables—about 5,000 miles, serving 16 different colonies—are almost ridiculous, the gross amount being about £2,300 a fortnight. When I happen to look over the receipts, not of telegraph but of other companies, I am struck with the extraordinary disparity of the results. Take, for example, that very excellent company called the Sweetmeat Automatic Delivery Company. It has almost double our receipts from selling, on the penny-in-the-slot principle, butter-scotch, chocolate, and that sort of thing, at our railway stations; but here is a great and important enterprise, that does so much for the Government of the country and holds together a great section of our colonial empire, which does not derive so much from its business as a company of that modest nature. In the accounts there is very little to remark upon. Situated as we are, we are obliged to keep down our expenditure to the very lowest sum consistent with an effective service, so that there is very little variation in those items over which we have control. One point of advantage in the accounts is the decrease under abstract "C," dealing with the expenses attending repairs and renewals of cables. This half year, owing to our having to put in the system 30 knots of cable less than we did in the corresponding period of the previous year, there is a considerable diminution in expenditure on cable repairs. In fact we have only had to charge ourselves with £2,831, as against £5,576 in the corresponding half of last year. There has also been an advantage in our having brought home the "Grappler" to take out a new supply of cable for stock, because if we had not brought our own ship home, we should have had to charter a vessel to carry out the new stock of cable. We have charged the cable so carried out with a fair amount of the expenses of the "Grappler" during the voyage home and out. That has saved us a sum of about £2,000. If it had not been for that saving we should not have been able to pay the wretched dividend on the ordinary shares that we are now offering you. With regard to paragraph 5, which deals with the reduction from £600 to £400 in the St. Vincent subsidy, I am almost inclined to think that the last words of the first part of the paragraph are too mildly expressed, and had not the colony of St. Vincent been in the old days one of the most liberal to us of all the British possessions we should have been inclined to use stronger terms. If the question of depression in one's circumstances is to justify one's not paying for what one gets, I think that this Company especially ought to have a strong claim under that depression principle. But the reduction has been approved by the Secretary of State for the Colonies, and therefore we must bow to his decision. Mr. Chamberlain is a fair man and a good man of business, and he is not likely to do anything that he thinks unjust or inexpedient. I dare say most of you will have seen the answer of Mr. Chamberlain in the House of Commons when he was asked about the proposed cable between Bermuda and Jamaica. We have been in communication with the Colonial Office with regard to that cable, and I need not say that it would be very improper to make any statement now on that correspondence. When the time comes if anything is settled we shall place the result before you and ask your opinion upon such terms as may be proposed to us. The question of that cable is a very old one. In 1882 there was a Conference of the colonies held at Barbadoes, at which it was advocated that that cable should be laid, and very strong pressure was put on the Government to do so. It was rather hard on us, considering that we had laid this system under conditions imposed by the legislatures of the West Indian colonies as to route and tariff, to be told when it was thought that our rates were rather high that they were to have a cable subsidised by Her Majesty's Government to compete with us. I must therefore read what Mr. Fawcett, who was then Postmaster-General, had to say on the subject: "Undoubtedly the Company have had great difficulties to contend with, but Mr. Fawcett believes that the present Board are striving to put their property on a sound basis, and, notwithstanding the opinion expressed by the Conference, that the Company have failed to meet the requirements of the West Indian Colonies, he fears that there would be just cause for complaint against Her Majesty's Government if it were now to subsidise a rival company, especially as such a company would in all probability require not much less support in the shape of subsidies than the present Company lays claim to, and directs me to observe that he thinks that any company would have reasonable ground for objecting to supply the bulletin of news which the Company are called upon to furnish free of charge." Now, influenced I may say by these words, the Company went on its course and continued the duplication of its system, which has given permanent and constant security in communication with the West Indies, and I am quite certain that any colonial minister or statesman of the present day, if these words of a very eminent public servant, the late Mr. Fawcett, were brought to his notice, would think that it would be a very unjust thing to employ the money of the ratepayers of this country for such a purpose. I shall be very glad to answer any questions that may be now put. Meantime I shall in conclusion move—

*"That the Directors' report and accounts to December 31, 1895, submitted to this meeting, be and the same are hereby received and adopted, and that, as recommended by the Board, a dividend of 6s. per share on the First Preference Shares, 6s. per share on the Second Preference Shares, and 6d. per share on the Ordinary Shares (the last free of income tax) be and the same are hereby declared."*

Mr. WM. ANDREWS seconded the resolution, which was carried unanimously.

The CHAIRMAN then moved the re-election of Mr. Andrews, the retiring Director, to his seat at the Board.

Mr. HENRY HOLMES seconded the motion, which was carried unanimously.

Mr. ANDREWS having briefly expressed his acknowledgment,

Mr. JOHN NEWTON moved, and Mr. CUFF seconded, the reappointment of the auditors, Messrs. Deloitte, Dever, Griffiths and Co.

The motion having been agreed to,

Mr. CUFF moved, and Mr. NEWTON seconded, a vote of thanks to the Chairman and his colleagues on the Board, for which the former briefly returned thanks, and the proceedings ended.

# NEW COMPANIES, STATUTORY RETURNS, &c.

*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1896, pages *318-346, &c., &c.*

**R. H. ACQUISITION SYNDICATE (LIMITED).**—This Company was registered on May 14th, with a capital of £5,000, in £50 shares, to carry on, amongst other businesses, those of mechanical engineers, electricians, electric light manufacturers and suppliers, machinists, metallurgists, electro-platers, &c.

**W. A. BAKER AND CO. (LIMITED).**—This Company has been registered with a capital of £100,000, in 5,000 Preferred and 5,000 Ordinary shares of £10 each, to acquire the business of electric light engineers and contractors, general ironmongers, founders, &c., carried on under the style of W. A. Baker and Co., at Newport, Mon. The first Directors are W. A. Baker, M. Mordey, J. T. Hamilton, and J. E. Baker.

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**CARBON (FOREIGN PATENTS) SYNDICATE (LIMITED).**—This Company was registered on May 14th, with a capital of £100,000, in £1 shares, to carry into effect certain agreements with Messrs. C. P. Shrewsbury, J. Cooper, F. L. Marshall and J. L. Dobell, and to carry on the business of manufacturers of and dealers in carbon plates, slabs, rings, crucibles, rollers, bars, rods and other articles for electrical, electrolytical and other purposes, and electrical and mechanical engineers, electricians, suppliers of electricity and manufacturers of and dealers in electrical apparatus of all kinds. The first subscribers, with one share each, are: Major A. D. Seton, J. Lindsay, F. L. Marshall, C. P. Shrewsbury, engineer, J. Cooper, S. Spill and J. L. Dobell, electrical engineer. The first Directors are: Major A. D. Seton, C. P. Shrewsbury, J. Cooper, F. L. Marshall, H. Dobbin and S. Spill.

**DIRECT ELECTRIC GENERATOR (FOREIGN PATENTS) SYNDICATE (LIMITED).**—This Company was registered on May 14th, with a nominal capital of £100,000, in £1 shares, to carry into effect certain agreements with Messrs. C. P. Shrewsbury, J. Cooper, F. L. Marshall and J. L. Dobell, to acquire, develop, and deal with any patents, licences, concessions, &c., and to carry on the business of electricians, generators and suppliers of electricity, mechanical engineers, and manufacturers of and dealers in all apparatus required for or capable of being used in connection with the generation, distribution, supply, accumulation and employment of electricity. The first subscribers, with one share each, are Major A. D. Seton, J. Lindsay, F. L. Marshall, C. P. Shrewsbury, engineer, J. Cooper, S. Spill and J. L. Dobell, electrical engineer. The first Directors are: Major A. D. Seton, C. P. Shrewsbury, J. Cooper, F. L. Marshall, H. Dobbin and S. Spill.

**GREAT HORSELESS CARRIAGE COMPANY (LIMITED).**—This Company was registered on May 14th, with a nominal capital of £750,000, in £10 shares, to acquire certain patents and patent rights, and to carry on the business of horseless carriage, cycle and motor manufacturers, repairers and dealers, electricians, mechanical engineers, machinists, wire drawers, metallurgists, electro-platers, &c.

**PRINTING TELEGRAPH RECORDER COMPANY (LIMITED).**—This Company was registered on May 15th, with a capital of £10,100, in 10,000 Ordinary, 100 Founders' shares of £1 each, to acquire, develop, and deal with any patents, inventions, concessions, &c., to carry on the business of manufacturers and repairers of and dealers in all telegraphic apparatus and particularly type-printing and other telegraph recorders and instruments, telegraph engineers, &c. The first subscribers are H. Moir, G Gray, engineer, W. G. Brookman, engineer, J. Girdwood and Hon. Henry J. Saunders, and H. M. Willis and A. Barrett. The first Directors are J. Moore, W. P. Forbes and (after allotment) W. S. Steljes.

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**CORLETT ELECTRICAL ENGINEERING COMPANY (LIMITED).**—The annual return to May 14th has been filed. The nominal capital is £10,000, in £10 shares; 620 have been taken up, and 100 of these have been issued as fully paid. The full amount has been paid on the remaining 520 shares.

**HASTINGS AND ST. LEONARDS-ON-SEA ELECTRIC LIGHT COMPANY (LIMITED).**—The annual return to May 8th has been filed. The nominal capital is £50,000, in £10 shares, and 2,722 of these have been taken up. The full amount per share has been paid.

**NORWICH ELECTRICITY COMPANY (LIMITED).**—The annual return to April 29th has been filed. The nominal capital is £50,000, in £10 shares; 3,525 have been taken up, and the full amount has been called and paid.

**ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED).**—The annual return to May 6th has been filed. Out of a nominal capital of £200,000, in £1 shares, 171,504 have been taken up, and 171,497 of these have been issued as fully paid. The full amount has been paid on the remaining seven shares.

**TELEPHONE COMPANY OF EGYPT (LIMITED).**—The annual return to May 5th has been filed. The capital is £100,000, in 16,000 Preference and 4,000 Deferred shares of £5 each: 12,071 of the former and all of the latter have been taken up, and 12,000 Preference and 4,000 Deferred have been issued as fully paid. The full amount has been paid on the remaining 71 Preference shares.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31 1/16d. per oz. (May 21st). Consols (2¾ per cent.) 112 3/8—112½ for money, 112 7/16—112 9/16 for account; 2½ per cent. 106⅛—106⅜ (May 21st). Stock Exchange Settling Days: Consols, June 1st; Stocks and Shares Continuation Day, May 27th; Ticket Day, May 28th; Pay Day, May 29th; Mining Share Carry-over Day, May 26th.

**BIRMINGHAM CENTRAL TRAMWAYS COMPANY (LIMITED).**—Messrs. W. Mackenzie (President of the Toronto Railway Company) and J. Ross Managing Director of the Montreal Street Railways Company) have made an offer to purchase the undertaking of the Birmingham Central Tramways Company on the basis of a par value for the debentures and Preference shares, and a bonus of £1 on the Ordinary shares. The authorised capital of the Company is £300,000, of which £194,000 has been issued in fully-paid Ordinary of £5 each, and £100,000 in Five per Cent. £10 Preference shares; and, in addition, there are debentures for £152,400. The last dividend on the Ordinary shares (1894-5) was at the rate of 3 per cent. The Directors of the Company have issued a circular, in which they strongly recommend the shareholders to accept the offer, stating that, though the operations of the Company since the last meeting have been satisfactory, any future improvement in their position must be effected by the adoption of an improved system of mechanical traction on the routes at present worked by steam. As soon as the Corporation have expressed approval of the proposal, meetings of shareholders will be called for the purpose of considering and approving the agreement proposed to be entered into between the parties, and for passing the usual liquidation resolutions.

**BUSINESS CHANGES.**—Owing to the increased demand for their well-known patent water-tube steam boilers, the business of Messrs. Conrad, Knap and Co. has, we are informed, been converted into a private limited liability company, under the style of Conrad, Knap and Co. (Limited). No shares are offered to the public.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended May 17th were £864, against £905 in the corresponding week of 1895, a decrease of £41. The total receipts for the half-year amount to £18,800, against £18,720 for the corresponding period of 1895, an increase of £80.

**COUNTY OF LONDON AND BRUSH PROVINCIAL ELECTRIC LIGHTING COMPANY (LIMITED).**—In reference to the recent issue of 10,000 Preference shares of this Company, we are informed by the Electric and General Investment Company that applications for over four times the amount offered were received.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 17th inst. amounted to £1,125. The amount for the corresponding week last year was £1,141; decrease, £16.

**LONDON ELECTRIC OMNIBUS COMPANY (LIMITED).**—This Company, which has been formed for the purpose of acquiring and working Mr. Radcliffe Ward's system of electric street traction, invites application for 170,000 £1 shares, payable 5s. on application, 5s. on allotment, and the balance in instalments of 2s. 6d. per share, at intervals of not less than one month. The authorised capital of the Company is £250,000 in £1 shares. The prospectus, which will be found in our advertisement columns, states that the entire purchase money except £20,000 will be taken in shares which will not participate in dividends until sufficient profits have been earned to pay in any one year a dividend of 7 per cent. It is claimed that the working capital allowed for is sufficient to provide for 125 omnibuses, running 70,000 miles per week. The Directors include Major S. Flood-Page (Director of the Edison and Swan United Electric Light Company), and Mr. Radcliffe Ward, who is also the Company's engineer. The manager and secretary (*pro tem.*) are Messrs. H. F. Lewis and A. Caillat, and the offices are at 36, Broad-street House, London, E.C. The list of applications closed yesterday (Thursday) for town, and will close this (Friday) morning for the country.

**NORWAY.**—6,000,000 kroner is to be devoted to the development of the telegraph and telephone systems of Norway, out of an issue of a new State loan of 25,000,000 kroner.

**READING ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual general meeting of this Company was held last week at Reading. The Chairman (Mr. H. Collins) said the income for the past year amounted to £1,453. 10s. 7d., and the net profit to £22. 13s. 4d., and the Directors considered these figures to be satisfactory, seeing that the new supply station was only in operation for the last two months of the year. There was an increased demand for current, and they anticipated a greatly increased revenue in the forthcoming year. At the end of 1895 they had 83 customers, representing 6,094 8-c.p. lamps, and at present these figures were 115 and 6,647 respectively. The price of current has been reduced from 8d. per unit (with discounts) to 6d. net, and as the Directors are anxious to create a day load they have decided to fix the price of current for motive power, cooking and heating purposes at 3d. per unit.

**REUTER'S TELEGRAM COMPANY (LIMITED).**—The report of the Directors of this Company, to be presented at the shareholders' meeting on the 27th inst., states that the net profits for the year ended December 31st last amount to £11,340. 12s. 3d., including £1,718. 16s 5d. brought forward from the last account. The sum of £6,382. 5s. 1d. has been placed to reserve, which now amounts to £14,000. The Directors propose to pay a dividend of 4s. per share, equal to 2½ per cent., making, with the interim dividend of 2½ per cent. paid in October last, a total distribution of 5 per cent. for the year. This will absorb £4,781. 10s., and the balance of £176. 17s. 2d. has been carried forward. The Directors state that they have decided to retain the advertisement business.

**SUSSMANN ELECTRIC MINERS' LAMP COMPANY (LIMITED).**—During the week a company with the above title, which has been registered with a capital of £80,000 in 39,250 Seven per Cent. Cumulative Preference, 39,250 Ordinary and 1,500 Deferred shares, all of £1 each, has issued a prospectus inviting applications for 31,750 Preference and a like number of Ordinary shares. The prospectus states that the Company has been formed for the purpose of acquiring the various British, foreign and colonial patent rights for the Sussmann electric miners' lamp. The vendors and promoters are "The Electric Exploitation Company," and arrangements have been made with the Edison and Swan Company to manufacture the lamps and to become wholesale agents for its sale in the United Kingdom.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended May 15th, after deducting 17 per cent of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,375.

**WEST AFRICAN TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company have declared a final dividend at the rate of 6s. per share, making with the interim dividend already paid a distribution of 4 per cent. for the year.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half month ended May 15th are £2,476, against £2,798 in the corresponding period of 1895.

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# COMPANIES' SHARE LIST.

| PRESENT AMOUNT. | AMOUNT OF SHARE. | LAST DIVIDEND. | NAME | PREVIOUS WEEK'S PRICE, MAY 13. | | Price Wednesday, May 20 | | RATE PER CENT. YIELDED. £ s. d. | DIVIDEND DUE | BUSINESS DONE DURING WEEK ENDING MAY 6. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS** | | | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 49 | 51 | 48 | 50 | 5 2 0 | Jan., Apr., July, Oct. | 50¼ | 49⅝ |
| £2,993,560 | Stock | 24'0 | Do. Preferred | 91½ | 92½ | 91½ | 92½ | 5 8 1 | " " | 93 | 91½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9½ | 9¾ | 9¼ | 9¾ | .. | .. | 9¼ | 9⅛ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 | 104 | 100 | 104 | 3 17 10 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10 | 11 | 10 | 11 | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 14⅜ | 15½ | 14⅜ | 15½ | 4 11 10 | Mar., June, Oct., Dec. | 15½ | 14⅜ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 | 117 | 113 | 117 | 4 6 7 | June and December | .. | .. |
| 10,000,000 | $100 | $1½ | Commercial Cable Capital Stock | 160 | 170 | 160 | 170 | 4 2 10 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 | 13 | 12 | 13 | 6 3 1 | February and August | 12½ | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20 | 21 | 19½ | 20½ | 4 17 7 | " " | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 4 | 5 | 4 | 5 | 4 0 0 | April and October | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 | 10½ | 10 | 10½ | 4 15 3 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 108⅝ | 109⅝ | 106⅞ | 109⅝ | 4 3 9 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ | 10 | 9½ | 10 | 4 0 0 | Jan., Apr., July, Oct. | 9⅝ | 9⅜ |
| 400,000 | 10 | 2/6 | Eastern | 17 | 17½ | 17 | 17½ | 3 14 4 | " " | 17½ | 17⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18 | 18½ | 18 | 18½ | 3 4 10 | " " | 18½ | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 130 | 133 | 130 | 133 | 3 0 2 | May and November | .. | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 | 109 | 106 | 109 | 4 12 10 | February & August | .. | .. |
| 250,000 | 10 | 6/6 | Eastern Extension | 18 | 18½ | 17⅞ | 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅜ | 17⅞ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 131 | 134 | 131 | 134 | 3 0 3 | February & August | 133½ | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 101 | 105 | 101 | 105 | 4 16 7 | January and July | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb., 1900 | 101 | 105 | 101 | 105 | 4 16 7 | " " | 102½ | 101½ |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 | 108 | 105 | 108 | 3 14 9 | February & August | 105 | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 110⅞ | 113⅞ | 110⅞ | 113⅞ | 3 10 10 | May and November | 112 | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust | 10½ | 11 | 10½ | 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅝ | 10½ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17 | 17½ | 17 | 17½ | 3 8 7 | " " | 17⅝ | 17⅛ |
| 150,000 | 10 | 10/0 | Great Northern | 23 | 24 | 23 | 24 | 4 3 4 | Jan., April, and July | 24 | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 Issue | 104 | 107 | 104 | 107 | 4 14 4 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 54 | 57 | 52 | 55 | 4 10 11 | May and November | .. | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | .. | .. | .. | .. | .. | .. | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 | 112 | 109 | 112 | 5 8 1 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 | 111 | 108 | 111 | 3 12 11 | .. .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 6 | 7 | 6 | 7 | .. | April and October | .. | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 135 | 140 | 135 | 140 | 4 5 9 | " " | 139½ | .. |
| 15,609 | 10 | 2/0 | West African Telegraph | 6 | 7 | 6 | 7 | .. | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 | 105 | 102 | 105 | 4 16 2 | March & September | 103 | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 | 2 | 1 | 2 | .. | January and July | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 97 | 102 | 97 | 102 | 8 0 0 | June and December | .. | .. |
| 88,321 | 10 | 1/3 | West India and Panama | 1⅛ | 1⅜ | 1⅛ | 1⅜ | .. | .. | 1⅛ | 1⅛ |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11¼ | 11½ | 11¼ | 11½ | 5 2 2 | May and November | 11⅝ | 11¼ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ | 10½ | 9½ | 10½ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 | 111 | 108 | 111 | 4 11 6 | June and December | .. | .. |
| 64,248 | 15 | 3/9 | Western and Brazilian | 9½ | 9¾ | 9½ | 9¾ | 4 12 4 | May and November | .. | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6½ | 7½ | 6½ | 7½ | .. | .. | 7 | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 104 | 108 | 104 | 108 | 5 12 8 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 104 | 108 | 104 | 108 | 5 12 8 | .. .. | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 | 115 | 110 | 115 | 6 2 0 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 | 105 | 102 | 105 | 5 15 6 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3 | 3½ | 3 | 3½ | .. | .. | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/16 | 3/16 | 1/16 | 3/16 | .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | 1/16 | 1/4 | 1/16 | 1/4 | .. | Yearly | .. | .. |
| 484,597 | 5 | 3,0 | National | 7½ | 8 | 7⅜ | 7⅝ | 3 2 2 | June and December | 8 | 7⅝ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 | 18 | 16 | 18 | 3 6 8 | " " | 18 | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16½ | 17½ | 16½ | 17½ | 3 8 7 | " " | 17 1/16 | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅜ | 7 | 6⅜ | 6⅝ | 3 12 9 | .. | 6⅝ | 6⅛ |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 4½% (red.) | 107 | 110 | 107 | 110 | 3 4 4 | January and July | 109¼ | 108 |
| 58,000 | 5 | 3/0 | United River Plate | 3½ | 4 | 3½ | 4 | .. | " " | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 97 | 102 | 98 | 103 | 4 19 0 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ | 15½ | 14½ | 15½ | 3 4 6 | .. | 15½ | 15⅛ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ | 17 | 15½ | 17 | 3 10 7 | .. | 16½ | .. |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 | 138 | 134 | 138 | 3 13 5 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. | .. | .. | .. | .. | .. | .. | .. |
| £30,000 | £5 | 3'0 | Charing Cross & Strand Electricity Supply Corp. | 8 | 8½ | 8 | 8½ | .. | .. | 8 5/16 | 8 |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. | .. | .. | .. | .. | .. | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 | 9 | 8½ | 9½ | .. | .. | 8⅜ | 8½ |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ | 13½ | 12½ | 13½ | .. | .. | 12¼ | .. |
| 8,322 | £5 | .. | House-to-House Electric | .. | .. | .. | .. | .. | .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. | .. | .. | .. | .. | January and July | .. | .. |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 7¾ | 8 | 8 | 8½ | 3 12 9 | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | .. | .. | .. | .. | .. | .. | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 14 | 15 | 14 | 15 | 2 13 4 | .. | 14⅞ | 14 7/16 |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 | 124 | 120 | 123 | 3 14 3 | June and December | .. | .. |
| 6,452 | £10 | 4,0 | Notting Hill Electric | 9 | 9½ | 9 | 9½ | .. | .. | .. | .. |
| .. | .. | .. | Rand Electric | ⅜ | ½ prem | ⅜ | ½ prem. | .. | .. | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 10½ | 10¾ | 10½ | 11 | .. | .. | 10¾ | 10⅜ |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 | 11 | 10 | 11 | 3 3 6 | .. | 11 | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9½ | 10 | 9½ | 10 | 3 8 4 | .. | 10 | 9 1/16 |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 90,000 | 8 | 1/6 | Brush Electrical Engineering | 1⅛ | 1⅜ | 1⅛ | 1⅜ | 5 8 8 | .. | .. | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅜ | 1⅞ | 1⅜ | 1⅞ | 3 4 0 | .. | 1⅜ | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 | 114 | 111 | 114 | 4 0 0 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 | 2½ | 2 | 2½ | .. | January and July | 2 | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United | 1½ | 1¾ | 1½ | 1¾ | .. | .. | .. | .. |
| £100,000 | Stock | 4½% | Do. 4% Mortgage Debenture Stock | 104 | 107 | 104 | 107 | 4 5 6 | .. | 104 | .. |
| £30,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 110,000 | 2 | .. | Electric Construction | 1⅛ | 1⅜ | 1⅛ | 1⅜ | .. | .. | .. | .. |
| 12,845 | 2 | 2/9? | Do. 7 per Cent. Cumulative Pref. | 2½ | 3 | 2½ | 3 | 4 13 4 | .. | 2½ | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ | ¾ | ⅝ | ¾ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23½ | 24½ | 23½ | 24½ | 4 1 8 | February & August | 24½ | 23½ |
| £200,000 | 100 | 4½% | * Do. 4½ per Cent. Debentures, 1896 | .. | .. | .. | .. | .. | March & September | 106 | .. |
| 15,995 | £10 | .. | International Okonite Ordinary | .. | .. | .. | .. | .. | .. | .. | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. | .. | .. | .. | .. | December and June | .. | .. |
| 20,000 | 9 | .. | Manchester Edison-Swan "A" (£1 5s. paid) | ⅛ | ¼ | ⅛ | ¼ | .. | .. | .. | .. |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 | 41 | 38 | 41 | 4 7 10 | March and July | 40 | 39 |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 | 105 | 102 | 105 | 4 16 10 | January and July | .. | .. |
| 37,514 | £5 | .. | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 41,093 | £5 | .. | Do. Preference (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16½ | 17½ | 16 | 17 | 3 8 7 | .. | 17⅛ | 16⅝ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 16½ | 17½ | 17 | 18 | 3 17 9 | .. | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 | 114 | 109 | 114 | 3 19 9 | .. | 113½ | 113½ |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 41 | 43 | 42 | 44 | 2 16 10 | May and November | 43 | 42½ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14⅜ | 15½ | 14⅜ | 15½ | 3 5 7 | .. | 15½ | 14⅜ |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 133 | 135 | 133 | 135 | 2 19 3 | May and November | .. | .. |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway | 14⅛ | 14½ | 14 | 14½ | 2 2 6 | .. | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 17 | 17½ | 17⅜ | 17⅝ | 2 16 10 | .. | .. | .. |
| 145,000 | Stock | 4% | Do. 4% Debenture | 114½ | 116½ | 114½ | 116½ | 3 10 10 | January and July | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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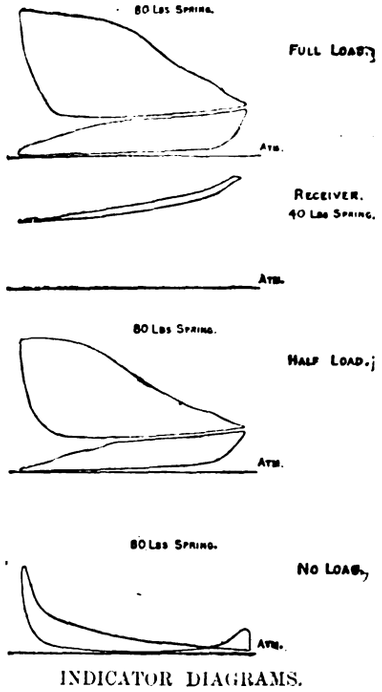
# THE UNIVERSAL ENGINE



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(RAWORTH'S PATENT).

# 3450

# HORSE-POWER

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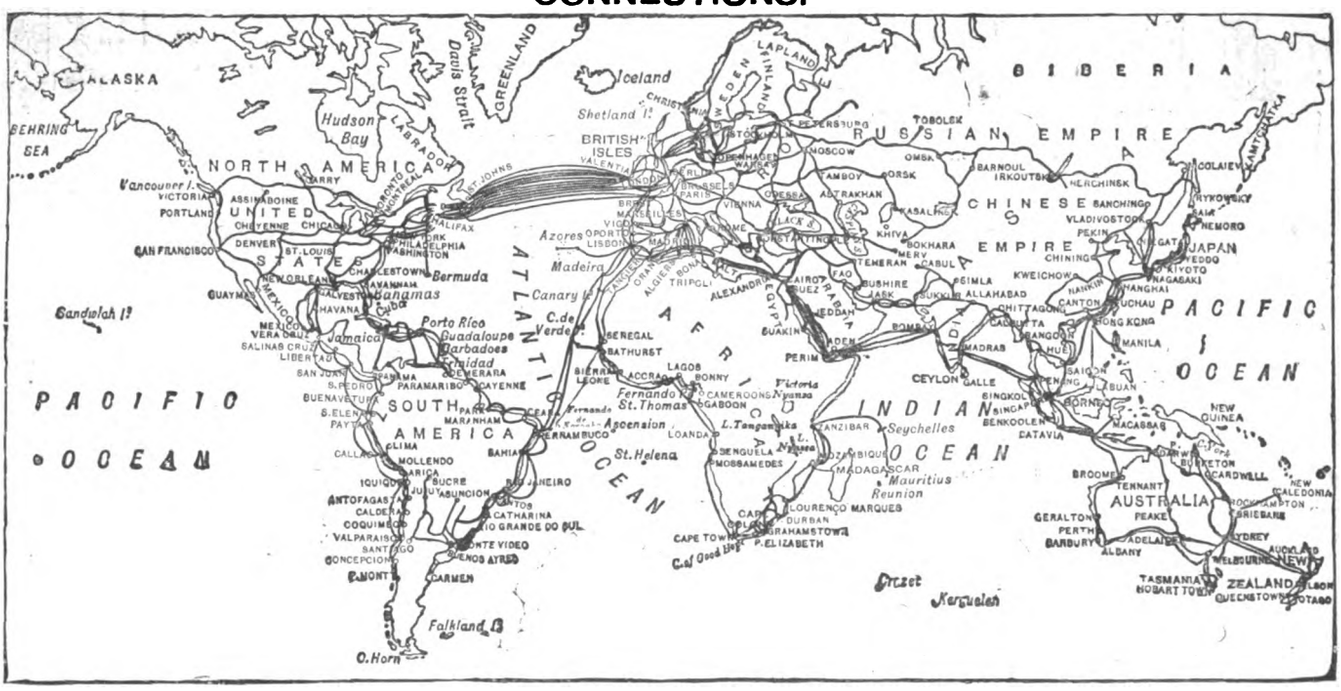
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

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By DIRECT DUPLICATE CABLE ROUTES to Madeira, St. Vincent, Brazil, Argentine Republic, Uruguay, also to Peru, Chili, and other parts of South America; and to Suakin, Perim, Penang, Malacca, Singapore, Labuan, Java, Australia, New Zealand, Tasmania, New Caledonia, Bangkok, Cambodia, Saigon, Tonquin, Hainan, China.

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Winchester House, 50, Old Broad Street, E.C. By Order, GEORGE DRAPER, *Secretary.*

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**Average Annual Valuations exceed £1,500,000 Sterling.**

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**TUESDAY, 2nd JUNE, 1896.**

WHEATLEY KIRK, PRICE and GOULTY have received instructions to

SELL BY PUBLIC AUCTION, WITHOUT RESERVE,

in the Lots of the Catalogue,

**THE ENTIRE CONTENTS**

Of the late Lighting Station of Messrs. THE READING ELECTRIC SUPPLY COMPANY, Limited, situate in

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(Owing to this Company having completed their New Central Station),

And which will include: 90 H.P. and 30 H.P. Babcock-Wilcox patent Water-Tube Steam Boilers; Loco. Multitubular Steam Boiler, by Fowler, Leeds; Worthington Pump; 25 I.H.P. Vertical Steam Engine, by Browett and Lindley; 25 and 50 I.H.P. Westinghouse Steam Engine, by Alley and Maclellan; 25 I.H.P. Armington-Sims High-Speed Steam Engine, by Greenwood and Batley; 3 K Type Thomson-Houston Dynamos, series wound; 1 ditto Alternating-Current Dynamo; 1 ditto Composite-wound Dynamo; 18 Transformers, 5 to 125 light, from 300 to 7,500 watts each; 6 M Type, 15 K Type and 47 M Type Thomson-Houston Arc Lamps, 1,200 c.p., 6·8 amperes each; Voltmeters; Ammeters and other effects.

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1. POLES for supporting Trolley Wire.
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5. ACCUMULATORS and SWITCHES.
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Particulars, plans and forms of Tender may be had (on payment of a deposit of £2 2s. for each contract, which will be returned on receipt of a bonâ fide Tender) from the City Engineer, Municipal Buildings, Leeds, or from

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SESSION 1896-97.

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Professors:—O. Henrici, LL.D., F.R.S. (Mathematics); W. C. Unwin, F.R.S., M.I.C.E. (Civil and Mechanical Engineering); W. E. Ayrton, F.R.S. (Physics and Electrical Engineering); H. E. Armstrong, Ph.D., F.R.S. (Chemistry).

**CITY AND GUILDS TECHNICAL COLLEGE, FINSBURY**

(Leonard-street, City-road, E.C.). The DAY DEPARTMENT provides Courses of Intermediate Instruction for Students not under 14 years of age, preparing to enter Mechanical or Electrical Engineering and Chemical Industries.

THE ENTRANCE EXAMINATION will be held on September 22nd, and the new Session will commence on October 6th.

Professors:—S. P. Thompson, D.Sc., F.R.S. (Electrical Engineering); J. Perry, D.Sc., F.R.S. (Mechanical Engineering); R. Meldola, F.R.S. (Chemistry).

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City and Guilds of London Institute,
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The SUBSCRIPTION LIST will be OPENED on MONDAY MORNING, 1st JUNE, and will be CLOSED at Four p.m. on Tuesday, 2nd June for LONDON, and at noon on WEDNESDAY, 3rd June, for COUNTRY applications.

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|---|---|---|---|
| Payable on Application | £10 | per £100 | Stock. |
| ,, Allotment | £10 | ,, | ,, |
| ,, 31st July, 1896 | £40 | ,, | ,, |
| ,, 31st January, 1897 | £40 | ,, | ,, |
| | £100 | | |

With option of payment in full on Allotment, under discount at the rate of 2½ per cent per annum, until the appointed dates of payment.

Repayable at par on 31st May, 1921, or, at the option of the Directors, on giving six months notice, at any time after 31st May, 1906, at the rate of £105 per £100 Stock. Interest will accrue from the respective dates of payment, and will be payable on 30th November next, and thenceforward half-yearly on 31st May and 30th November in each year.

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BROKER.—Hugh Campbell, 16, Tokenhouse-yard, E.C., and Stock Exchange.

SECRETARY.—Charles S. Essex.

Offices and Works—Rugby and Thames Ditton.

Temporary London Office.—14, George-street, Mansion House, E.C.

### PROSPECTUS.

The Debenture Stock is secured by a charge upon the undertaking and upon all the property and assets of the Company. According to the audited Balance-sheet, dated 27th December last, a copy of which is enclosed with the Prospectus, the property and assets amounted on that date to £216,368 7s. 8d., exclusive of goodwill, while the whole indebtedness of the Company amounted to only £12,298 18s. 6d.

The Company's Freehold Properties at Rugby and Thames Ditton have been specifically mortgaged to the Trustees for the Debenture Stock Holders, and the same deed creates a floating charge upon the other property of the Company. The two Freeholds, when the Rugby Works are completed, will stand in the books at about £80,000.

The money to be borrowed is required for completing the new Works at Rugby; for providing additional plant and machinery; and for further working capital.

The business, which is chiefly that of making the well-known Willans Engine, was founded at Thames Ditton in 1881. Owing to its rapid growth, it was converted into a private Limited Company in 1888, and the same cause led to the formation of the present larger Company in 1894; the business has continued to increase rapidly, and has far outgrown the capacity of the Works at Thames Ditton. The horse-power of Engines ordered, in recent years, is as follows:—

| | | | | |
|---|---|---|---|---|
| Old Company | 1891 | 11,100 | indicated | horse-power. |
| | 1892 | 13,800 | ,, | ,, |
| | 1893 | 18,950 | ,, | ,, |
| New Company | 1894 | 26,624 | ,, | ,, |
| | 1895 | 27,883 | ,, | ,, |

The orders in the present year show a great advance upon the above rate of increase. In the first four months of 1896 the horse-power ordered exceeded that for the whole of 1895. Besides the Willans engine, the Company possesses another valuable speciality in the Niclausse water-tube boiler, which it is intended to manufacture upon a large scale at Rugby.

The net profits of the new Company for two years of its existence, including interest paid upon Debentures and Mortgages, taken over from the old Company, all since paid off, have been:—

| | |
|---|---|
| 1894 | £15,708 |
| 1895 | 23,275 |

after carrying £5,737 8s. 5d. and £7,531 13s. 7d. to Depreciation Account in the respective years.

Dividends have been paid each half-year at the rate of Seven per cent. per annum upon the Ordinary Shares, and a Reserve Fund, invested in Securities outside the business, has been created to the amount of £7,646; the sum carried to reserve in 1895 was £5,000. The dividends upon the Ordinary Share capital of the old Company from 1889 to its reconstruction at the end of 1893 averaged 7 per cent., and large sums were reserved in addition.

The Works at Rugby, the buildings for which are far advanced, occupy, with approaches, &c., a portion (about eight acres) of a valuable and well-placed site of 24 acres, adjoining the London and North-Western Railway; the remainder of the land is reserved for extensions. As regards both construction and equipment, the works will be of a very complete and substantial character, and the buildings are laid out to allow of rapid and easy extension upon a pre-arranged plan.

The Trust Deed can be inspected at the Offices of the Solicitors, and copies of the Deed and of the Memorandum and Articles of Association of the Company, together with plans of the Freehold Properties at Rugby and Thames Ditton, can be seen at the Company's Temporary London Office.

Applications for the Stock, in sums being multiples of £10, on the Form enclosed with the Prospectus, accompanied by a remittance of the amount of the deposit on the sums applied for, should be sent to Lloyds Bank (Limited), 72, Lombard-street, E.C. Prospectuses and Forms of Application can be obtained from the London Office, and from all Branch Offices, of Lloyds Bank, as well as from the Company's Solicitors; from the Broker; and from the Secretary of the Company, at either the Thames Ditton or the London Temporary Offices.

If the whole amount applied for by any applicant be not allotted, the amount paid on deposit will be appropriated towards the sum payable on Allotment. In the case of an applicant to whom no Allotment is made, the deposit will be returned in full. Failures by allottees in payment at the due date of any instalment will render the Allotment liable to cancellation and the previous payments to forfeiture.

Certificates will be issued by the Company as soon as possible after the payments are completed.

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25th May, 1896.



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Canvassing members of the Council will disqualify a candidate.

St. Peter's Churchyard, Silver-street, Lincoln, 18th May, 1896.

H. K. HEBB, Clerk of the Urban Sanitary Authority and Deputy Town Clerk.

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The appointment will date from September 29th, 1896, but the candidate appointed will be expected in the meantime to consult with the Principal as to the equipment and organisation of the Department.

Conditions of appointment, and forms of application, may be obtained from the Secretary, at the Institute, Holloway-road, London, N.

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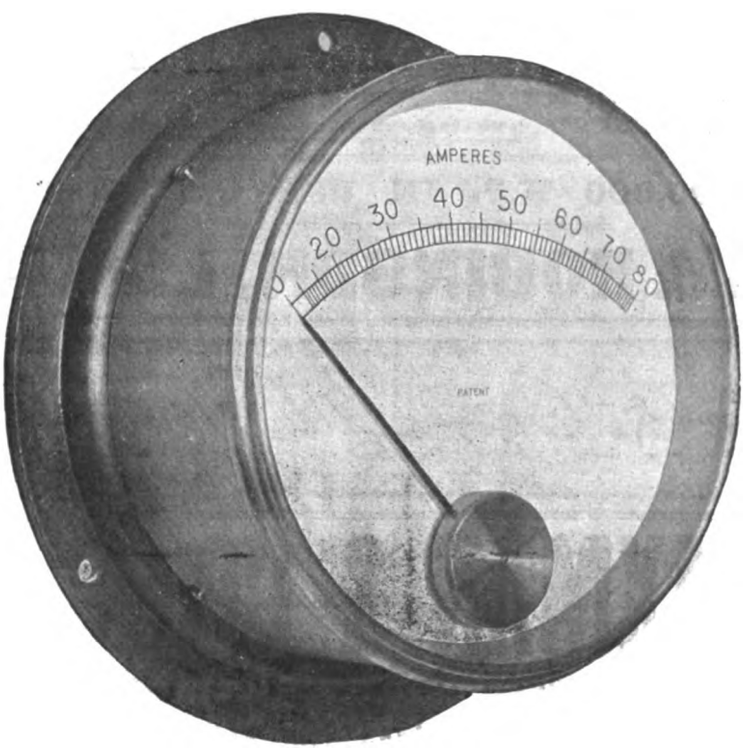


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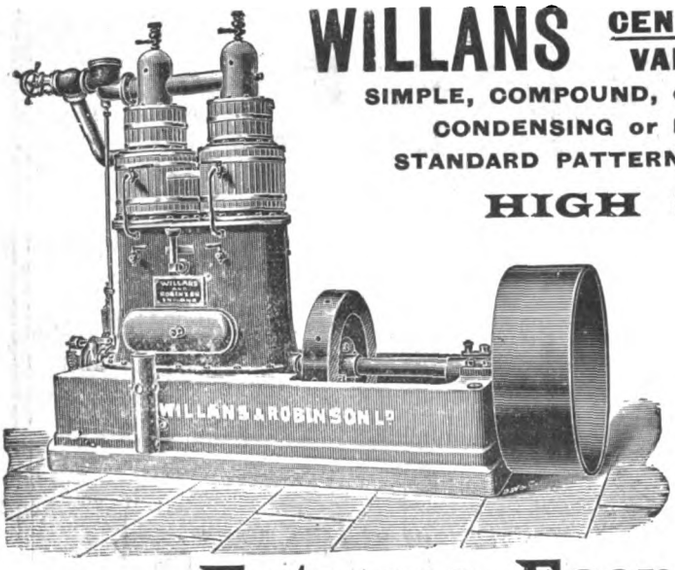


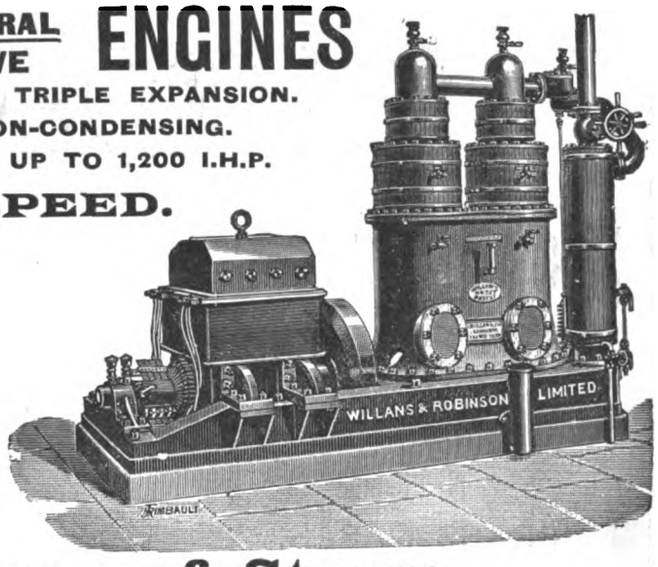


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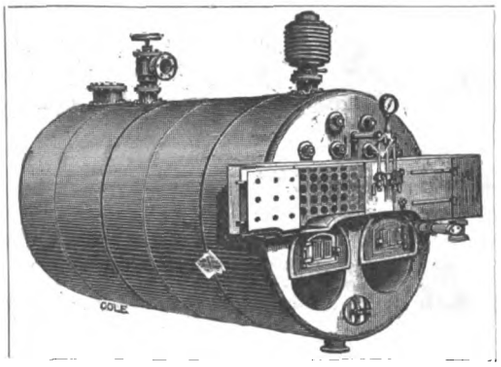

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 941. [Vol. XXXVII. No. 5.] FRIDAY, MAY 29, 1896. PRICE SIXPENCE.

## NOTES.

In another column will be found the alterations in the Articles of Association of the Institution of Electrical Engineers, which the Council propose to submit to the Members at the Special General Meeting to be held this afternoon. It would certainly be possible to suggest still further improvements; but the alterations, as they stand, are a notable and generous concession to the demands of those who, like ourselves, have long advocated a liberal measure of reform in the machinery of the Institution.

In the future there will be a regular and sufficiently rapid flow of members through the Council chamber; greater opportunity will be afforded to add to the Council's annual list and to discuss the affairs of the Institution; and, lastly, the voting power of Past-Presidents will be reduced to a reasonable amount. To our mind the way in which this last and most important reform has been achieved reflects great credit on the statesmanship and good feeling of the Council. The complete disfranchisement of a particular section of the community always savours somewhat of red-revolution; it invariably causes bad blood and paves the way for reaction. The Council avoids all this by the simple and politic process of giving votes only to the four senior Past-Presidents present at any meeting of Council. The proviso by which the immediate President retains his vote for a year is also an excellent one. The rule that when candidates for the Council are nominated by outside members their names and those of their supporters shall be shown separately, is to be commended; it will tend to prevent unnecessary and undesirable additions to the house list, and, moreover, Council cannot, in common fairness, be expected to father other than their own recommendations.

On the other hand, it is to be regretted that it has not been thought expedient to confine the proceedings at the Annual General Meeting solely to the reception of the Annual Report of Council, to the passing of the accounts and to the consideration of the affairs of the Institution. In peaceful times there might not, indeed, be much to say, but we believe that if members knew one evening every year would be allotted to the amicable discussion of questions concerning the management and welfare of the Institution, many valuable suggestions would be forthcoming, and many grievances would be nipped in the bud. It is pleasant to think that good sense has prevailed, and an unedifying wrangle been avoided.

As the time approaches when the scientific and technical societies will commence their summer vacation, increasing activity in electrical matters prevails among them. What promised at the beginning to be a somewhat dull session has proved to have been full of interesting and useful matter relative to electrical theory and practice. On Friday last, at the meeting of the Physical Society, no less than three electrical Papers were read, while later in the same day Prof. EWING delivered before the Royal Institution his popular lecture on "Hysteresis."

A LONG string of topical jokes served to introduce Prof. EWING'S *bizarre* subject. There had been, he said, an all-night sitting of the House of Commons and an all-night standing of the great Wheel, both of which were due to a form of hysteresis —internal friction. There had been "angelic whisperings" into his ear previously to the lecture, by a lady who was curious to know whether the lecture was to be on "hysterics, hypnotism and whisperings of the angel GABRIEL," but he regretted that he had heard no angelic whisperings—since she ceased to speak. In a recent lecture Prof. KENNEDY had said there was hysteresis in everything, while only a few days ago the editor of an art magazine had declared he could not find "hysteresis" anywhere, not even in OGILVIE'S dictionary—whether of the two was correct? And since joking served so well to start his lecture, Prof. EWING decided to be humorous at its close, when he told his audience that "if while he had been engaged in delivering one difficult sentence they had been occupied in trying to understand the one which had preceded it, they were but exhibiting in their own minds a form of—hysteresis!"

BUT though beginning and ending in this light and happy vein of humour, the lecture was by no means devoid of solid and instructive matter. A subject difficult to treat of in a popular manner was handled with masterly care and discretion, the mysteries of the B – H curve being unveiled in language that must have been intelligible to even a non-technical audience. Or, if language failed to help them, there was the actual curve itself on the wall, outlined by a curve-tracer of dazzling light, to say nothing of the colony of wobbling little magnets whose shadows the lantern threw upon the screen. Indeed, the experimental illustrations afforded by Prof. EWING'S ingenious instruments were both numerous and effective. Of special interest was the experiment which reproduced the conditions, first pointed out by

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SWINBURNE and subsequently verified by BAILY, under which a mass of magnetic metal, rotating in a magnetic field, does not exhibit hysteresis. Nor, though the lecture was in the main directed to the unscientific and non-technical hearer, were the leaders of science who were present allowed to go empty away; for Prof. EWING hazarded a hypothesis, not altogether new, which might be expected to give them plenty of food for reflection, viz., that all friction is in the nature of hysteresis arising from the breaking up and rearrangement of molecular chains, the forces binding which together are not magnetic but electrostatic. For ourselves, we are more impressed with the ingenuity of the suggestion than convinced of its truth.

PROBABLY the most important matter brought before the Physical Society on Friday last was the Paper by Prof. VIRIAMU JONES on "The Magnetic Field due to an Elliptical Current at a Point in the Plane of the Ellipse." The Paper itself, being of a mathematical character, was not read; but one of its most important consequences was discussed, viz., that by the aid of the correction for ellipticity which Prof. JONES thereby had been enabled to apply to his method of evaluating the ohm, the international ohm had been brought more nearly into accord with the true ohm. The original evaluation obtained by Prof. JONES was 106·309cm. of mercury, while the correction now applied reduced the length of the mercury column to 106·302cm. This practical outcome of the Paper is sufficient answer to Mr. WALKER'S absurd statement that the Paper was unfitted for presentation to the Physical Society, and should have been taken to the Mathematical Society. There is an obvious difference between physical research by the aid of mathematics and purely mathematical research.

MR. APPLEYARD'S Paper on "Dielectrics" chiefly interested the members present on account of the use of Mr. PRICE'S guard ring which had been made in the investigations described. In order to eliminate error due to surface leakage over the core end in testing a length of cable, a guard ring, placed so as to intercept the surface leakage, was used. Prof. AYRTON pointed out that when this ingenious device was adopted, it was no longer necessary to prepare the cable end in the careful manner that had been the time-honoured custom, and thus a great deal of time might be saved when making cable tests. Some discussion arose as to the best method of preparing a cable end when a guard ring is not used. Prof. AYRTON stated that it had been formerly his custom, as we know it also has been the custom in other places, to cover the well cut end with filtered paraffin wax; but Mr. APPLEYARD preferred to wash the insulation with naphtha, and not to apply any paraffin wax. Fortunately, it does not much matter which of these methods is the better, for Mr. PRICE'S guard ring is so efficacious and so easily and quickly used that we doubt if anyone would now perform a test on a cable end without employing it.

WE transcribe elsewhere certain portions of an estimate of the manufacturing cost of calcium carbide, based on data obtained under conditions precluding biassed observation, at the Willson Aluminium Company's works, at Spray, Rockingham County, North Carolina. The figure arrived at, viz., £7. 4s. per ton of crude calcium carbide, yielding about 80 per cent. of its theoretical output of acetylene, is a good deal more favourable than any previous estimate having a similar right to be considered trustworthy, while it is correspondingly less favourable than the glowing figures freely published on very slender authority a few months back. Any enterprising Briton intending to manufacture acetylene, and confident of a market at the rates implied by this estimate, should study the report in full, and especially consider those relations of cost of power to cost of raw materials which are there fully worked out and even crystallised into empirical formulæ. The calculation of the cost of generating, purifying, collecting and compressing the ultimate product acetylene still awaits the advent of a competent and unprejudiced observer possessed of the necessary opportunities. Meanwhile, the fact announced in a companion article that the calcium carbide works at Niagara Falls have been started, and that it is expected to be able to supply the carbide at $23 per ton, leads us to hope that this further information will soon be available.

SOME curious results have recently been obtained by Mr. T. A. VAUGHTON with an electric current passing through a light cantilever spring, making an electrical contact at the point of support. In certain circumstances, which are stated in the account of these experiments Mr. VAUGHTON contributes to our columns this week, when the spring is artificially set in vibration the passage of an electric current maintains it in vibratory motion. The action appears to be analogous to that of the well-known Trevelyan rocker, which consists in a heated mass of metal of such a shape that when placed on a surface which will rapidly conduct away the heat it is thrown into vigorous rocking, and emits a musical note. There is also, we suspect, some connection between the curious phenomenon investigated by Mr. VAUGHTON and the remarkable change in friction at an electrical contact between certain substances, which was first detected by EDISON, and used by him in his chalk telephone receiver.

**Obituary.**—Mr. Francis Rudall, who for many years was the telegraphic engineer to the London, Chatham and Dover Railway, died on Tuesday, May 19th, at the age of 69, at his residence at Anerley.

**The P.Q. Atlantic Cable.**—The "Seine" has restored communication across the Atlantic by this cable. The deep water repair was completed on Friday last, and we understand that the "Seine" is now on her way home.

| **Cable Interruptions.** | *Date of Interruption.* |
|---|---|
| Puerto Plata—Martinique ..... ..... | Dec. 19, 1895. |
| Ceara—Maranham ..... | April 28, 1896. |
| Monte Alegre—Santarem ..... ..... | May 5, 1896. |

**Lectures at the Berlin Industrial Exhibition.**—The administration of the Berlin Exhibition, under the presidency of Dr. Bödiker, has made arrangements with several well-known scientists to deliver lectures every evening throughout the exhibition season, with the exception of Sundays. From a full list of the lectures, published by the *Elektrotechnische Zeitschrift* this week, we find that a very wide range of subjects is covered.

**Bavarian Exhibition at Nuremberg.**—As at the other German exhibitions electricity plays an important part in the Nuremberg Exhibition. Besides the lighting of the buildings and the grounds several interesting electrical exhibits by Bavarian manufacturers are on view. A three-phase trans-

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mission plant, running at 41,000 volts, erected by Messrs. Schuckert and Co., is shown at work. A continuous-current transmission plant at 3,000 volts is run with a single generator. The Pollak system of charging accumulators by alternating currents is shown on a large scale. A Nuremberg toy factory shows the wholesale manufacture of toys with electrically-driven tools.

**Electric Mountain Railway at Zermatt.**—A company has been started for the construction of an electric rack railway from Zermatt up the Gornergrat. This eminence is about 10,500ft. high, and is a well-known point for obtaining a good view of the surrounding Alps. The railway will be six miles long, and will have an average gradient of 15 per cent. and a maximum gradient of 20 per cent. Each train is to consist of two cars and to carry 100 passengers. The time for either journey will be two hours. Power will be obtained from the Findelen river. The total cost of the line is estimated to be about £140,000, and the opening of the line is expected to take place in 1898.

**The New Paris-London Telephone Line.**—We are able to state that the negotiations between the British and French Governments for the formation of a new telephone line between London and Paris are approaching completion. The route selected for the new line will probably not differ substantially from that of the existing telephone line; and, as is now occasionally done on the present system, the new system will when necessary be used for simultaneous telegraphic and telephonic service. It is stated that the French Government has entered into an arrangement with the Paris Stock Exchange, by which the latter undertakes to pay the French share of the costs of the system.

**Electric Traction in Germany.**—Electric traction on the overhead system is making rapid progress in Germany. Not a week passes but we read of one or two new lines being opened or old horse lines converted into electric lines. It is not surprising that tramway companies and municipalities are adopting electric traction, seeing what profit has already been obtained with it. Several of the concerns are now paying dividends of 8 and 10 per cent. A few days ago an electric tramway was opened at Kiel. The total length of the line is about 12 miles, and there are to be 35 motor cars and 18 trailers in the full service. The system employed in this instance is the overhead trolley of the Allgemeine Electricitäts Gesellschaft.

**Telephone Facilities on Tramways.**—A simple system of telephone communication between tramcars and the superintendent's office has, says the *Electric Railway Gazette* of New York, been put into operation on the Bangor, Orono and Old-town Railway, Bangor, America. It consists of hanging a telephone wire alongside the trolley wire a sufficient distance away to insure immunity from accidental contact between the two. Each car is provided with a set of telephone instruments, which may be connected across from the trolley to the wheels when desired, but which are, of course, normally cut out. When a conductor desires to communicate with the office the car is stopped, the trolley is transferred from its own wire to the telephone wires alongside, and the telephone set is put in circuit.

**Gas Accident at Southsea.**—The Portsmouth Electric Lighting Committee has received a report from Major Cardew relative to the recent accident when a cabman was injured by an electric shock from a lamp column. Major Cardew reported that he had examined the column and switch and found them in perfect order, the explosion being due to an escape of gas. There was no electric leak, but gas had escaped from a pipe which was found to be broken in two, and passed through the ducts to the column. When the arc light was turned out, and the incandescent lamps switched on, the gas exploded, and this was the cause of the accident. The injured man showed signs of electric shock, the muscles of his right arm being contracted; and Major Cardew having laid the matter before Lord Kelvin, the reply was that flame was a conductor of electricity, and that the current had been communicated to the man in this way.

**The Specific Heat of Electrolytic Solutions.**—An interesting investigation on the specific heat of solutions has, says *Nature*, been given by Herr G. Tammann in the *Zeitschrift für Physikalische Chemie*. It is well known that weak solutions of certain electrolytes have a smaller capacity for heat than the water present in them possessed previously to the introduction of the salt, and the object of the investigation is to establish a connection between this phenomenon and the contraction of volume which accompanies the process of solution. This contraction has often been accounted for by the hypothesis of a certain internal molecular pressure. Herr Tammann calculates the specific heat of the water present in a number of solutions of this class on the supposition that their pressure is the *increased* pressure postulated by the above theory, and he also calculates the specific heat of the dissolved substance, that of the mixture being deduced by adding the thermal capacities of the two components. The theoretical values thus obtained are found to agree closely with the values experimentally found by observing the solutions themselves, and it is inferred that contraction is the sole cause of the diminution of specific heat arising from the presence of the dissolved matter.

**Cable v. Electric Traction.**—Some of the disadvantages of cable traction, says the *Electric Railway Gazette*, of New York, have been clearly demonstrated by a recent accident on the Broadway cable line. "A strand in the cable broke and promptly caught in the grip die of a neighbouring car, which at once became a runaway. The cable was stopped, and after a ten-minutes interval the relief cable was adjusted and traffic resumed. Then another strand broke and caught the grip of the nearest car with unfailing precision. The car proceeded up town, smashing the smaller vehicles and pushing aside the larger ones. As it continued in its destructive career it accumulated both cars and momentum. Fully seven cars were incorporated in this battering ram before the cable was stopped. The street was strewn for blocks with wreckage. The relief cable was a new one, and no such accident was anticipated. No one was killed, but many were injured and much damage to property was caused. It is difficult to imagine an equally destructive accident on the lines of an electric traction system. With every improbable occurrence exaggerated to the utmost, this common cable road accident stands unrivalled."

**Lord Kelvin's Jubilee.**—The following is stated by *Nature* to be the programme of the jubilee celebrations of Lord Kelvin's professoriate at Glasgow. On the evening of Monday, June 15th, at 8:30 p.m., the University will give a conversazione, when there will be an exhibit of Lord Kelvin's inventions. On Tuesday, June 16th, addresses will be presented to Lord Kelvin by delegates from home and foreign University bodies, from several of the learned societies of which he is a member, from student delegates from other universities, and from the students and graduates of the University of Glasgow. It is expected that the honorary degree of LL.D. will be conferred on the same day on several of the distinguished foreign visitors. On Tuesday evening, June 16th, the city will give a banquet to Lord Kelvin, to which the visitors who have come to do him honour have been invited. On Wednesday, June 17th, the senate of the University will invite the visitors of the University staff to sail down the Clyde. The students of the University also invite the student delegates from other Universities to a similar trip. Representative scientific men—about 50 in number—from America and the British colonies, and from all the European countries, and about 150 from the United Kingdom have signified their intention to the present.

**The Beauchamp Tower Search-Light Platform.**—Admiral Henry Boys presided recently at a meeting held at the Royal United Service Institution, when Mr. Tower described his hydraulic apparatus for providing a steady platform at sea for search-lights, &c. Those present included Vice-Admiral Lord Charles Scott, Captain Count Loratelli, Mr. Brunel and Mr. Thornycroft. The first practical machine was fitted up on a small steam yacht, 50ft. long and 11ft. beam, and was subjected to a laborious course of experiment, extending over about two years. It was experimented with by the officers of Her Majesty's ship "Vernon" as a means of mounting search-lights, and by the officers of Her Majesty's ship "Excellent" as a means of mounting machine guns. In both cases their reports showed that the machine answered the purpose for which it was designed perfectly. After these experiments, a machine for mounting

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a 24in. search-light projector was ordered by the Admiralty to be fitted to Her Majesty's gunboat "Bloodhound," tender to Her Majesty's ship "Vernon," for further experiment, which showed that the machine could be depended on to keep a search-light ray absolutely steady on a small vessel in a heavy sea, and further favourable reports were sent to the Admiralty on the subject. Since then Sir W. G. Armstrong, Mitchell and Co. had taken up the manufacture, and were fitting the device to the torpedo-destroyers "Swordfish" and "Spitfire," which they were constructing for the Navy. They were also supplying Tower platforms to the order of the Chilian Government for a cruiser building at Elswick.

**Gas-Driven Electric Supply Stations.**—Commenting on our last week's editorial notes on the recently published accounts of the Belfast gas engine electric supply station, in which we analysed these accounts, the *Journal of Gas Lighting* publishes a long leading article, in the course of which it makes the following observations:—

> How pleased and proud Denny Lane would be, were he alive to see this justification of his views in this regard! These results show that where gas can be had for anything like the same price, it is far better for a small electric lighting undertaking to try gas power, at any rate for a start, than to put down steam-engines, which cannot possibly be worked at first, if ever, at an economical load. The difficulty of the "peak of the load" will always remain in the path of small electric lighting companies; and, unless satisfactorily negotiated, it will effectually bar their way to dividends. The gas engine is the very thing to remove this trouble. It is only to turn the gas key, and the power is there at the instant; while a suitable accumulator will fill up the gap by day and after midnight. It may be said, of course, that this is to throw the burden of the load factor upon the gas supply. But a little thing like this will not make the slightest difference to a gas undertaking, the proprietors of which would as soon sell gas to an electric lighting company as to any other consumer. We are not now, and we never have been, in favour of a gas company venturing upon an electric lighting branch department. All the same, there is no reason why the company should not offer every facility to those who provide or use electricity for lighting purposes, in the form of cheap gas and plenty of it. It is painful to see a corporation or private electric lighting station standing almost idle for the greater portion of the 24 hours, or working under ruinous conditions, while the gas-main that passes by the doors has within it the potentiality of curing the worst of the electricians' troubles. Why should a small county town—like Kingston-on-Thames, for instance—go to the ridiculous expense of a steam-power electricity generating station, with little or nothing for it to do, while the gas company could supply all the power needed for trying the experiment of whether the district needs electric lighting at the minimum of expense to the unfortunate rate-payers? Truly, the history of municipal enterprise in the way of electricity supply furnishes still another illustration of the truth of the exclamation: "With what little wisdom are we governed!"

**The E.M.F. of the Clark Cell.**—The February number of the *Journal de Physique* contains a Paper, by M. C. Limb, on the determination of the electromotive force of a Clark cell in absolute measure. Instead of adopting the usual method, which is to compare the difference of potential at the ends of a known resistance when traversed by a known current with that of the cell, the author, says *Nature*, has adopted a novel method which is independent of the units of current and resistance. A magnet is rotated inside a long helix about an axis perpendicular both to its own magnetic axis and the axis of the coil. The magnetic moment of the magnet is determined by Gauss's method. If H is the field which would be produced at the centre of the long coil if the spirals were traversed by unit current, $\omega$ the angular velocity of the magnet and M its magnetic moment, then the maximum value of the electromotive force induced in the coil will be $H M \omega$. A correction has to be applied on account of the finite length of the coil which involves the distance between the poles of the magnet. The angular velocity is measured by simultaneously registering the turns made by the magnet and the beats of a seconds pendulum, the velocity being maintained constant by a specially-designed tachyometer. By means of a commutator fixed to the axle of the magnet, the circuit of the coil is only closed at the moment when the induced electromotive force is a maximum. This maximum electromotive force is compared with that of the cell by means of a modified form of Clark potentiometer, a Lippmann capillary electrometer being employed to indicate when the balance is secured. This electrometer is capable of indicating a difference of potential of 0·0005 volt. The Clark cell was of the H pattern, and the author gives as his final result for the electromotive force of this form of cell at 0°C. the number 1·4535. The number obtained by Lord Rayleigh was 1·4527 volts.

**An American Combined Gas and Electric Fitting Patent.**—Judge Coxe, says the *Electrical World*, gave judgment on March 10th in the case of George Maitland *v.* Archer and Pancoast, which sustains the Stieringer patent for improvements in electrical fixtures. The point at issue was the validity of a patent claim for an electric light fixture, wholly or largely of metal, provided with insulating conducting wires conveying current to lamps thereon, in combination with an insulating joint at the upper end of the fixture. Judge Coxe in his opinion says that he is convinced that Stieringer was the first to make the use of gas chandeliers a practical success in the art of electric lighting; that while prior structures were not only dangerous, but awkward and ungainly, that of Stieringer is absolutely safe, and at the same time preserves the symmetry and graceful contour of the fixture. "When," he says, "the conditions surrounding the genesis of electric lighting are remembered, it can hardly be denied that the man who yoked the old with the new, and fully developed the art of electric lighting, was something more than a mechanic. It is plain that he who utilised for electric lighting the expensive and intricate gas light systems then existing, and the fixtures which embodied a multitude of graceful designs, took a long step forward. He made electric lighting cheap, convenient, simple and safe. . . . A number of accomplished inventors were at work on this very problem. They accomplished nothing. Stieringer succeeded. It is not an unreasonable presumption that one who succeeds in doing what so accomplished an inventor as Edison failed to do is on a distinctly higher plane than a mechanic. Not only did Edison fail himself, but he was among the first to acknowledge the merits of the invention, practically as well as theoretically, for his firm took out a licence under Stieringer's patent." The opinion proceeds to say that Stieringer's joint, located at the ceiling, seems to be regarded as one of the absolutely essential features, where an internally-wired metal fixture is used. The court defines the combination in suit as having the following elements:—First, a metallic fixture for electric lights, containing insulated conducting wires; second, an insulated joint, located at the upper or inner end of the fixture, and having metallic coupling portions and an intermediate section of insulating material; third, the grounded piping of a house, by which the chandelier is thus supported. The decision is that this claim is infringed, and the complainant is entitled to the usual decree.

**Contemporary Electrical Science.**—A simple and ingenious device for measuring the frequency of an alternating current is described by T. Wulf in the *Wiener Berichte*. A Mariotte flask with a narrow tube is mounted on an iron stand. The water flows out through the tube in a fine jet. An electromagnet excited by the current is placed close to the iron stand. This vibrates with each alternation, and breaks up the jet into a series of drops varying in size according to the frequency. By rotating a stroboscopic disc in front of the jet a speed may be found at which the drops appear stationary. This speed measures the frequency.——M. Ch. Margot describes a process for copper-plating aluminium in the *Archives des Sciences Physiques et Naturelles*. The difficulty has always lain in overcoming the resistance of the alumina formed. The plate is cleaned in a warm solution of an alkaline carbonate. This makes it rough and porous. It is then washed in running water, dipped in a hot 5 per cent. solution of hydrochloric acid, washed and dipped into a dilute acidulated solution of copper sulphate until it has a slight coating of copper. It is washed again, and dipped once more into the copper sulphate, and a current is sent through the solution. The metal then takes a coating of copper of any thickness desired.——A Bonn physicist, rejoicing in the name of Krummenacker, has investigated the surface resistance of glass. An abstract of his dissertation appears in *Wiedemann's Beiblätter*. Surface resistance, he finds, depends upon the moisture of the surrounding air, and this can be governed by placing the glass in a closed vessel over sulphuric acid of various degrees of concentration. Employing Siemens's condenser method, he obtained for the surface resistance of 1sq. cm. of lead glass 6,000 megohms. For soda glass it was 700 megohms. Glass left to solidify was less conducting than polished glass. The highest surface conductivity was obtained with fractured and with ground glass.

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## ELECTROMAGNETIC THEORY.—LXXXVI.*

BY OLIVER HEAVISIDE.

(*Continued from page 849, Vol. XXXVI.*)

§ 346. The preceding electrical reasoning will enable us to understand the results produced in the formulæ when the inner boundary is shifted to the origin. At the same time they do not absolve us from making the examination, because without it we cannot say what special form is assumed when the terminal condition is potent.

In the original formula (22) put $\lambda=0$. There are three results. If $n$ is not less than 1, we get $a=-\sin m\pi$. If $n$ is not greater than $-1$, we get $a=+\sin m\pi$. In the intermediate case, when $n$ is between $-1$ and $+1$, we get

$$a=\sin m\pi\,\frac{1-u}{1+u},\quad\text{where}\quad u=\frac{Z_0q}{Z}\left(\frac{2}{q}\right)^n\frac{\lfloor m}{\lfloor -m-1}. \tag{78}$$

That is, in the first case the $x$ function in (22) reduces to $2I_{mx}$; but in the second case to $2I_{-mx}$; whilst in the intermediate case $Z_0$ remains potent, and $a$ has the special value shown in the last equation.

From the above may be derived the changes in the other formulæ, or they may be done separately. Thus, in the alternative formulæ (32) and (50), which are connected by

$$-f=\frac{r\sin m\pi}{1+r},\qquad -g=\frac{s\sin m\pi}{1+s}, \tag{79}$$

we have $r=0$ when $n>1$; $r=\infty$ when $n<-1$, and $r=u^{-1}$ intermediately, $u$ being as in (78). Therefore $s=0$, or $g=0$, is the reduced form of the determinantal equation when $n>1$, or $b+\sin m\pi=0$, or

$$(I_m+BI_{m+1})_e=0,\quad\text{or}\quad(J_m-B'J_{m+1})_e=0. \tag{80}$$

Also, when $n<-1$, the determinantal equation is $s=\infty$, or $g+\sin m\pi=0$, or $b-\sin m\pi=0$; or

$$(I_{-m}+BI_{-m-1})_e=0,\quad\text{or}\quad(J_{-m}+B'J_{-m-1})_e=0. \tag{81}$$

As regards $a$ in (61) when $\lambda=0$, first we have $a=0$ when $n>1$. Then $a=-\tan m\pi$, when $n<-1$. Intermediately

$$a=\frac{-\sin m\pi}{\cos m\pi+v},\quad\text{where}\quad v=\frac{Z_0s}{Z}\left(\frac{2}{s}\right)^n\frac{\lfloor m}{\lfloor -m-1}. \tag{82}$$

So, in the first case, we have

$$V_1=\frac{\frac12\pi Zh}{(xy)^m}J_{mx}\left(G_{my}-\frac{J_{my}}{\beta}\right),\qquad(n>1) \tag{83}$$

and $\beta=0$ is the determinantal equation of normal systems; the same as (80).

In the second case the $x$ function is $J_{-mx}/\cos m\pi$, and

$$V_1=\frac{\frac12\pi Zh}{(xy)^m}\,\frac{J_{-mx}}{\cos m\pi}\,\frac{\beta G_{my}-J_{my}}{\beta+\tan m\pi},\qquad(n<-1) \tag{84}$$

whilst the determinantal equation is equivalent to (81).

Intermediately, using $a$ as in (82), the determinantal equation $a=\beta$ is represented by

$$(J_{-m}+B'J_{-m-1})_e+v(J_m-B'J_{m+1})_e=0, \tag{85}$$

where $v$ is as in (82), and $B'$ is $Z_1s^n/Z$, as before.

As a test of avoidance of error in the way of wrong factors, make $n=0$, or $m=-\frac12$ in the last equation. It reduces to

$$\tan sl\,(1-Z_0Z_1s^2/Z^2)+Z_1s/Z+Z_0s/Z=0. \tag{86}$$

Comparing with (75), § 293, we find proper agreement, allowing for the present generalised meanings of Z and $s$ compared with their meanings in that place.

The peculiarities of infinite resistance or permittance at the origin with suitable values of $n$ place restrictions upon the restraints possible. The source at $y$ cannot raise the potential at the origin above zero when $n$ equals or is less than $-1$. We may, however, also have the potential zero there when $n$ is greater, namely, up to just less than $+1$, but then it must be done by external restraint, through $Z_0=0$, being equivalent to a short circuit if a pair of conductors be in question. But when $n=$ or $>1$ it is no use trying to make the potential vanish.

Similarly, the current at the origin due to the source at $y$ vanishes naturally when $n=$ or $>1$. We can also make it vanish there when $n$ is less, down to just over $-1$, by external restraint, through $Z_0=\infty$. It is equivalent to a disconnection in the case of wires. But it is no use trying to make the current vanish when $n$ equals or is less than $-1$.

Equation (85) only applies when $n$ is between $-1$ and $+1$, but it harmonises with the proper forms outside those limits. Thus $v$ vanishes when $Z_0$ does, which makes the potential be zero terminally, provided $n$ is intermediate, and then (85) reduces to (80). Also, if $Z_0$ is infinite (85) reduces to (81), the other form.

If we impose the condition $V_2=0$ at $l$, then $B'=0$, and (85) becomes

$$(J_{-m}+vJ_m)_e=0,\quad(-1>m>0\ \mathrm{Km}<0). \tag{87}$$

If, in addition, $V_1=0$ at origin by external restraint, then $J_{-ml}=0$ is the determinantal equation. This is replaced by $J_{ml}=0$ if the current is zero at the origin by external restraint.

§ 347. The development in Bessel series when $h$ is steady or impulsive is to be done in just the same way as for Fourier series, which department has been somewhat elaborated. So little need be said about it. First find the final steady state, when there is one, as is nearly always the case in practical problems. Let this be $V_0$. Then apply the $p(d/dp)$ operation to the denominator $a-\beta$ (or other form) in the operational solution, according to the expansion theorem. Thus, using (61), and supposing $h$ to be steady, beginning when $t=0$, we expand it to

$$V_1=V_0+\sum\frac{\frac12\pi Zh}{(xy)^m}\,\frac{(J_m-aG_m)_x(J_m-\beta G_m)_y}{p(d/dp)(a-\beta)}\,\epsilon^{pt}. \tag{88}$$

The values of $p$ being the roots of $a=\beta$, over which the summation ranges, we see that either $a$ or $\beta$ may be eliminated from the numerator. The interchange of $x$ and $y$ makes no difference. Therefore the formula for $V_2$, on the right side of the source at $y$ is just the same as for $V_1$ as far as the summation goes. It can only differ in the expression of the steady part $V_0$.

In passing, it may be remarked that cases may arise in which there is no tending to a steady state. For instance, if the above refers to a circuit consisting of a pair of parallel wires, and the insulation is quite perfect intermediately and terminally, then the effect of $h$ accumulates incessantly, and $V_1$ rises to infinity. The outside term then contains $t$. But such exceptional cases need not delay us here, but can be treated when they arise. At present assume that there is a steady state tended to. There must be one when the source is impulsive, and there is waste of energy in some part (no matter how limited) of the connected system, and there must be one with a steady source unless there is perfect insulation in the way mentioned.

Now in (88) the J and G functions concerned have $sx$ for argument, and the values of $s$ are settled by the determinantal equation. Also $s^2$ is a function of $p$, and so is Z. The further development therefore rests upon the nature of Y and Z in the original circuital equations, for we naturally want to have the result entirely in terms of $s$. If $Z=R$, and $Y=Sp$, we have diffusion, with one value of $p$ for one of $s^2$. Then

$$s^2=-RSp,\quad\text{and}\quad\frac{d}{dp}=-\frac{RS}{2s}\frac{d}{ds}. \tag{89}$$

This brings us to

$$V_1=V_0-\sum\frac{\pi Qs}{S(xy)^m}\,\frac{(J_m-aG_m)_x(J_m-\beta G_m)_y}{(d/ds)(a-\beta)}\,\epsilon^{pt}, \tag{90}$$

where the value of $p$ in the time function is $-s^2/RS$.

If $a=0$, which occurs naturally when $n$ is 1 or more, the last reduces to

$$V_1=V_0+\sum\frac{\pi Qs}{S(xy)^m}\,\frac{J_{mx}J_{my}}{d\beta/ds}\,\epsilon^{pt}, \tag{91}$$

where $\beta=0$ finds the values of $s^2$ and $p$. If the potential is constrained to be zero at $l$, then $B'=0$ in $\beta$, making $J_{ml}=0$ be the determinantal equation. Also $V_0=0$ now. So

$$V_1=\sum\frac{\pi Qs}{Sl(xy)^m}\,\frac{J_{mx}J_{my}G_{ml}}{J'_{ml}}\,\epsilon^{pt}=\sum\frac{2Q}{Sl^2(xy)^m}\,\frac{J_{mx}J_{my}}{(J'_{ml})^2}\,\epsilon^{pt}, \tag{92}$$

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if the accent denotes differentiation to the argument $sl$. The second form is derived by the conjugate property

$$J_m G'_m - J'_m G_m = -\frac{2}{\pi sl}, \qquad (93)$$

remembering that $J_{ml}=0$. Equation (92) expands an arbitrary form of $x$ to suit the conditions stated. Put $Q=Sy^n v dy$, and integrate with respect to $y$ from 0 to $l$. The result is the V arising from the initial distribution of potential $v$. This also applies when $n$ is smaller, down to just over $-1$, provided $Z_0=\infty$ is imposed terminally.

But if $n$ is $-1$ or less, the solution takes a different form, as before explained. We get, by (57),

$$V_1 = -\frac{\frac{1}{2}\pi R p Q}{(xy)^m}\frac{J_{-mx}(J_m-\beta G_m)_y}{(J_{-m}+B'J_{m+1})_e}(G_m - B'G_{m+1})_e, \qquad (94)$$

with any $Z_1$. So $Z_1=0$, making $B'=0$, makes

$$V_1 = -\frac{\frac{1}{2}\pi R p Q}{(xy)^m}\frac{J_{-mx}}{J_{-ml}}(J_m-\beta G_m)_y G_{ml}, \qquad (95)$$

where $\beta$ is $J_{ml}/G_{ml}$, which makes $V_2=0$ at $l$, $V_2$ being got by interchanging $x$, $y$. The last expands to

$$V_1 = -\Sigma\frac{\pi Q s}{(xy)^m S l}\frac{J_{ml}J_{-my}J_{-mx}}{J'_{-ml}\sin m\pi}\epsilon^{pt}, \qquad (96)$$

subject to $J_{-ml}=0$. The cases in which $m$ is integral had better be kept in terms of $J_m$ and $G_m$. The connection is

$$J_{-m} = J_m\cos m\pi + G_m \sin m\pi, \qquad (97)$$

A companion formula is

$$G_{-m} = G_m\cos m\pi - J_m\sin m\pi. \qquad (98)$$

[See equations (66), (67), (70), (71). But for $\frac{1}{2}m\pi$ in them write $-\frac{1}{2}m\pi$. Also, in (59), $\rho-\sigma$ should be $(\rho-\sigma)\sin m\pi$.]

Equation (96) does not look right. But we have the conjugate property,

$$J_m J_{-m-1} + J_{-m}J_{m+1} = -\frac{2}{\pi sl}\sin m\pi = -J_{-m}J'_m + J_m J'_{-m}, \qquad (99)$$

which may be derived from (29). So, since $J_{-ml}=0$ at present, $J_{ml}$ may be eliminated from (96). This brings it to

$$V_1 = \Sigma\frac{2Q}{Sl^2(xy)^m}\frac{J_{-mx}J_{-my}}{(J'_{-ml})^2}\epsilon^{pt}; \qquad (100)$$

that is, the same form as (92), except in the reversal of the sign of $m$ in the J functions. It is valid when $m$ is $-1$ or less, but the range may be extended up to just under $m=0$ by a terminal restraint making $V_1=0$ at the origin.

§ 348. In the more general case in which R, L, K, S, are all finite, and

$$q^2 = -s^2 = (R+Lp)(K+Sp), \qquad (101)$$

there are two $p$'s for every single $s^2$; thus,

$$p = -j\pm k,\quad j=\tfrac{1}{2}\left(\frac{R}{L}+\frac{K}{S}\right),\quad k=\left\{\tfrac{1}{4}\left(\frac{R}{L}+\frac{K}{S}\right)^2-\frac{RK+s^2}{LS}\right\}^{\frac{1}{2}}, \qquad (102)$$

$$\frac{dq^2}{dp} = -\frac{ds^2}{dp} = S(R+Lp)+L(K+Sp) = \pm 2LSk. \qquad (103)$$

The sum of the two time functions of the form $Z\epsilon^{pt}/(dq^2/dp)$, got by using the above two values of $p$, is therefore

$$\frac{1}{S}\epsilon^{-jt}\left\{\cosh kt + \frac{R/2L - K/2S}{k}\sinh kt\right\} = \frac{\phi(t)}{S}. \qquad (104)$$

To show the application, take the simple case of the potential constrained to vanish both at $\lambda$ and $l$. Then in (90) $V_0=0$, and

$$\frac{d}{ds}(\alpha-\beta) = \frac{d}{ds}\left(\frac{J_{m\lambda}}{G_{m\lambda}}-\frac{J_{ml}}{G_{ml}}\right) = \frac{2}{\pi s}\left(\frac{1}{G^2_{m\lambda}}-\frac{1}{G^2_{ml}}\right), \qquad (105)$$

by using the conjugate property (93), with argument $s\lambda$ or $sl$, as the case may be, and remembering that $\alpha=\beta$.

Therefore (90) takes the special form

$$V_1 = \Sigma\frac{\pi^2 s^2 Q}{2S(xy)^m}\frac{(J_{mx}-\alpha G_{mx})(J_{my}-\alpha G_{my})}{(G_{ml})^{-2}-(G_{m\lambda})^{-2}}\phi(t), \qquad (106)$$

where $\alpha$ is $J_{m\lambda}/G_{m\lambda}$, and $\phi(t)$ is the time function in (104). Its value is 1 when $t=0$, so we can expand any initial state U of potential by (106), by putting $Q=Sy^n U dy$, and integrating.

§ 349. The inclusion of the self-induction in the last makes the magnetic energy operative. The specification of the initial state is therefore incomplete if the potential alone is given. We require to know the initial current as well. Instead of the above $h$, let the source at $y$ be $e$, producing a jump in the potential, thus, $e=V_2-V_1$ at $y$, but with continuity of current, or $C_2=C_1$. To find the result, we need not go through the work in detail, but generalise the former result when the zeroth Bessel function was concerned, § 330. We shall now have

$$V_1 = \tfrac{1}{4}\pi q e\frac{y^{m+1}}{x^m}\frac{(H_m+\alpha K_m)_x(H_{m+1}-bK_{m+1})_y}{b-a}, \qquad (107)$$

$$V_2 = \tfrac{1}{4}\pi q e\frac{y^{m+1}}{x^m}\frac{(H_m+bK_m)_x(H_{m+1}-\alpha K_{m+1})_y}{b-a}; \qquad (108)$$

$V_1$ being on the left, $V_2$ on the right of $y$. We turn $V_1$ to $V_2$ not by interchanging $x$ and $y$, but by interchanging $a$ and $b$ and negativing the result.

The operation $-x^n Z^{-1}(d/dx)$ finds the current. So

$$C_1 = -\tfrac{1}{4}\pi q e\frac{(xy)^{m+1}}{Z(b-a)}(H_{m+1}-\alpha K_{m+1})_x(H_{m+1}-bK_{m+1})_y, \qquad (109)$$

and now $C_2$ is got by interchanging $x$ and $y$.

It is easy to test that these satisfy the conditions at $y$ and terminally, $a$ and $b$ being the same as before, by the conjugate property

$$H_m K_{m+1} + K_m H_{m+1} = \frac{4}{\pi qy} = K_m H'_m - H_m K'_m, \qquad (110)$$

the argument being $qy$, and the accent denoting differentiation to it.

Similarly, to find the solution in terms of $J_m$ and $G_m$, we may derive the results from the last, putting H, K in terms of J and G; but this is tedious, and the results are easily got independently. Thus,

$$V_1 = -\tfrac{1}{2}\pi s e\frac{y^{m+1}}{x^m}\frac{(J_m-\alpha G_m)_x(J_{m+1}-\beta G_{m+1})_y}{\alpha-\beta}, \qquad (111)$$

$$V_2 = -\tfrac{1}{2}\pi s e\frac{y^{m+1}}{x^m}\frac{(J_m-\beta G_m)_y(J_{m+1}-\alpha G_{m+1})_x}{\alpha-\beta}, \qquad (112)$$

show V due to $e$ at $y$. The current on the left of $y$ is

$$C_1 = -\frac{s\pi e}{2Z}(xy)^{m+1}\frac{(J_{m+1}-\alpha G_{m+1})_x(J_{m+1}-\beta G_{m+1})_y}{\alpha\quad\beta}, \qquad (113)$$

and interchanging $x$ and $y$ produces $C_2$. In deriving this we use

$$\frac{1}{s}\frac{d}{dx}\frac{J_m}{x^m} = -\frac{J_{m+1}}{x^m},\qquad \frac{1}{s}\frac{d}{dx}\frac{G_m}{x^m} = -\frac{G_{m+1}}{x^m}, \qquad (114)$$

the argument being $sx$. The continuity in C at $y$ is obvious. The discontinuity in V is easily tested, for we get

$$V_2 - V_1 = \tfrac{1}{2}\pi s y e(J_m G_{m+1} - G_m J_{m+1}) = e. \qquad (115)$$

Since $\alpha$, $\beta$ are as before, the same limitations mentioned apply when $\lambda=0$.

The development in Bessel series is similar. For an initial state of current, let $e$ be impulsive, say $e=p\mathrm{P}$, when P is the momentum generated, as explained in § 327.

Then we get

$$V_1 = -\Sigma\pi s^2 \mathrm{P}\frac{y^{m+1}}{x^m}\frac{(J_m-\alpha G_m)_x(J_{m+1}-\beta G_{m+1})_y}{\frac{ds^2}{dp}\frac{d}{ds}(\alpha-\beta)}\epsilon^{pt} \qquad (116)$$

Here we see that if the potential is made to vanish terminally, and $s^2$ is as in the last section, making two $p$'s to one $s^2$, the two time functions to be added are not the same as before The time function is now $\epsilon^{pt}\div(ds^2/dp)$. The sum of the two is $-(\mathrm{LS}k)^{-1}\epsilon^{-jt}\sinh kt$. So, using this, and (103) and (105) again, we convert (116) to

$$V_1 = \Sigma\tfrac{1}{2}\pi^2 s^3\frac{\mathrm{P}}{\mathrm{LS}k}\frac{y^{m+1}}{x^m}\frac{(J_m-\alpha G_m)_x(J_{m+1}-\alpha G_{m+1})_y}{(G_{m\lambda})^{-2}-(G_{ml})^{-2}}\epsilon^{-jt}\sinh kt, \qquad (117)$$

showing the potential due to the initial momentum P at $y$. Put $\mathrm{P}=Ly^{-n}c\,dy$, and integrate from $\lambda$ to $l$ to show the potential due to the initially given state $c$ of current.

In finding the current due to the initial current, say by the operational solution (113), the presence of Z in the denominator should not be overlooked. Its vanishing introduces another term depending upon $p=-\mathrm{R}/\mathrm{L}$. The interpretation is that if the initial state is $c=$ constant, and we have also

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$V=0$ imposed terminally, the result is a current $ce^{-Rt/L}$ at time $t$.

The case of terminal resistances is also easily managed, and the same may be said of other terminal arrangements so far as formulæ go, provided we choose them so that the energy is either all electric or all magnetic, which will produce real values of $s^2$. But beyond that, with complex values of $s^2$, and terminal energy concerned, the transformations are troublesome. The work will certainly not be undertaken here, for the sufficient reason of want of space, if there were no other. We have done for the present with normal expansions, and now turn over a new leaf.

*(To be continued.)*

## INSTITUTION OF ELECTRICAL ENGINEERS.

The following are the alterations in the Articles of Association of the Institution, which it is proposed to consider at the Special General Meeting of Members only, called for 4 p.m. this afternoon, at the offices of the Institution :—

| Proposed Alterations. | Old Rules. |
|---|---|
| By striking out the word "twelve" in the second* line of the 36th Article, and substituting the word "fifteen." | 36. The Officers of the Institution shall be a President, four Vice-Presidents, twelve ordinary Members of Council, three Associate Members of Council, two Auditors of Accounts, an Honorary Treasurer, an Honorary Solicitor, an Editor of the Publications of the Institution, a Secretary, and a Librarian. |
| By striking out the word "twelve" in the third line of the 38th Article, and substituting the word "fifteen." | 38. The Council shall consist of the President, all Past-Presidents (including Past-Presidents of "the exi-ting Society"), four Vice-Presidents, twelve Members, three Associates, the Honorary Treasurer, and all these (except the three Associates) shall be chosen from the class of Members. |
| By striking out the 40th Article, and substituting the following Article :— | |
| 40. The following Members of Council, namely—the President, one Vice-President, the Honorary Treasurer, five Members, one Associate—shall be elected annually by ballot. They shall retire annually, and, save as hereinafter provided, be immediately eligible for re-election. Provided that no President, Vice-President, Member of Council, or Associate Member of Council shall hold office in the same capacity for more than three years in succession. | 40. The President, Vice-Presidents, Auditors and Treasurer shall be elected annually by ballot, and, with the exception of the President, shall be immediately eligible for re-election; but the President shall be ineligible for re-election to that office during the following year. |
| By striking out the 41st Article, and substituting the following Article :— | |
| 41. The Auditors shall be elected annually by ballot, but shall be eligible for re-election on the expiration of their year of office. | 41. Three Members of the Council and the three Associate Members shall retire annually, and be ineligible for re-election during the following year. |
| By the addition at the end of the 42nd Article of the following words :— | |
| But the Member so chosen shall retain his office so long only as the vacating Member of Council would have retained the same if no vacancy had occurred. | 42. Casual vacancies in the Council during the year may be filled up by the Council and announced at the next meeting of the Institution. |
| By striking out all words after "Council" in the 7th line of the 43rd Article to the end of that Article, and substituting the following words :— | |
| At an Ordinary General Meeting, held not less than twenty-eight days before the Annual General Meeting, the Chairman shall announce the candidates so nominated. Any two Members, supported by eight other Members, may thereupon nominate in writing any duly qualified person to fill any vacancy by forwarding such nomination, together with the written consent of such person to accept office if elected, to the Secretary within seven days after such meeting. Thereupon a ballot list, containing the names of all persons duly nominated to fill the vacancies on the Council, stating which persons are nominated by the Council, and giving the names of the two Members by whom every other person is nominated, shall be forwarded to the Members and Associates of the Institution not less than seven days before the Annual General Meeting; and each Member or Associate shall be at liberty to make a selection from such list, provided the number of names so selected shall not exceed in any case the number requisite to fill the vacancies. Ballot papers shall be so marked and recorded as may be from time to time determined by the Council. | 43. The Council shall, previous to the Annual General Meeting in each year, prepare a list of members whom they propose as suitable for the offices of President, Vice-Presidents, and Treasurer for the ensuing year. The list shall also contain the names of a sufficient number of Members and Associates to fill the vacancies in the Council, and whom the Council nominate as fitted to become Members of the Council.* A copy of such list shall be forwarded to the Members and Associates of the Institution not less than seven days before the Annual General Meeting, and each Member shall be at liberty to make a selection from the list, or to substitute the name or names of any duly qualified persons for each respective office, but the number of names so selected or substituted must not in any case exceed the number requisite to fill the vacancies. |
| By striking out the words from after the word "quorum" in the third line of the 47th Article down to the word "prescribe" in the fifth line of the same Article, and substituting the following words : | |
| The Council may appoint Committees chosen from their own body, and Committees for special purposes consisting of Members of Council and Members or Associates of the Institution and others, with such powers as the Council may prescribe. | 47. The Council shall meet as often as the business of the Institution may require, and at every meeting five shall constitute a quorum.* The Council may appoint sub-committees chosen from their own body, for special purposes, and with such powers as the Council may prescribe.* In the absence of the President, the senior Vice-President, or, if none be present, the senior Member of Council present shall take the Chair at Council Meetings and at Ordinary Meetings. |
| By striking out the words in the 48th Article from the beginning of the Article to the word "vote" in the third line, and substituting the following words :— | |
| 48. Questions shall be decided at any meeting of the Council by the votes of the Members present, each of whom shall, save as hereinafter mentioned, have one vote: provided that, in the event of there being more than four Past-Presidents at any meeting, the votes of the immediate Past-President and the four senior Past-Presidents present and voting shall alone be counted upon any division; but the Chairman shall have a casting vote. | 48. All questions shall be decided in the Council by the majority of Members present, the acting Chairman having a casting vote*; but at the desire, expressed in writing, of any two Members present, the determination of any subject may be postponed to the succeeding Meeting of the Council, but not beyond that Meeting unless required by a majority of such Meeting. |
| By striking out the 50th Article, and substituting the following Article :— | |
| 50. The financial year of the Institution shall end on the 30th of September in each year; and a statement of the funds of the Institution, and of the receipts and expenditure during such financial year, shall be made, under the direction of the Council, each year, and, after having been verified and signed by the Auditors and approved by the Council, shall be laid before the Annual General Meeting next following. | 50. A statement of the funds of the Institution, and of the receipts and payments during the year, shall be made under the direction of the Council to the close of each year; and, after having been verified and signed by the Auditors, shall be laid before a General Meeting as soon thereafter as may be convenient. |

* The reference here, and similar references later, are to the lines in the official printed Articles of Association.—Ed. *E.*

* Word designated in proposed alterations.

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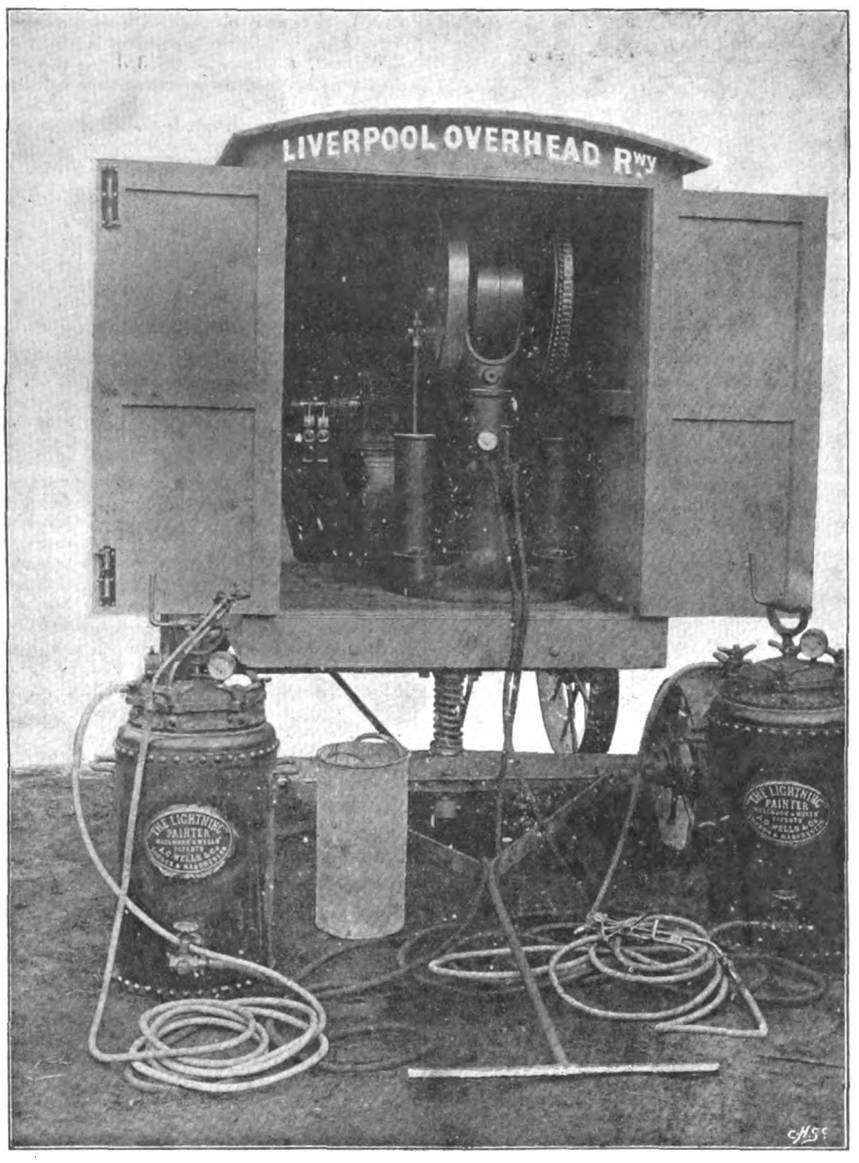
## PORTABLE ELECTRIC PAINTING PLANT FOR THE LIVERPOOL OVERHEAD RAILWAY.

One of the minor but by no means small advantages of an electric system of traction is the existence along the line of power which can be used for driving portable repairing and painting machinery. In any trolley system, or where there is a continuous supply of power by surface conductor rails, as in the City and South London Railway, and the Liverpool Overhead Railway, or again in conduit systems, it is not at all difficult to run an electrically-driven repairing tool by means of power derived by tapping the main power conductor at any convenient point. Thus repairs may be performed more quickly and cheaply than by hand, and heavier repairs than could be done without the aid of motor power can be performed *in situ*.

The latest example of this use of electric power is to be found in a portable painting plant, which has been built by Messrs. A. C. Wells & Co., of London and Manchester, for the Liverpool Overhead Railway. The accompanying illustration has been prepared from a photograph of this plant. Within the car which has been specially built for this painting machine is an electric motor, coupled to the force pump of a Wallwork and Wells spraying painter, together with the paint reservoirs, hoses and auxiliary details. This car can be run on the tramway which lies immediately beneath the overhead track of the electric railway, and by means of flexible cables power can be obtained from the surface conductor on the electric line above. By this means the whole of the extensive girder work on which the electric railway is carried can be covered by the paint spray. Hitherto some 40 hands have been required for painting these girders, and there is little doubt that great economy of time and labour will be effected by the new arrangement. The spraying method, we should mention, is not only used for painting extensive surfaces with a uniform colour, but also, by the aid of stencil plates, it is adopted for painting letters and ornamental work.




Wallwork and Well's Portable Electric Painting Plant.

We understand that for smaller work Messrs. Wells and Co. are making a hand-driven spraying plant, and that their method of spraying the paint, instead of laying it on with a brush, effects considerable economy in the quantity of paint used. Such plants, even when of very small size, if fitted with electric motors, now that power for driving motors is so readily available in large towns, ought to find very general use. They would add one fresh item to the central station engineer's chief delight—a good day load. Though continuous current might be considered preferable, there would be no difficulty in using single-phase alternating currents for this work, as the motors could easily be started by hand.

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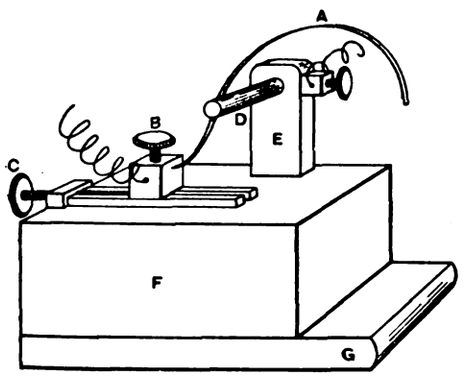
## AN ELECTRICAL TREVELYAN ROCKER.

BY T. A. VAUGHTON.

The following account of what appears to be a new electrical phenomenon which I have been investigating will probably be of interest to the readers of *The Electrician*. In making these investigations I have used an apparatus, of which the accompanying illustration shows the general form, which I have manufactured in the following manner. A piece of watchspring, A, curved into the shape shown, is fixed into the terminal B. This terminal moves along a slide and carries the spring with it, and by means of the screw C the pressure of the spring against the metallic rod D is regulated. This rod is supported by a wooden support, E, and the whole is fixed on to the top of a wooden sounding box, F, which has a projecting piece, G, by means of which it may be clamped down to the bench when in use. On regulating the pressure with which the spring presses against the rod, and the position on the spring of the point of contact, a point will be found on which the spring, when pulled on one side and released suddenly, will vibrate freely in a transverse direction. If, while the spring is thus vibrating, an electric current of a definite strength be passed through the bar and down the spring, the vibrations will be maintained and a musical note will be given out, the pitch of which depends on the length of the free end of the spring. The temperature of the spring and rod gradually rises until a point is reached at which the vibrations cease.




If the apparatus is immersed in water or alcohol just deep enough to cover the point of contact between the spring and rod, the vibrations take place as before, but the sound emitted is weaker. By placing a small split bullet in various positions on the free end of the spring the rate of vibration may be varied and the amplitude increased, and by fixing a small concave mirror on to the spring and reflecting a spot of light from it on to a screen the vibrations may be magnified and observed.

When it is vibrating in water or alcohol the temperature of the liquid rises rather more rapidly than when it is at rest, with the same current passing through it. If the liquid be gradually heated while the vibrations are proceeding, the vibrations gradually weakened, but are not stopped.

The steel spring may be replaced by one of platinum or German silver, but in these cases the vibrations are more feeble. Rods of almost any hard metal may be used, but steel gives the best results, and is followed by iron, German silver, platinum, brass, gas carbon, aluminium and nine-carat gold, in the order named. I have not been able to obtain any sustained vibration with rods of copper, silver, tin and lead, although even with these metals the dying away of the vibration appears to be considerably retarded by the passing of the current. No visible sparking takes place, and there seems to be no interruption of the current.

These phenomena appear to be the effects of the heat generated at the point of contact, although the fact of their taking place under water would at first sight seem to negative this assumption. The apparatus appears to be a sort of electrical Trevelyan rocker.

I have not been able to obtain any results with springs of good conducting metals such as gold, silver and copper, with any current I have used. The rise of temperature at the point of contact does not appear to be enough to give the necessary impulse, and being such good thermal conductors also, the heat is diffused through the mass of the metal more quickly. I have tried springs of various widths from 1mm. up to 7mm., those of about 5mm. being the most easily managed.

There visible to be two or three positions on each spring where the contact may be made and the vibration obtained, the positions between these points not giving them. In these experiments I have used from one to six Bunsen quart cells, coupled in various ways, depending on the size of the spring and its conducting power.

## THE COST OF PRODUCTION OF CALCIUM CARBIDE.

A noteworthy article has appeared in an American publication, the *Progressive Age*, embodying a report by Prof. Houston and Messrs. Kennelly and Kinnicutt, on the cost of production of calcium carbide by the Willson process as worked at Spray, North Carolina. Of the gentlemen named, the first two are well-known electricians, and the last is a recognised chemist, so that the "Commission" constituted by them was competent to decide, as far as data were obtainable, the vexed question of the cost per ton of the raw material for acetylene manufactured on an industrial scale. The Commission was instituted and its cost was borne by the *Progressive Age*, which is entitled to full acknowledgment of its enterprise, and of the successful issue to which that enterprise has been brought. It may be noted that the dubious subject of patent rights for the production of calcium carbide, has also been investigated, but that the present time is not deemed propitious for a definite pronouncement. Further, that the report is presented without comment, and readers on this as on that side of the Atlantic are free to draw their own deductions from the facts and figures supplied.

The plant used at Spray consists of a turbine of about 300 H.P., coupled to alternators which deliver current at 1,000 volts to transformers whereby the pressure is reduced to 100 volts at the furnace terminals. There are two furnaces, each having a floor space of 3ft. by 2ft. 6in., the base being formed of an iron plate protected by a carbon plate 8in. thick. The upper electrode of each furnace is a built-up carbon block 12in. by 8in. in cross-section and 3ft. in length, which can be raised and lowered at will; this electrode is stated to be consumed at the rate of about $\frac{1}{15}$th of an inch per working hour. In making a run, a mixture of coke and lime, containing about 52 per cent. of Ca O and 37 per cent. of C (the balance consisting of moisture and impurities), is used as the charge, and is introduced into the furnace little by little, after the previous establishment of an arc between the upper electrode and a few shovelfuls of the mixture constituting the initial charge. The arc is about 3in. long, and as the calcium carbide is formed by its action, the upper electrode is raised and fresh portions of the mixture added until the furnace is filled to its full height. A mass of crude carbide, of rectangular section and tapering towards the top, is obtained; only about 25 to 50 per cent. of the charge is converted into calcium carbide.

Two complete runs were made, all due care being taken in weighing, sampling, and analysing the charge and the product, and in measuring the electrical energy actually supplied to the furnace. Working with a charge of about 2,000lb. (1 short ton), an output of about 200lb. of calcium carbide was obtained, yielding 80 to 85 per cent. of the calculated quantity of acetylene. The total electrical energy supplied to the furnace was 432 and 386 kilowatt-hours in the two cases, or for the first run of 3 hours, 193·1 H.P., and for the second run of 2 hours 40 minutes, 195·3 H.P. The cost of the carbide made, reckoning the price of power at the turbine shaft at $5 per horse-power year, and that at the furnace terminals at $5·98 per year, taking the cost of the plant at $12,000, and of labour at $11 per day, the value of the carbon of the upper electrode at 6 cents per lb., of the coke at $4·55 per ton, and of the lime at $6·3 per ton, together with

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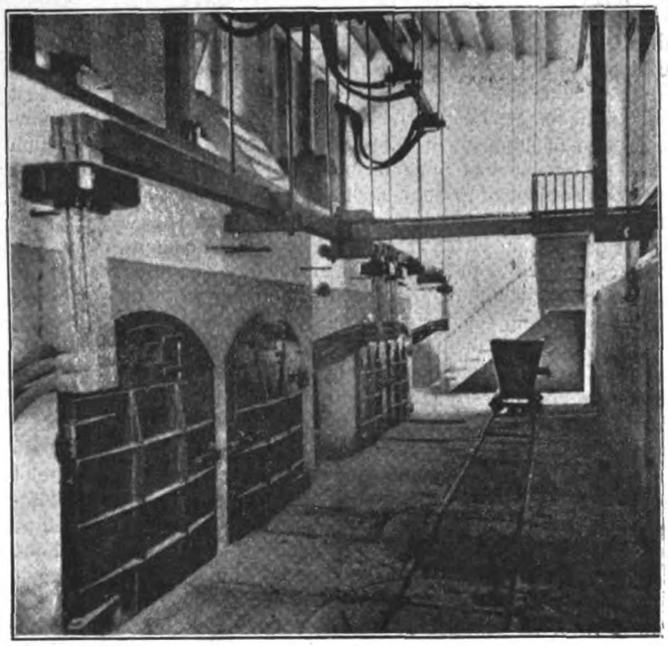
fair allowance for depreciation and repairs, is $32·767 for per ton of 2,000 lb. of "gross carbide," *i.e.*, carbide mixed with about 5 per cent. of slag. This corresponds approximately with £7. 4s. per ton of 2,240lb. of a carbide giving about 78 per cent. of the theoretical yield of acetylene.

It will be noted that while the price taken for power is low, the cost of raw material is high, and that the latter item constitutes nearly one-half the total expenditure, whence it follows that places less favourably situated than Spray for obtaining cheap power may nevertheless produce calcium carbide at an equally low rate, by virtue of the smaller expenditure necessary for raw materials.

## CALCIUM CARBIDE PLANT AT NIAGARA FALLS.

The accompanying illustration is prepared from a photograph of the battery of four furnaces for the manufacture of calcium carbide, recently erected by the Acetylene Light, Heat and Power Company, at their works at Niagara Falls. A descriptive account of this electro-chemical factory was published in our issue of April 17, 1896. The factory is supplied with electric power by the Niagara Falls Power



Ca'cium Carbide Furnaces of the Acetylene Light, Heat and Power Company's Works at Niagara Falls.

Company, and each of the four furnaces now erected is designed to consume about 500 H.P., and to manufacture about two and a-half tons of calcium carbide *per diem*. The works have only recently been put into regular operation, and we understand that the inaugural ceremony was a great success, calcium carbide of very satisfactory quality being turned out. It is stated that from the data thus far obtained it is anticipated by the Company that they will be able to manufacture calcium carbide at 23 dollars per ton, in which connection we would refer our readers to the immediately preceding article, where some estimates of the cost of production are summarised.

## BOOKS RECEIVED.

"Journal of the Institution of Electrical Engineers." Edited by F. H. Webb. Vol. XXV., No. 122. (London : E. and F. M. Spon. Price 2s.)

"Miscellaneous Papers." By Heinrich Hertz. (London : Macmillan and Co., Limited. Price 10s.)

"Die Grundlehren der Elektricität." By W. Ph. Hauck. Leipzig : A. Hartlebern.)

## EXPERIMENTAL TESTS ON THE INFLUENCE OF THE SHAPE OF THE APPLIED POTENTIAL DIFFERENCE WAVE ON THE IRON LOSSES OF TRANSFORMERS.*

Speakers who have returned their proofs revised are denoted by an asterisk.

DISCUSSION.

*Prof. FLEMING said that as the authors had made some reference to opinions expressed by him at one time and another, perhaps it might be desirable that he should make a few remarks on the Paper, if it were only to correct some erroneous opinions attributed to him. He thought that the authors had not done quite sufficient justice to the work of Dr. Rössler on the subject. A very full and elaborate account of that work was published some six or twelve months ago, in which Dr. Rössler described the investigations he made with machines giving E.M.F. curves in different forms, in order to settle some of those points which had been dealt with in the authors' Paper. Practically he thought Dr. Rössler really covered the whole of the conclusions which the authors had arrived at. Dr. Rössler pointed out most distinctly that the question of the hysteresis loss in transformers when worked off alternators giving different E.M.F. curves really depended upon the ratio between the R.M.S. value and the E.M.F. curve and the true mean value. That was really implied in the conclusions that were arrived at by the authors. The paragraph in which they summed up the whole of their conclusions, pointing out that it depended upon the area of the applied P.D. curve, was really only another way of saying the same thing. He had found it convenient to define a term called the "form factor," which was really the reciprocal of the quantity used by Dr. Rössler, and to define the form factor as the ratio between the true mean value of the P.D. curve and the R.M.S. value. They were all aware of the fact a long time ago that the form of the curve had a great deal to do with the power loss in transformers, and that, broadly speaking, the curve with the peaked or pointed form gave a less loss than those which had the more rounded or square form with the same R.M.S. value. The authors seemed to imply in their Paper that they had the idea at one time that the sine curve gave the greatest loss. He had no intention of implying that notion, for he knew very well that it did not. It was merely the sentence of a letter written to *The Electrician* under the circumstances of the controversy then going on in which some writers had suggested that machines giving sine curves gave less loss, and he pointed out that experiments showed that that was not the case. The authors seemed inclined to minimise the value of experiments made with actual machines. They said at the end of their Paper, "We were anxious, however, to experiment on the waves not actually met with in practice, since our aim was not so much to find out which alternator now on the market was the best, but rather to give some information, if possible, which might be a guide in the future design of alternators for use on transformers." The word "best" was a very large word to use; most people would be prepared to admit that there was no best alternator outside the manufacturers' catalogues, but that each one had certain advantages of its own. In the selection of machinery for particular purposes they had to be guided by the end in view, and in order to improve any existing apparatus the first step was to know what the present forms were able to achieve. Therefore the obvious direct process was to investigate with some care the behaviour of well-known and different types of alternators in that respect. That was what Dr. Rössler did. He took two machines of a well-known form—Ganz and Wechsler machines—and analysed their performances very carefully. His (Prof. Fleming's) own attention was directed chiefly to the Mordey, Thomson-Houston and Ferranti machine for the same purpose, because machines that had had so much experience and brains put into them had not been designed without a great deal of thought, and therefore any attempt to improve them must be preceded by a very careful study of what they were able to do. With regard to improving any piece of machinery, all good design was really a compromise, and they could not have all they wanted; they must be prepared to give up some things in order to get others, and the adaptation of the different portions of the design one to another must be governed by the end in view. So it was with regard to the problem before them. It had been well understood for a long time that the peaked form of the E.M.F. curve gave the least loss, or a smaller loss, on the transformer than did a curve with a more rounded form. Any manufacturer would be prepared to give a machine with a curve as sharp as a serpent's tooth, but that would be accompanied with certain other great disadvantages, because it would be well understood that the secondary drop on the transformers was increased thereby, and also that with the increase of the maximum value of the curve a greater strain was brought upon the insulation. Of two sets of machines on one of the London supply stations, one of the machines gave 1,000 volts more maximum pressure than another working at the same R.M.S value. Although the station voltmeter showed the same value on the machines, yet there was an absolute maximum of 1,000 volts more in one than in the other under certain conditions; there would be no total advantage gained by purchasing a diminution in the core loss by a greatly increased secondary drop, and at the same time running the risk of breaking down half the cables every time the machine was switched on. From the practical point of view the question of what form should be given to the E.M.F. curve must be governed, not only by the question of the loss of the transformer, but also by the question of the secondary drop, and the insulation difficulties that occurred. His own feeling was that there was not a great deal which could be done in that direction, because of those two conflicting results arising from altering so much the

* Paper read before the Institution of Electrical Engineers.

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E.M.F. curve. They could give it a little more peaked form, and in that way diminish the hysteresis loss of the transformer; but at the same time they were bringing themselves into other difficulties. The machine which the authors had designed gave them the power of arbitrarily varying the form to a much greater degree than was found in actual practice. Although it was a common idea that an alternating-current machine had a particular wave form attached to it, that was not the case at all; it depended very largely on the nature of the load the machine was carrying, and on what the armature reaction in that machine was. But, at any rate, it was known perfectly well that the forms which were likely to be useful in practice would not vary over very wide limits, and, therefore, there was nothing in the mere fact of the discovery that some very unusual or extravagant form of curve would have certain peculiar difficulties in respect of the core loss, because that must be governed by the number of different conditions. Looking at it from the point of view of the station engineer, they had to consider not only the questions involved in the form of the curve, but also the various other qualities which the alternator must possess. His own feeling at the present moment was that there was not a great deal to be done in that direction. Something might be done, but at the same time, as regarded the diminution of losses in transformers, there was a great deal more to be gained by studying the transformer itself and by improving it than there was to be gained by dealing with the form of the E.M.F. curve. A far more important question that presented itself as a very practical matter was the discovery of some means for preventing that increase in the core loss of transformers that went on at that time. The iron could be annealed down to a point at which that loss became a decimal, but the difficulty was to keep it there. With regard to the point that the authors had mentioned as to the possibility of building up the wave form with a few harmonics, there was no question that with regard to forms which were likely to be met with in practice, or which were met with in practice, the first three odd harmonics were quite sufficient to build up that curve. But at the same time it was also perfectly true that the moment they went away from forms which were more or less regular, then that was an insufficient number to give the required synthesis. It would have been an important addition to the Paper if the authors had been able to make some careful quantitative measurement in that respect, having groups of widely different form factors having, of course, the same R.M.S. value for the E.M.F., and then making exact measurements of the hysteresis loss in one and the same transformer worked off those different P.D. curves, and showing whether the form factor was actually proportional to the loss or whether it merely increased with it. In some statements concerning the increase of core loss in transformers some time ago he guarded himself against the expression of opinion that it was precisely proportional to the form factor, because at that time he had no means of actually proving it. That was a point he looked for in the Paper, but he did not find it set out in the manner in which he hoped it would be, and if the authors with the appliances at their command were able to settle that point definitely he thought they would have added to the knowledge on the subject.

*Mr. W. G. RHODES said the subject might be attacked from a slightly theoretical point of view. As the Paper dealt entirely with transformers on open secondary it was permissible to consider the P.D. of the primary terminals to be approximately the same as the back E.M.F. Consequently, if A was the area of the core and N the number of turns on the primary, the P.D. at the primary terminals might be written equal to $A N \frac{d b}{d t}$, where $b$ is the induction at any instant. If the equation were integrated they would obtain the integral of $V\,dt = A N B$, where B was the maximum value of the induction, the limits being taken as explained in the paper by the authors. The integral $\int V\,dt$ was the area of the P.D. curve, and representing that by S, the following equation was obtained, $S = A N B$. They knew, partly from theory and partly from previous experimental work, that the total losses in the transformer, divided into hysteresis losses and eddy currents, were given by

$$k_1 n B^{\alpha} + k_2 (n B)^2,$$

the power $\alpha$ varying from 1·4 to 1·6. They could substitute the value of the maximum induction in terms of the area of the P.D. curve and get for the total iron loss,

$$\frac{k_1 n S^{\alpha}}{A^{\alpha} N^{\alpha}} + \frac{k_2 n^2 S^2}{A^2 N^2},$$

which showed that the total iron losses depended simply upon the area of the P.D. curve. It also showed that it was not strictly proportional to the area; part of it was proportional to the square of the area and part to the area raised to the power $\alpha$ (=1·4 to 1·6). This assumed that the frequency was constant. With regard to the problem of making those losses as small as possible, although one might have to compromise between losses in one way and losses in another way, still it was a matter of practical interest to know how the iron losses could be reduced to a minimum. There might be particular circumstances connected with the machine in which it was advisable that the iron losses should be very small, and it was well to know exactly what to do in order to minimise them. If they had to work at a given virtual P.D. that was to be constant, they would have to make the integral of the square equal to some constant, and at the same time make the integral $V\,dt$ a minimum, or

$$\int V^2\,dt = C,$$

and $\int V\,dt = \text{min.}$

Theory showed that there was no minimum provided they did not limit their maximum P.D. The maximum P.D., of course, was in practice limited according to the special circumstances of any particular case: that would fix the minimum to which they could possibly work, but there was no absolute minimum. They could fix any minimum they liked.

*Mr. S. EVERSHED said that when he read the Paper a day or two ago he rather felt with Dr. Fleming that from the point of view of the designer of alternators there was practically little to be done in the direction indicated by the Paper. It would hardly pay to design machines to give any different wave from those which were now in common use. But while he came to that conclusion he did not see that it detracted in any way from the value of the record of experimental work such as had been brought forward that evening. The whole subject of alternate current machinery had been so involved in mystery and so wrapped up with the sine wave that it was very desirable that experimental work should be done once for all to clear up some of the mysteries. It seemed to him, however, that in dealing with the design of alternating current machinery, they had to think more of the central station engineer; and he would at once ask, "How many Board of Trade units per annum am I going to save if I adopt a more efficient wave?" If they took a station delivering two or three million units per annum, they might fairly say that if the transformers were banked, they would practically have to magnetise all day long the cores of a number of transformers whose total capacity would be possibly four million units per annum. They might by economical working manage to do with less magnetised iron than that, but at the present moment it was quite fair to say that that would at least be the amount. If they took the differences given in the Paper for the different wave forms, the differences in the iron losses, they found that if they were to substitute for the present machines—which might be assumed to be giving sine waves more or less—some of the machines which gave a better form, they might reckon in practice to save 10 per cent. of the present iron loss; that was to say, they might save 10 per cent. of the 2½ per cent. now lost. The 2½ per cent. on 4,000,000 units worked out at exactly 100,000 units, so that it would amount to a saving of 10,000 Board of Trade units per annum. But the 2d. or 3d. per unit which those units cost at the works would not be saved if they were not produced. All that would be saved would be the coal and a little oil and waste and things of that kind. The total saving per unit might be put at 1d., and therefore the whole saving would amount to £42 per annum. He doubted very much if there was any central-station engineer who would think it worth while to change his machinery to save that; and he thought that even if anyone was starting a station he would hardly consider, in choosing his machinery, whether the machine had the most "efficient" form of wave. He thought he would be quite content with the sine wave so long as the machines were otherwise satisfactory. It was very well known that machines giving the "efficient" type of wave mentioned by the authors must have notched armatures, that was, they must have iron pole-pieces going by fixed iron poles, and machines of that type were necessarily subjected to a good deal more vibration than simple core or coreless dynamos. Those were considerations which would be of far more importance than the actual shape of the wave. He thought the authors would agree with him that the shape of the eddy current waves should be exactly the same as that of the P.D. waves. That being so he thought they should look for experimental errors, or arithmetical errors, when they found that the eddy current wave was not the same. He noticed that the authors spoke throughout of the R.M.S. value of current. He did not like that. They had all been so accustomed to speaking of "effective" current and "effective" E.M.F., that he must really enter a little protest against a new phrase.

*Mr. TREMLETT CARTER disagreed with Mr. Evershed who had stated that the form of a wave was not a practical question. He wished that the discussion might be shared partly by American and partly by English engineers, as the Americans are taking a very great interest in this question, both from the theoretical and practical point of view. In fact, it was the practice of American engineers in building so-called sine wave alternators which first turned the attention of electrical engineers in England to the matter. At the present time, in America, where alternate-currents are used for more diverse purposes than they are here, alternator builders are making and advertising alternators, giving very different types of wave form. They will offer a saw-tooth shape of wave for general purposes and a flat-topped wave, curiously enough, for transformer work—just the opposite to that which the authors of this Paper recommend, and have proved is the best for the purpose—and they will offer a simple sine wave alternator practically without harmonics of any sort for very long distance transmission. They contend that for long distance transmission the absence of harmonics diminishes the line drop. He thought, therefore, that this was a very practical question. He also thought that the use of different kinds of waves in transformers should be decided by what the transformer is intended to do. A recent Paper read by Mr. Frith before the Physical Society of London showed that for arc-lighting purposes the arc has the power of modifying the shape of the wave so as to make it a flat-topped wave when it is applied directly to the alternator, but that it has not that power of distorting the wave when it is run off a transformer of a lighting circuit. Consequently, for arc-lighting purposes we ought to consider what type of wave we are going to send into the transformer, and we should use a different type of wave from that which we require if we are going to use transformers for general supply or incandescent lighting. He had not had time to study the Paper thoroughly, and was unable at that early stage to criticise it in detail, but he congratulated the authors both on their development of the subject from the engineering point of view and for the ingenuity with which they had devised apparatus to obtain their results, and to draw the conclusions which were so lucidly brought before the meeting in their Paper.

*The CHAIRMAN (Prof. Ayrton) said that while the authors were engaged on this investigation Dr. Fleming, who had himself made experiments on the subject, stated as his conclusion, that "the iron core loss in any transformer was greatest on that alternator the E.M.F. curve of which most closely approximated to a sine wave." That was published in June last. It was but fair, therefore, for the authors to say, to themselves, "If that is the case, then we may draw a very important con-

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clusion—if the sine wave be the worst to use let us use a very flat wave." He did not think they had brought that out sufficiently in their Paper. They all knew what Dr. Fleming had told them, that certain dynamos having the same R.M.S. wave of P.D. might have a very much higher maximum which might break down the insulation. Therefore let them use a wave that would not have a high maximum, and they would, according to Dr. Fleming, have an efficient wave. It was as much that as anything else that the authors set themselves to try and solve, to try and find out by experiment, "Is it true that a very flat wave, which is a very safe wave, is also efficient for transformers? If so, it is the very thing to use." That did not, however, turn out to be the case—it was not good to use. It was not a fact that the sine wave stood out as a very bad wave, and that whether they went up or down, whether they had a dangerous or safe wave, they got a more efficient wave. The authors had shown that if they went up they no doubt got danger, but they got much greater efficiency; whereas, if they went down and flattened the wave, they got less efficiency. The sine wave was neither very good nor very bad. He did not think it could be said that the authors had not done full justice to Dr. Rössler's investigations. These investigations were fully acknowledged in the Paper, but to save time the authors had omitted to read their remarks on them. It might be said that if they obtained those results last year, why were they not published at once? He was personally to blame for that, because the authors were desirous of publishing their investigations in *The Electrician* about the middle of last year. Had they followed their own wishes the Paper would have appeared several months ago, and there would have been no question of precedence. He had advised them, not knowing what was being done in other places, to offer the Paper to the Institution of Electrical Engineers. It was impossible to hold the first meeting of the Institution this session because the building was not ready, and then followed a long period devoted to the discussion on house wiring. With reference to the injector, of course in laboratories, when old and young were working together, ideas might come from the older to the younger members, but in the present case the idea of the injector was absolutely the authors' own. He agreed with Dr. Fleming that it was a valuable and economical instrument for enabling one to get any shape of wave. Mr. Taylor had said that condensers were expensive, and it might be thought that the injector only represented a small fraction of the whole cost, and that a large sum must be spent in buying condensers; but it was pointed out in the Paper that the greatest change in the wave was produced by the use of the very smallest capacity. The great value of the arrangement was that it enabled one to make a wave exactly in the way one drew a person's face. They did not have a number of harmonics and wobble about when they wanted to draw the forehead—the forehead was drawn. The same thing applied to the mouth, nose and chin. By combining machines, pulleys and cords, combining a series of harmonics, they might try to get a certain result by wobbling all the time, but that was not the best way, because every part of the wave was influenced by the remainder. He congratulated the authors on the success of their instrument and in their application of it to the examination of the iron losses in transformers.

*Mr. J. MARK BARR, in reply, said that Prof. Ayrton had so very admirably replied to Dr. Fleming's criticism that he felt that there was not much for him to say. The illustration with reference to the drawing of a face as a Fourier function, he thought utterly disposed of the idea of easily combining the harmonics as being better than using the injector. As the authors had said in the Paper, when they have a smooth fundamental, if they wish a piece taken out of it they take it out directly; not destroying that fundamental first, and then dealing anew with a large number of complicated elements. As Prof. Ayrton had pointed out, that was a great advantage. Prof. Ayrton had also very well disposed of other things that Dr. Fleming had said, and he could hardly do more than merely thank him. There was one thing more that he would like to say. The authors had laid no emphasis on the fact that they wished absolutely to avoid trying any wave produced by a dynamo in practice. He simply felt that heretofore when anyone had experimented on the effect of different wave shapes, and, therefore, had used machines in practice, he had been beset with this difficulty and danger, that for the same effective value of volts or R.M.S. value, he did not get much difference in the shapes of the waves or in the area. The authors noticed, among hundreds of people interested in the subject, that the results with different wave forms of practice did not differ much, and therefore a great danger came in when such differences were found. One asks, Are not these differences due less to the variations in wave shapes than to experimental difficulties and errors? So the authors said they would supplement the known tests by experiments made with waves exaggerated. Then, if, as a wave was more and more peaked better results were obtained, and, on the other hand, if, as the waves were made flatter and flatter a higher iron loss was obtained, the published results were correct, and also their results were correct. In order to establish the validity of a law one should take advantage of the relations of the more marked effects, and deal with quantities differing by values as large as can be obtained. He thought he had disposed, then, of one great danger in the statements made at the conclusion of the experiments of Dr. Rossler and others. In every case, especially in one of the theoretical cases, the waves they used did not differ enough in shape, and when they differed enough in shape they did not differ enough in area. That was the great point. Dr. Fleming, in speaking of the injector, said it was wrong to regard a dynamo as having a given wave form attached to it. That was hardly so, because although in a machine with a sine wave, the form of the P.D. changed with the load, it was not a very radical change. The wave form is rather a rigid thing, and with one dynamo it was very hard to get a number of wave shapes differing enough in contour and area for a given effective voltage. One must have some definite method of absolutely cutting a piece out of the wave if one wanted to change it very much.

*Mr. C. P. TAYLOR, in reply, after thanking the speakers for the kind manner in which they had criticised the Paper, said that Dr. Fleming had stated that practically the condition of the effect of the wave form on the iron losses in a transformer was a very small one in the question of central station economy. That might be so, but he thought it must be an advantage to know that condition, and, indeed, all the conditions, more accurately in order to decide how to design a central station, and in order to obtain the maximum efficiency of distribution. He did not agree with Mr. Rhodes that the eddy current losses varied with the square of the maximum induction: he thought it varied with the square of the effective P.D. They considered that their experiments showed that, and, if the eddy currents did act like a secondary, it was evident that it did not depend on the maximum induction at all. It was also shown in Dr. Rössler's Paper that the eddy currents did not depend on the maximum induction, but on the mean value of $\left(\frac{d\,B}{d\,t}\right)^2$—*i.e.*, on the square of the effective P.D.

He regretted that, owing to want of time, he had not mentioned Dr. Rössler's work in reading the paper; they had found it very interesting, and had made several notes on it, which appeared at the end of their communication.

*The CHAIRMAN proposed that they should accord a hearty vote of thanks to the authors for the very interesting communication to which they had listened, and this was carried unanimously.

## NOTES ON SOME AMERICAN ALTERNATING-CURRENT MACHINERY.*

*(Continued from page 22.)*

### Generators and Synchronous Motors.

Although the alternating current and alternating-current systems have opened an extensive and important field of application, and notwithstanding the difficulties which may be surmounted by their employment in the long-distance transmission of power and light, made possible by the use of high potentials, there still remains an important commercial field in which, were it impossible to transform to direct currents, their applications would be considerably reduced, and the development which they have at present attained could not possibly have taken place. The necessity for having direct currents is to be met on every hand, and it is by means of the rotary transformer that this necessity has been supplied.

*Rotary Transformers.*—This very important class of electrical machinery, invented some years ago by Mr. Bradley, permits of the use of alternating-currents transmitted through very long distances and at high potentials, and with a consequent small loss, to be transformed into direct currents at the place of consumption, so that they may be utilised in their various applications, as for street railway propulsion, electrolytic purposes and numerous chemical processes. Any continuous-current machine can be made a rotary transformer of any polyphase type by tapping the armature at the desired number of equidistant points, and connecting these points to independent collector rings. Obviously, the frequency of the alternating currents must be directly proportional to the speed of the machine and the number of pairs of poles. As an instance may be mentioned the Portland and the Lowell transformers, both of which are used for street railway work. They are built for a 550-volt continuous current. Two-phase rotary transformers are employed by the Pittsburg Reduction Company at Niagara Falls. Two-phase currents at a difference of potential of 2,000 volts are generated at the power-house at Niagara and transmitted a short distance to the power-house of the Pittsburg Reduction Company, where the potential is reduced to 110 volts alternating by means of stationary transformers of the air-blast type. This two-phase current supplies the rotary transformer, and the continuous current taken from its commutator side has a potential of $110 \times \sqrt{2} = 105$ volts. These rotary transformers are each of 400 kilowatts capacity, have 20 poles, and run at 150 revolutions per minute; that is, at 25 cycles per second. The Portland three-phase transformers are each of 400 kilowatts capacity, have eight poles, and run at 500 revolutions per minute. Both types are simply continuous-current machines, having their armatures tapped at three equidistant points for the three-phase transformer and at four equidistant points for the two-phase transformer. The ratio between the continuous and the three-phase voltage is $1 : \frac{1}{\sqrt{3}}$, or 1 : 0·577, and between the continuous and the two-phase $1 : \frac{1}{\sqrt{2}}$, or 1 : 0·708.

The transformers are made self-exciting. In starting a rotary transformer, or, in fact, any synchronous motor, it has at first no field excitation. The field is thrown on after synchronism is attained, the armature currents furnishing in the meantime sufficient reaction to give the necessary starting torque. Even

* Abstract from the *Electrical World* of New York. We are indebted to our New York contemporary for the blocks illustrating this article, which gives a useful insight into American methods.

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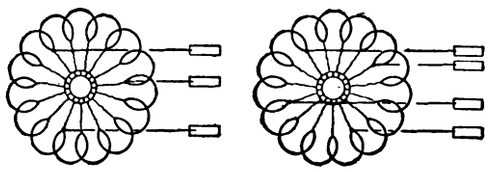
with the same load, by varying the field excitation, the current received by the synchronous motor or rotary transformer can be greatly varied, since either is capable of producing a leading or lagging current in the lines. A leading current increases the magnetisation of the generator, and tends to demagnetise the transformer, while a lagging current tends to demagnetise the generator and increase the magnetisation of the transformer. If the transformers have sufficient compounding so as to have always a higher counter E.M.F. than the impressed, the current in the line will lead, and consequently increase the magnetisation of the generators. This feature offers a means of compounding the generators with the armature reaction without series-field. Figs. 19 and 20 show how the connections are taken from the armatures of the three-phase and two-phase rotary transformers.

*Alternating-Current Systems.*—Two standard alternating-current systems have been adopted by the General Electric Company, viz.: the three-phase and the monocyclic. It is only in special cases that the two-phase system is employed. The three-phase system is used in places where power is to be transmitted at very high



FIGS. 19 and 20.

potentials and for long distances, and chiefly supplied to motors. One very important advantage of the three-phase system over the single-plase is that the saving in copper is about 25 per cent. All of the standard three-phasers are built for 60 cycles. Generators which are wound for the line potential are preferably used when the line is not long, and then in connection with step-up transformers. The standard three-phasers are at present being wound for 1,150, 2,300, and 3,450 volts. Higher voltage machines are used in special cases. In stepping up or in distributing three-phase power, two or three transformers may be used. If two are used they are connected in series across the mains, so as to have a main at each side of each transformer, as indicated in Fig. 21.

Three transformers ought preferably to be used, so that if one should be damaged by lightning or other cause, the plant need not be shut down, but can be operated on the remaining two.

On the three-phase system, synchronous as well as induction motors can be operated. The synchronous motors are practically always self-starting, but start with moderate torque, and with a current of about two or three times that required at full load. When in synchronism they run at constant speed, being always in

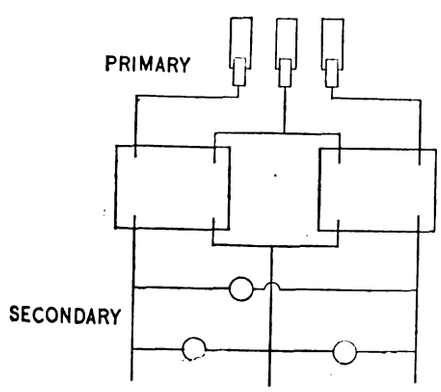



FIG. 21.

perfect synchronism with the generator. They have no idle currents, and consequently do not load up the generators and line unnecessarily. Since the generators and synchronous motors are identical in sizes from 50 kilowatts to 1,000 kilowatts, the standard generators are used as synchronous motors.

*Induction Motors.*—The induction motors start with any desired torque for which they are designed. The standard make have about 50 per cent. greater starting torque than the full load running torque. The current required in starting is the same as that when running with the same torque, consequently if a motor is designed with a 50 per cent. greater starting torque than running torque, the starting current is 50 per cent. greater than the running current. These motors are designed with and without external resistance in the secondary induced member; that is, in the revolving armature. The advantage of this resistance is obvious, since the starting torque, the drop in speed, and efficiency are dependent thereon. If the motor is designed with no special starting resistance, but with such high armature resistance as to give twice the starting torque of the full load running torque, the efficiency will be low and the drop in speed considerable. If the motor be designed with a special resistance in the armature that may be cut out when the motor is running, we have in starting the advantages just mentioned; that is, we have a motor giving any desired starting torque, with the same amount of current corresponding to this torque, and further, a motor that is very efficient and which will show a very small drop in speed when running under variable load. The exciting

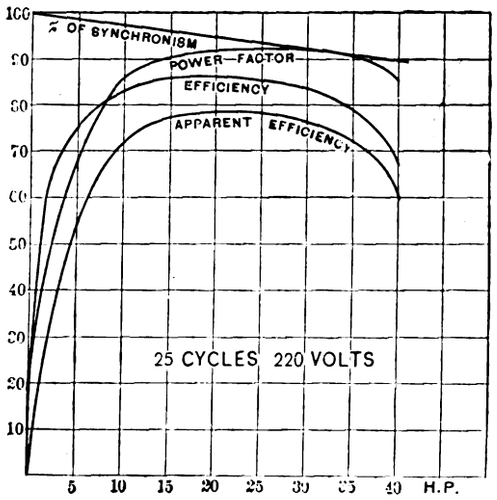



FIG. 22.

current of these motors, that is, the current taken when the motor is running light, is between 25 per cent. and 30 per cent. of the full load current, but since the power factor when running light is very small, as, for instance, from 10 to 15 per cent., this current represents scarcely any power.

The induction motors are designed with an exceedingly simple field and armature winding. The slots are open, so as to have as small self-induction as possible, and the coils, which are machine wound, are put in the slots after being insulated. The great

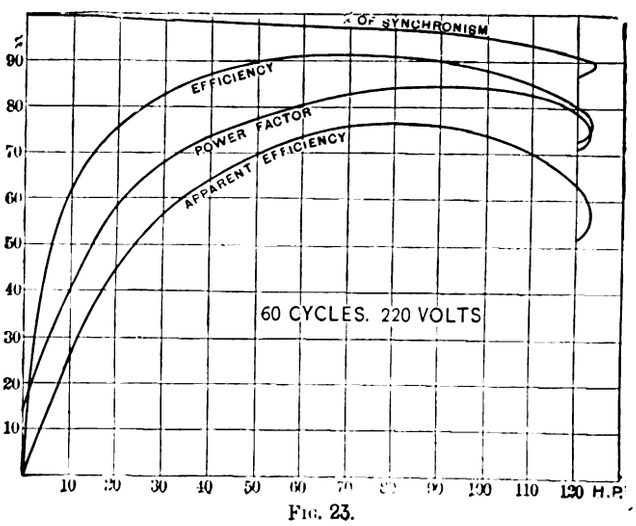



FIG. 23.

advantage in the use of induction motors is the absence of any movable contacts, either in armature or field. Consequently these motors can advantageously be used in places where, due to fire insurance restrictions, no continuous-current motor or alternating-current motor with collector rings would be allowed, on account of the danger due to sparking.

We give in Figs. 22, 23 and 24 complete curves showing the behaviour of some of these motors, the power factor, apparent efficiency and the current input. One of these curves is for a 20-H.P. 25-cycle motor, the other for a 75-H.P. 60-cycle motor, and the third of a 5-H.P. 60-cycle motor.

By looking at the curves of the 25-cycle motor, it will be seen that the maximum efficiency of this motor is 86 per cent., the maximum power factor which is reached rather near to the full load point, 92 per cent., and the maximum apparent efficiency is as high as 78·5 per cent. At full load, that is at 20 H.P., the efficiency is



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86 per cent., the power factor 91·51 per cent., and the apparent efficiency 78·5 per cent. The power factor running light is extremely low, being only 18 per cent., which shows that a very small part of the current consumed while running light represents energy. The drop in speed at full load is 4·5 per cent. The maximum output of this motor is 40 H.P., or 100 H.P. more than the full load power. The starting torque of this motor is about 150 per cent. greater than the full load torque.

Fig. 23 gives the data concerning the 75-H.P. 60-cycle induction motor. The maximum apparent efficiency of this motor is reached at full load and is as high as 76 per cent. The maximum efficiency is 91 per cent., and the maximum power factor 84 per cent. At full load the power factor is 83 per cent., the efficiency 91 per cent.,

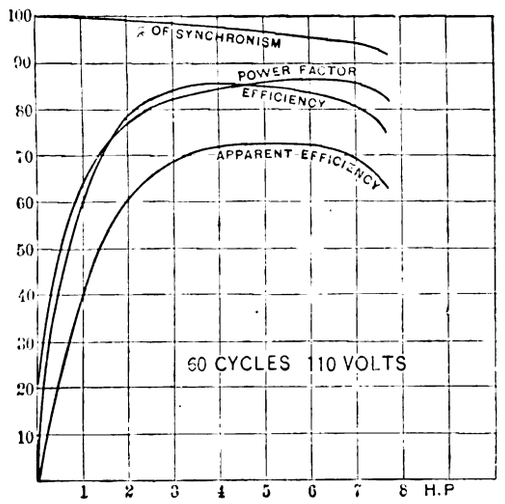


Fig. 24.

and the apparent efficiency, as stated above, 76 per cent. The drop in speed is only 3 per cent. The power factor running light is only 14 per cent. The starting torque of this motor is 80 per cent. more than full load torque.

Fig. 24 gives the data pertaining to a 60-cycle motor. The curves show that this motor for its size is as near perfection as can be expected. At full load the efficiency is as high as 85 per cent., and at three-quarter load as high as 86 per cent. The power factor at full load is 85 per cent. and at 6·6 H.P. a maximum of 86·5 per cent. The apparent efficiency is as high as 72·5 per cent. over a very wide range of power. The starting torque is 60 per cent. greater than the full load torque. The drop in speed at full load 2·5 per cent.

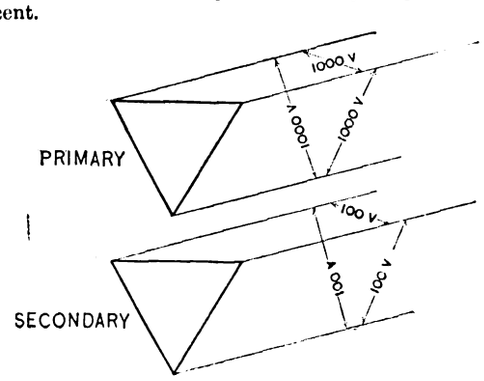


Fig. 25.

The most important features to be considered in an induction motor are the efficiency, power factor, apparent efficiency, the current taken by the motor when running light, the starting current, the starting torque and the variation in speed under a variable load. The efficiency of the motor depends upon the amount of copper and iron used in its construction, upon the current used and the friction loss, since the various losses consist of the $C^2R$ loss, the hysteresis loss and loss due to friction. It is the ratio between the watts utilized by the motor and the watts supplied. The power-factor, which is the ratio between the energy current and total current supplied, depends therefore upon the amount of magnetising current in the motor, and is consequently lower, the larger the length of the air gap, the larger the density in the gap and in the iron, and is expressed as the ratio between the watts input and the total volt-amperes input.

The apparent efficiency is the product of the efficiency and the power factor, and is consequently the ratio between the total output and the total volt-amperes input. The induction motor when running light consumes a certain amount of current, part of which is wattless and part of which represents energy. The wattless current is the current magnetising the motor, so as to produce the same counter E.M.F. as the impressed. The energy current is the current consumed by Foucault currents and hysteresis and the cur-

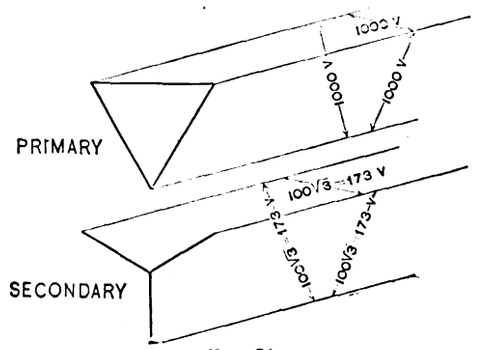


Fig. 26.

rent necessary to drive the motor in its own bearings, that is, the energy current is partly a hysteretic current and partly a current consumed by friction losses.

The magnetising current is 90 deg. behind the E.M.F., and does not represent any energy, consequently, although considerable current is consumed when the motor is running light since most of it is the magnetising current, this current cannot be considered as representing any actual power taken from the generator.

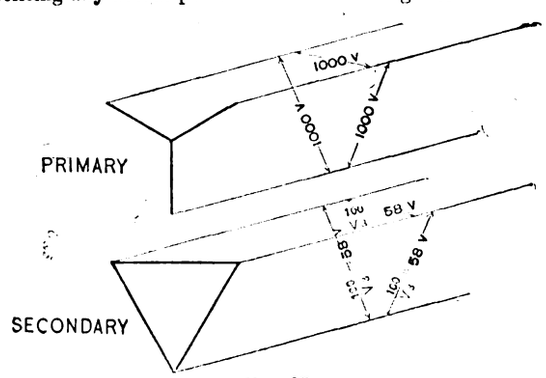


Fig. 27.

*Lights.*—Lights can be operated from the three-phase system, either from a single transformer placed in one leg only, in case the number of lights to be carried is small compared with the total output of the generator, or from all three legs if the amount of lighting to be done is large.

Figs. 25 to 28 show some of the different methods of connecting transformers in the three-phase system in order to obtain different

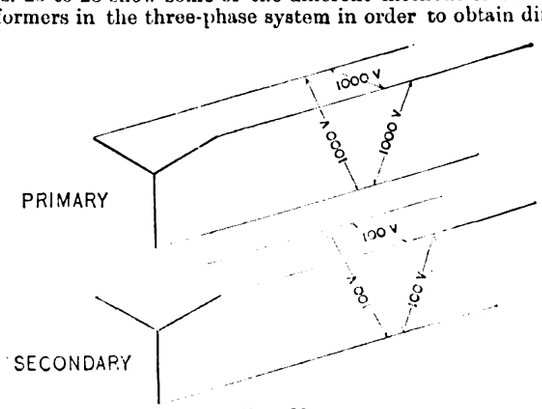


Fig. 28.

voltages. It is found that with the same transformer the potential at the terminals of the secondary may vary considerably, depending upon the connections of the primaries and secondaries. In Fig. 25 with the primaries and secondaries Δ connected, the ratio of transformation of primary and secondary is the same as the ratio of transformation of the transformers, so that for instance, if the transformers have the ratio 10 : 1, and the primary potential between the lines is 1,000 volts, the potential at the secondary

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between each of the three legs is 100 volts. If the primaries are Δ connected and the secondaries Y connected, as in Fig. 26, the potential between the three secondary lines will be 173 volts, or $100 \times \sqrt{3}$. If the primaries are Y connected and the secondaries Δ connected, (Fig 27) the potential between each of the secondary mains will be $\frac{100}{\sqrt{3}}$ or 58 volts. The most economical system of distributing lights from the three-phase secondaries is by the use of the common connection; that is, by having the secondaries connected in the Y manner. And finally, if the primaries and secondaries are Y connected (Fig 28) the voltages are transformed in the ratio of transformation of the transformers. Each transformer is then subjected to a lower voltage than that of the main, the ratio being $1 : \sqrt{3}$.

*Monocyclic System.*—This system is used where most of the power generated is to be utilized for lighting purposes, since in this system no unbalancing can occur. The monocyclic system takes

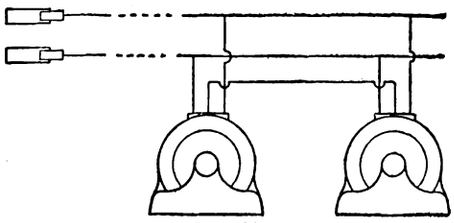

Fig. 29.

a trifle more copper than the straight single-phase system, as the monocyclic mains have to be calculated in the same manner as the single-phase mains and the teaser wire added, but since this system requires but two mains to those places where lights only are located, and the third teaser conductor to places only where motors are to be operated, the question of copper in the line of the monocyclic system can be treated in the same way as in the straight single-phase system. The monocyclic system does, however, not necessarily include the monocyclic generator. Its main feature lies in the establishing of a displaced voltage which is used in starting and running motors. This displaced E.M.F. need not necessarily be derived from the generator, but can be supplied from any part of the system of distribution. Consequently if power is required at great distances from the generator, two mains only are run to those points, and by other means the displaced E.M.F. is established.

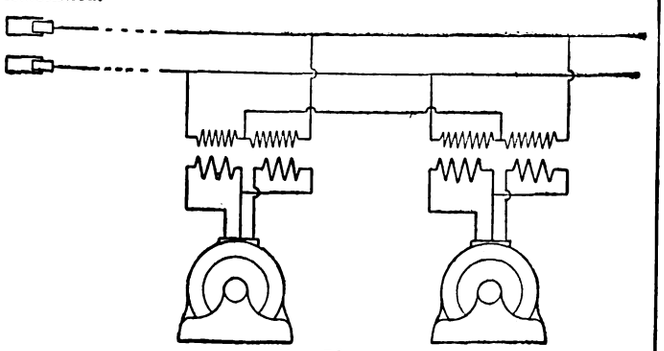

Fig. 30.

This may be accomplished, for instance, by a three-phase induction motor running single-phase. Although this motor is running single-phase, due to the interaction between its impressed and counter E.M.F., it will be found that at the terminals there exist E.M.F.'s of an approximate three-phase relation. One of these E.M.F.'s is that due to the main, the others being due to the resultants of the main and the out-of-phase E.M.F. established by the motor.

If leads are brought from this second terminal of the induction motor to other motors, as shown in Figs. 29 and 30, these motors will not only run up to full speed, but will start practically with any desired torque.

The action between the first motor and the others will be practically the same as if this third phase was supplied from a monocyclic generator or a special teaser winding. To go into a scientific explanation of this feature is outside the scope of this article, but we may briefly explain it by stating that since the field of the three-phase induction motor is supplied with a single-phase current, the three windings on the armature successively cut the magnetic field generated by the single-phase current, and consequently in the armature is induced a three-phase E.M.F. and current. This counter E.M.F. of the armature consequently induces a three-phase E.M.F. in the field. The interaction between this induced three-phase and impressed single-phase gives an E.M.F. of practically a three-phase relation at the field terminals.

The output of induction motors, when used on the monocyclic system, is about the same as when used on the three-phase system. The current required at light load, the efficiency, the power factor and the apparent efficiencies are practically of the same magnitudes.

Fig. 31 shows how the transformers supplying power to induction motors operated on the monocyclic system are connected. It is seen that the primaries of the two transformers are connected in series, and secondaries are connected in a reversed relation to each other. The teaser wire is brought over to the connection between the two transformer primaries and the two mains to the outside of

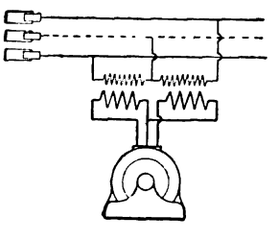

Fig. 31.

the two transformers. In the secondary circuit the wire coming from the common connection of the two transformers is practically the return wire for the other two, and consequently carries considerably more current than those—in fact, about twice as much.

In the primaries leading to the induction motor the currents vary considerably, depending upon the load of the induction motor and the condition of the external circuit. It is better not to operate motors from the transformers carrying lights, since the drop in the transformer will vary due to the variation of load on the motor.

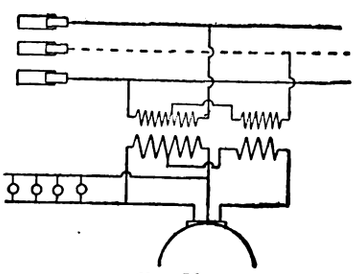

Fig. 32.

If the power is supplied through a secondary network—that is, if the entire power is distributed from, say, one or two large transformers—motors might be operated from these secondary mains. To do this the connections shown in Fig. 32 should be used.

*(To be continued.)*

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, May 29th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*4 p.m.* Special General Meeting of Members only at the Offices of the Institution, 28, Victoria-street, S.W., to consider alterations in the Articles of Association of the Institution.

**SATURDAY, May 30th.**

INSTITUTION OF JUNIOR ENGINEERS.

*10:30 a.m.* Visit to the Fowler-Waring Cables Works, North Woolwich.

**MONDAY, June 1st.**

SOCIETY OF ENGINEERS.

*7:30 p.m.* Ordinary Meeting at the Royal United Service Institution, Whitehall.

SOCIETY OF CHEMICAL INDUSTRY.

*8 p.m.* Meeting at Burlington House. Paper to be read: "The Electro-Deposition of Zinc," by Sherard Cowper-Coles.

**TUESDAY, June 2nd.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Annual General Meeting of Corporate Members only, to receive the Report of the Council and to elect the Council and Auditors for the ensuing year.

**FRIDAY, June 5th.**

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Electric and Magnetic Research at Low Temperatures," by Prof. J. A. Fleming.



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## EVOLUTION IN ENGINEERING.

In his recent "James Forrest" lecture, Prof. A. B. W. KENNEDY suggested that there is "something in relation to things inorganic which closely resembles the position of natural selection in the organic world," and proposed the "working out of a theory of evolution in relation to engineering progress." Such a theory, fully developed, might fill a ponderous tome, and the space which can be devoted to it in a leading article is altogether inadequate; but we propose to draw attention to some of its more salient features. In the form suggested by Prof. KENNEDY, the relation of engineering evolution to organic evolution is merely a parallel or analogy. He sees in the development of machinery and engineering arts something akin to the forces of natural selection and of the struggle for existence which mould and fashion the world of organic species. But to us it appears that in the science of engineering evolution there is more than this. It was far more than a mere parallel between the laws of human society and the laws of all organic life that Mr. HERBERT SPENCER drew in his "Sociology"; it was a discovery of their identity—of the inclusion of the lesser within the greater. Social evolution exhibits not parallel but identical laws with biologic evolution, because human society is one of many organic species, and its customs are but the habits of one particular form of life. Now, the development of the engineering arts marks the progress of one department of social need, in human life, together with the manner in which the need, from time to time, has been more or less completely satisfied. Engineering, therefore, is but a branch of sociology and consequently of biology; it is the science of one set of habits, of one form of living organism. Accordingly, it should not surprise us when we find that the laws of evolution which operate over the entire universe of bioplasm also operate in engineering. To properly understand that this is so we have only to transfer our thoughts from the

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human species to some lower form of life, such as the ant or the beaver. Antic or beaver engineering is admitted without hesitation to be the legitimate study of the biologist. And, though transcendently higher in its achievements, the purpose of human engineering does not differ, in its relation to the species which carries it on, from that of the interesting operations of the beaver or the ant.

Before attempting to discuss in detail some of the instances where the laws of organic life are discernible in engineering, we may direct attention to some of the popular errors regarding those laws themselves. To the man in the street evolution means only two things: the survival of the fittest, in the sense of the *best*, and the descent of mankind—from monkeys. Science, we need scarcely say, knows nothing of either of these two extraordinary ideas. Confusion between "fittest" and "best," as regards evolution, is very common, even among educated people, and Prof. HUXLEY was at great pains to make clear the distinction between them. If, as has been predicted, the future has in store an earth inhabited only by gigantic land-crabs, it would scarcely be flattering to then extinct humanity to call this species the best, though it undeniably would be the fittest for the occasion. Nor in the Reign of Terror or in the Indian Mutiny were the murderous outlaws the best, though indisputably they had better adapted themselves to their environment at the moment than the unhappy people whom they butchered. The fittest is often the worst, and it will always be so in a decadent environment. Nor is the distinction between "best" and "fittest" any less necessary when we look for evolution in engineering. Speaking of engineering productions, Prof. KENNEDY said: "There is also among them a survival of the fittest, and the laws which determine what is the fittest at any time and how the standard of fitness alters as time goes on are probably capable of fairly exact statement." As instancing one particular example of adaptation, these remarks are scientifically correct; but if we were to interpret them to mean that among any class of engineering products—say, boilers, dynamos or engines—there was a tendency for the best to survive, the facts would often be against us. Where Ignorance is the chief customer, it is folly for the manufacturer to be wise. At a time when prejudice controls the market salesmen naturally push their most successful wares, even though these may be intrinsically inferior in quality. Moreover, copious advertising and large capital interests will often give to an inferior article an additional impetus that will enable it to win the race with better goods. In such a case it is the fittest, but certainly not the best, that survives.

Another element which reduces engineering work from the ideal best to the sordid level of the commercially fittest is the influence that competition exerts upon manufacturing processes. Take as an example the selection of an engine. Ideally, that engine should be designed in all its details to be best adapted to do the work for which it will be employed. Practically, in the majority of cases, it is chosen from a number of stock sizes and patterns duly set forth in the makers' catalogues. And, in order that prime cost and the cost of repairs may be reduced to a minimum, all these stock pieces of machinery are so increasingly being made with interchangeable parts, by template, gauge and jig, and the details are machine-finished so accurately before being sent to the fitting shop, that the survival of the fittest in this instance threatens the complete extinction of the fitter. This practice is more to be regretted in some branches of mechanical engineering than in others. In the manufacture of hydraulic turbines, for example, it has largely been adopted in America, and the fashion is unfortunately being followed by turbine makers in this country; yet, of all forms of engines, water motors most require to be specially constructed to suit each individual works.

This compulsion to build only standard sizes and patterns of machinery, which in certain circumstances the struggle for existence has wrought in manufacturers, is also continuously modified by a process of natural selection, which brings about an adaptation of the standard patterns to the most common requirements, and produces in them, from time to time, such changes as are necessary on account of gradual variations in the demand. Thus old types vanish and new ones appear. And thus, too, unless they keep pace with the times, old firms vanish and new ones spring into existence. Not an insignificant illustration of this fact is shown by the rapid growth in modern times of steam engineering firms who have adapted themselves to the novel requirements of the electric supply industry. Older firms apparently were prejudiced with the old-fashioned notions of steam practice; and believing with foolish fondness that the electrical industry would have to follow along the old lines, they let the chance slip between their fingers. And precisely as this has happened in the electric supply industry, so does it promise to occur in regard to electric traction. Unless steam engine builders are prepared to supply engines which are electrically best, *i.e.*, fittest for the purpose of an electric traction station, the manufacture of such engines will drop out of their hands. But, after all, it requires no theory of evolution nor science of biology to teach us that.

From the relation of the detailed laws of organic evolution to the success or failure of any given branch of engineering work, let us turn to consider the science of engineering in its relation to the most general law of evolution, whether social, organic or cosmic, that has yet been formulated. We refer to the principle which HERBERT SPENCER has described as being embodied in "a progress from a state of undifferentiated homogeneity to a state of highly differentiated heterogeneity." Whether we consider the evolution of stellar and solar systems, of organic species or of social communities, we find that the progress is the one indicated in the law just enunciated—one of change from simplicity of structure to highly complex structure; and we find the same when we turn either to engineering as a whole or to any one or other of its manifold branches. In a leading article which we published in our issue of July 13, 1894, we directed attention to the manner in which this generalised law is exhibited in the evolution of machinery. We showed that, contrary to the popular view of the matter, machinery does not tend to develop into more and more simple forms, but rather into forms of higher complexity. As an illustration, we cited the engines of an ocean-going steamer. In the earliest steamers the machinery was of a simple kind, and the number of working parts was smaller than in a first-class liner of to-day. While there is always in machinery a tendency to simplicity of function of each separate detail, *i.e.*, while the tendency is to reduce the number of duties of each element of the machine as much as possible—there is a corresponding tendency to multiply the number of parts.

In this broadest aspect of the subject it would have been possible for Prof. KENNEDY to have discovered a further relation between physical experiment and engineering, and thus for him to have combined the subject upon which he had desired to speak with that on which he did speak. For, from the progress of physical science which has been a direct consequence of experimental investigation, engineering has received some of her richest accessions of territory. Or, to put the matter more into the language of evolution, it has

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been the impetus afforded by experimental research that has produced the larger part of the evolution of engineering from "a state of undifferentiated homogeneity to a state of highly differentiated heterogeneity." We will cite a few illustrations in support of this. Through physical research on the properties of steam and on the manufacture and strength of iron and steel, engineering has acquired her departments of steam engineering and railroading; the experiments on and with primary batteries added telegraphy; the researches of HENRY and of FARADAY contributed the possibilities of telephony and heavy electrical engineering; later researches of modern physicists and engineers have enlarged the sphere of engineering by the departments of electric traction, polyphase transmission, electro-chemistry, &c. In all these instances, and in an immense number which we have not space to cite, the progress of engineering has been assisted by experimental research, and that progress in each and every case has been one of evolution along the lines indicated by the great general law already enunciated.

## THE MAXIMUM EFFICIENCY OF TRANSFORMERS.

BY BERNARD P. SCATTERGOOD, M.A., OXON.

In designing a transformer to fit a particular load-curve, it is obviously desirable so to arrange matters that the mean efficiency of the transformer, when averaged over a whole day's output, is as high as possible. The point, however, at which the efficiency of the transformer ought to be a maximum, will vary with the form of the load-curve. In sub-station transformers, for instance, which are switched on and off the circuit to suit the load on the mains, and are worked at as nearly full load as possible, the efficiency should clearly, for economical working, be a maximum at or near full load. On the other hand, in house transformers, where for a great part of the day the load is very small, it will pay the central station to have the maximum efficiency occurring at half-load, or even less. In all cases a transformer should be so designed as to give its maximum efficiency at or near that load which will give the greatest economy in working, when the nature of the variations of load is taken into consideration. The simple results which are worked out below are not, perhaps, very generally known, and will be found useful. Their application would, for instance, prevent the possibility of such an anomaly as a transformer whose maximum efficiency occurs at a load which is beyond the safe carrying capacity of the wire with which it is wound.

The problem is, to determine the conditions of maximum efficiency in a transformer. Now, in a transformer the total losses are made up of the losses in the iron core (hysteresis and eddies) which may be considered, to a first approximation, as constant at all loads,—and of the copper losses, which vary as the square of the current in the secondary, unless the power-factor of the transformer be very small. In this latter case the effect of the magnetising current in increasing the copper losses in the primary coils will have to be allowed for. In dealing, however, with a closed-iron circuit transformer of good design, in which the magnetic leakage is small and the power factor large, the above statement is practically correct. Writing $w$ for the iron losses in watts, $p\,C^2$ for the copper losses when a current C is passing though the secondary, and E for the secondary terminal voltage under the same conditions, we have as the expression for the efficiency at a secondary output of E C watts,

$$\eta = \frac{E\,C}{w + p\,C^2 + E\,C}.$$

It is easily seen that $p$ in the above equation is equal to $r_1\zeta^2 + r_2$, where $r_1$, $r_2$ are the hot resistances of the primary and secondary windings respectively, and $\zeta$ is the conversion ratio of the transformer. The "conversion ratio" I define as the number which expresses the ratio between the secondary and the primary terminal voltages, at a given load. The "constant" $p$ is thus really a function of the resistances of the primary and secondary windings, and of the secondary terminal pressure of the transformer. Of course, strictly speaking, $r_1$ and $r_2$ are themselves functions of the current C, since the resistance varies with the temperature of the wires, and therefore with the current; but it will not introduce a serious error if the temperatures of the windings are estimated and the resistances $r_1$ and $r_2$ are calculated on this basis and treated as constant. We may also neglect the drop in E.M.F., and take E as being equal to the open circuit voltage of the transformer, and therefore a constant. In this case $p$ will also be a constant. This, again, will not introduce a serious error, especially as the lessened values of $p$ and E, when the drop in E.M.F. is taken into account, tend to cancel each other; but if it is thought necessary, both in this case and in that of the resistances, after a first approximate determination has been made of the value of C which will make $\eta$ a maximum, the value of C thus obtained may be used to determine more accurately the values of $r_1$, $r_2$ E and $p$, and by the substitution of these corrected figures a more exact evaluation of C may be obtained by the method of successive approximations. It will be found, however, that in practice this is a quite unnecessary refinement.

In the expression, then, for the efficiency given above, we have $w$, $p$, and E constants, the only variable being the current C. To find the value of C which makes the efficiency a maximum, we differentiate with respect to C, and equate the resultant expression to zero. We thus obtain—

$$\frac{1}{E}\frac{d\eta}{dC} = \frac{1}{w + p\,C^2 + E\,C} - \frac{2\,C^2 p + E\,C}{(w + p\,C^2 + E\,C)^2}$$

$$= \frac{w - p\,C^2}{(w + p\,C^2 + E\,C)^2} = 0.$$

Thus, for the efficiency to be a maximum it is necessary and sufficient that

$$w - p\,C^2 = 0,$$

or

$$w = p\,C^2.$$

That is to say, the *condition for maximum efficiency is, that the copper losses should be equal to the iron losses.*

Making $w = p\,C^2$ in the expression for the efficiency given above, we obtain as the value of the maximum efficiency—

$$\eta_{max.} = \frac{E\,C}{2\,p\,C^2 + E\,C},$$

$$= \frac{E}{E + 2\,p\,C},$$

C being determined by the equation

$$p\,C^2 = w$$

or

$$C = \sqrt{\frac{w}{p}}.$$

Hence

$$\eta_{max.} = \frac{E}{E + 2\sqrt{p\,w}}.$$

As an example, take the following case of an actual transformer:—

Iron loss on open circuit $= w = 140$ watts.
Primary resistance, hot $= 1{\cdot}75$ ohms.
Secondary resistance, hot $= 0{\cdot}006$ ohms.
Ratio of conversion, from 2,000 to 102 volts at no load $= \frac{1}{19{\cdot}61}$.

Hence $p = 0{\cdot}01055$, and the load at which maximum efficiency is reached is—

$$C = \sqrt{\frac{140}{{\cdot}01055}} = \sqrt{13270} = 115 \text{ amperes, nearly.}$$

Also the efficiency at this load is

$$\eta_{max} = \frac{102}{102 \times 2\sqrt{140 \times 0{\cdot}01055}}$$

$$= \frac{102}{104{\cdot}43} = 97{\cdot}67 \text{ per cent.}$$

To show the small error which is introduced by taking in the above formulæ the open circuit value of the voltage,

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instead of the value as affected by the drop, we will work out the drop and make the calculation of the efficiency afresh.

We find, then, that the drop in E.M.F. due to the secondary resistance is

$$115 \times 0{\cdot}006 = 0{\cdot}69 \text{ volts},$$

while that due to the primary resistance is

$$\frac{115}{19{\cdot}61} \times \frac{1{\cdot}75}{19{\cdot}61} = 0{\cdot}523 \text{ volts}.$$

Thus the total copper drop = 1·213 volts. There remains the drop due to magnetic leakage. This must be estimated by a comparison of the behaviour of similar types of transformers. In the one we are considering, 0·4 or 0·5 volts would be a fair estimate; we get then for the total drop at 115 amperes 1·213 + 0·5, or say 1·7 volts. E then becomes 102 – 1·7 or 100·3 volts, and a recalculation of the maximum efficiency with this correction gives us

$$\eta_{max} = \frac{100{\cdot}3}{100{\cdot}3 + 2\sqrt{140 \times 0{\cdot}01055}}$$

$$= 97{\cdot}63 \text{ per cent.}$$

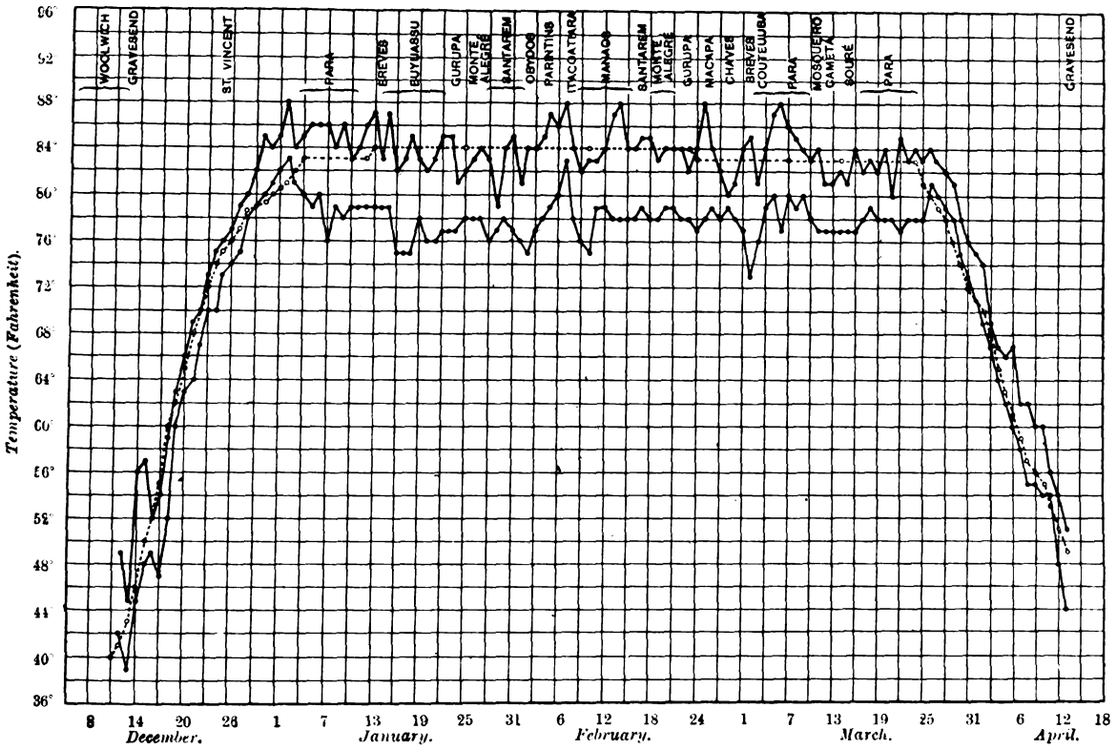
or practically the same value as that obtained when the open-circuit value was taken, the drop being neglected. If we substitute in this last equation the corrected value of $p$, that, namely, corresponding to a secondary terminal pressure of 100·3 instead of 102 volts—that is, if we substitute 0·0104 for 0·01055—the value of $\eta_{max}$ works out to 97·65, which is still nearer to the figure obtained by the approximate formula given above.

These very simple formulæ, then, namely, $C = \sqrt{\frac{w}{p}}$ and $\eta_{max} = \frac{E}{E + 2\sqrt{pw}}$, may safely be used to determine the conditions of maximum efficiency, and ought to be familiar to all who are concerned either in the designing or in the practical running of transformers.

**The Utilisation of Niagara.**—An extra Friday evening meeting of the members of the Royal Institution will be held on June 19th, when Mr. Thomas C. Martin, one of the editors of the *Electrical Engineer* of New York, and American delegate to the Kelvin Jubilee, will deliver a lecture on "The Utilisation of Niagara."

## THE AMAZON CABLE EXPEDITION.

Some particulars of the system of telegraph cables which has recently been completed by Messrs. Siemens Bros. and Co. in the Amazon River and its tributaries were given in our issue of March 20th (Vol. XXXVI., p. 681), and in our last issue we gave some account of Mr. Alexander Siemens' recent lecture on the subject. Through the kindness of Mr. Siemens we are now enabled to publish a reproduction of the curves of temperature readings which were taken during the expedition when the cables were laid. The upper of the two full-line curves gives the maximum, and the lower of these the minimum temperature of the air, while the dotted line gives the temperature of the water. The curves give the readings both on the outward and return voyages, and include the ocean temperature readings between England and Pará.




Temperature Readings taken during the Amazon Cable-Laying Expedition (1895-6).

## SOME EXPERIMENTS WITH HITTORF TUBES AND RÖNTGEN RAYS.*

BY ANTONIO ROITI.

The Accademia dei Lincei at Rome permits me to show to it some of the many experiments which I have made in this matter, although they are still imperfect and poor in comparison with the labour which they have cost, and although I may have been anticipated by others who probably have succeeded better than I.

1. *Shadows and Penumbras.*—Röntgen says that the X-rays proceed from that point where the side of the tube is struck by the cathode rays, and adds that if the internal rays are turned aside by a magnet, the X-rays proceed from another point, which in its turn is the end of the cathode rays. All other observers confirm this circumstance; some suppose that the cause of the Röntgen rays is the fluorescence generated in the glass by the cathode rays, others believe that such fluorescence is a necessary condition of their emission, a few others are more reserved, and among these last am I, who incline to consider the fluorescence a purely concomitant phenomenon.

But before treating this question I have wished for my own satisfaction to try to determine the geometrical point whence the Röntgen rays emanate and the manner of their emission. The X-rays proceed from the side of the tube; but do they come from any point of it as prolongations of the internal cathode rays, or do they emanate from the wall of the tube in a normal direction or in all directions?

* Rendiconti della R. Accademia dei Lincei. Read March 1, 1896.

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It occurred to me to observe the shadows and the penumbras caused, and, in fact, limiting the radiating points with suitable metallic screens, suitably pierced, I am persuaded that the penumbras are always there, even if the cathode rays proceed from one point, however short the distance of the opaque body from the shutter. At first sight, one might think that this was a phenomenon of diffraction, since there are nearly always alternations of greater and lesser intensity in the penumbras; but it is necessary to proceed cautiously, knowing that the internal cathode rays are reflected by metal and glass. The matter is complicated, and doubt is justified by our ignorance with regard to the wave-length, since the outlines may be lost with high frequencies if the rate of propagation is very great.

At all events I have attempted to reduce to a point the place of the emanation of the X-rays, taking for cathode a spherical mirror with the centre of curvature on the side of a glass bulb.*

The bulb is represented a third of the natural size in Fig. 1. Its concave mirror of aluminium has a radius of curvature of 40mm.; the filiform anode is placed in the little side tube. After I had exhausted it as highly as I possibly could, it showed a splendid fluorescence, but displayed it over the whole of its surface and with somewhat greater intensity in the tubulure containing the anode. I noted incidentally that, having put the anode in communication with the gas pipe, the fluorescence was concentrated over the hollow surface opposite the cathode, ready to shine everywhere if I breathed on the bulb. Then, immersing the bottom of the bulb in water deposited over a very thin plate of mica the fluorescence disappeared as if internally. In these conditions I have been able to obtain well-marked impressions whilst the objects were close to the photographic plate, but they disappeared when they were distant from it. For example, a metal grating with a mesh of 1mm., inclined at 45deg. to the plate and to the axis of the mirror, has only given very distinct shadows at points immediately adjacent; but at about 1cm. from the plate the meshes were hardly to be distinguished, and the plate was about 14cm. from the bottom of the bulb.

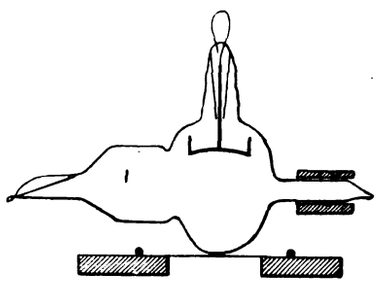

FIG. 1—(One-third actual size).

Do the disappearances arise perhaps from the circumstance that the rays proceed only from that single point of the bulb where the centre of the curvature of the cathode rays is situated, or from the periodicity of an action not regular enough to give the diffraction fringes, but sufficiently long in time to disturb the accuracy of the outlines?

A little electric lamp, with a ground-glass bulb of the same size as the bulb employed, placed at the same distance, gave me the shadows almost as ill-defined as those made on the aforementioned plate. And although the conditions might not be identical, because the lamp shone all round about, whilst the bulb was slightly fluorescent only in the immediate vicinity of the centre of the mirror, yet it appears to me that also in the case of the Röntgen rays the disappearance may be attributed to the diffusion from the glass wall, which in order to emit them does not need to be fluorescent.† In confirmation of this I can mention shadows with well defined outlines which I have obtained even at a considerable distance, when I have limited the radiating point by a screen having a small aperture. But of this I shall speak later on.

2. *The behaviour of a Tube during Exhaustion.*—The tube which I call H (Fig. 2) is cylindrical, 150mm. in length and of 40mm. in diameter. It has a spherical mirror with a radius of curvature of 4cm., and the centre of curvature is in the centre of a ring of aluminium wire, which serves as anode. From the mirror to the bottom of the tube, which is a spherical cup, is 122mm.

I have used this tube, keeping it always attached to an excellent Geissler pump so as to vary the rarefaction at pleasure. To enable me to follow the various phases of luminosity, I inserted it in series with a spark-gauge with balls, on the secondary of a large Ruhmkorff coil excited so as to give, with a rapid Deprez interruptor, sparks of 6cm. in air between the points. The insertion of the spark-gauge (spinterometer) is necessary, if in the first stages one wishes to eliminate the luminosity produced by the current at "make," which by the persistence of the images on the retina may be superimposed upon the luminosity evoked by the currents at "break." The mirror was the cathode for these latter currents, and the anode was the ring communicating with the spark-gauge.

I pass over the preliminary stages, in which the positive luminosity is still visible, and confine myself to the *first stage* of the negative luminosity only, in which one may begin by distinguishing three bands—the first nearest to the cathode, and of a tan colour; the second is called the dark space, but it is really, as Goldstein has shown, of a blue colour; the third band, more brilliant than the first two, is of various colours, according to circumstances, violet in rarefied air, whitish for the most part when all the air has been extracted and the tube is affected by the air already absorbed by the electrodes and by the glass.*

In this first stage the second band forms the double bluish cone with a vertex in the centre of the curvature of the mirror; it passes beyond the whitish luminosity, and where it comes in contact with the glass it causes fluorescence, much more vivid at the bottom of the tube, which is heated to such a point as to appear red for a moment, when the discharge is discontinued.

Increasing the exhaustion, the third band enlarges; it grows paler and finally disappears. Here, we may say, commences a *second stage*, in which one can bring the balls of the spark-gauge into contact with-

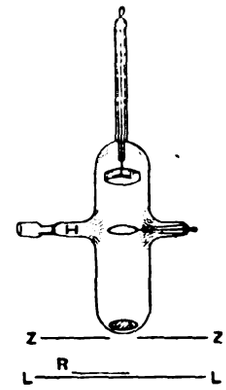


FIG. 2.

out the anode becoming luminous. The vertex of the double blue cone is no longer in the centre of curvature, but more distant from the cathode, and the tan colour of the first band is prolonged. The fluorescence becomes more intense along the walls ascending from the bottom, and the bottom of the tube falls in temperature so that one can touch it without scorching oneself. With the disappearance of the whitish light, which is characteristic of the *second stage*, the bottom of the cryptoscope coated with platino-cyanide of barium begins to be plainly seen, and so one may say that the Röntgen action proper† really begins from this point onward.

* I have had to surmount great difficulties in the construction of these vacuum tubes, but after innumerable failures Signor Adolfo Calamandrei, curator of the Museum of Ancient Instruments, although inexperienced, commenced with great perseverance to try, and has succeeded in blowing such a tube as I require, and which is sufficiently regular. It is fitting that I should express my thanks to him for it.

† As a matter of curiosity I show the print of a shadow of nuts, walnuts, almonds and chesnuts in their shell, obtained when the bulb was hardly luminous at all. Leaves of the oleander and the ilex have left on the negative some light traces of their venation; and it is certain that lovely photographs of the skeletons of leaves can be obtained in this way, by suitably varying the length of exposure.

* This whitish luminosity is most difficult to eliminate, especially if the tube has been long in communication with the atmosphere. I have had for several years a tube made open for me by Müller, of Bonn, and never exhausted. Now, after a prolonged working of the mercury pump, making the electric discharge pass through without stopping, I have succeeded in making it assume a lovely green phosphorescence, and in obtaining a well-marked photograph; but since then the whitish luminosity has again appeared, and the tube is no longer efficacious. And this has repeated itself three times after exhaustion. It is by the colour of the luminosity that I judge whether a tube is spoiled, perhaps by the opening of some very small pore, or whether it arises from air already condensed in the interior: the colour is violet or reddish in the first case, whitish in the second. Useful precautions to make a tube last are to make it red-hot all over whilst it is being blown, and to connect it with the pump without delay, or even to keep it hermetically sealed. During the action of the pump it is best to continually pass through the tube alternate discharges, stronger and more frequent than those which are to be sent through after detachment from the pump. I may here mention the case of a Bessel-Hagen pump, which I left unused for some years communicating with the atmosphere, because there was no mercury in it. With it, although it has remained perfect, I have never yet succeeded in eliminating entirely the whitish luminosity of the third cathode band, and I kept it in action for about a week!

† *Added in the correction of the proofs* (March 5th).—I have obtained a photograph also from a tube which was in the first stage, and was all filled with the whitish luminosity; but‡ this was on condition that I sent some sparks 4cm. long through the air in front of the anode. Suppressing these sparks, there was no photograph in spite of a long exposure.

[‡ Exact meaning of original not very plain.—ED. *E.*]

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Pushing the rarefaction still further, the double cone continues to taper off more; it also grows pale, and becomes invisible, and at last even the tan-coloured aureole almost disappears where it spread right up to the concavity of the cathode. In this *third stage* the brilliance of the lateral walls and that of the cryptoscope are at a maximum; the bottom of the tube is hardly warm and scarcely shines, it has also the appearance of being stained by a coffee-coloured fluid which rises up in the way in which alcohol rises when thrown to the bottom of a cup filled with water.

Continuing to pump in this third stage, which I consider the most efficacious, the passage of electricity becomes more difficult. There may occur, as it were, palpitations, in connection with which some sparks light up the external wall of the tube without detaching themselves from the electrodes, and the external conductors of the tube send out splashes of purplish light. But before this the fluorescence becomes paler on the lateral walls, and returns to the terminal basin, and the field of the cryptoscope continues to grow weaker. Two other tubes were also followed by me through all these phases of luminosity.

3. *Shadows Directly Magnified.*—I have placed the tube H horizontally, I have arranged at 5mm. from its bottom the slit of a diffraction bench giving it the width of 1mm.: at 48mm. from the slit placed parallel with it, a screen formed of threads of copper so thin that there were only 25 of them in 20mm. Behind the screen and at various distances I placed the photographic plate wrapped up in several folds of black paper.

In taking the photograph I was careful to maintain the exhaustion in its third stage, in such a condition that the tan-coloured aureole could no longer be seen, and all the walls had an intense fluorescence. In order to do this I was obliged to work the pump frequently, since the prolonged discharges altered the condition of the air inside. Under these conditions, and with a rapid interruption, I obtained among others the two photographs *p* and *q*, which

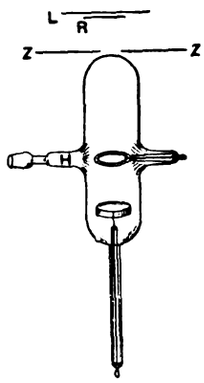


Fig. 3 (One-sixth actual size).

I show, and with slow mercury interruptor the photograph *r*. For the photograph *p* the distance between the screen and the plate was 13mm.; for photograph *q* it was 96mm., and for *r* 120mm.

We are still far from *magnifying the invisible*, but at any rate we have obtained a magnification from two to seven with outlines quite well defined.

4. *Fluorescence does not appear to be a Necessary Condition for the Emission of Röntgen Rays.*—It appears to me that we may conclude from what precedes that the waves (if they are waves) of the Röntgen rays must be short, and I maintain that I have proved that the disappearance of the shadow, as in the case of the bulb I, may be ascribed to the great size of the emitting surface, although the fluorescent portion may be very small.

My other experiment seems to me to shew that Röntgen rays can be produced without fluorescence. In the tube H described before, a disc of mica was enclosed which, in the horizontal position before adopted, did not intercept the cathode rays. When, however, the tube was vertical and the disc supported on the bottom as in Fig. 2, or on the ring as in Fig. 3, the discharge heated the mica all round its centre to a bright red, but the green fluorescence did not reach so far. It was impossible for me in these circumstances to pass from the second to the third stage. It was impossible, therefore, to make the double cone disappear, although it was much tapered off.

In the arrangement shown in Fig. 2 I had placed at 3mm. from the end of the tube a zinc diaphragm Z Z with an aperture 18mm. in diameter; and below, at the distance of 22mm., a piece metal gauze R, which only covered about half of it, and was supported directly on the black paper which enveloped the photographic plate L L with many folds. The positive *a* is taken from the impression obtained in this manner.

In the arrangement shown in Fig. 3 the tube was upside down, having been turned round upon the tube which joined it to the pump, and the disc of mica entirely covered the ring which formed the anode. When matters were so arranged the red-hot part was larger, although the mica was now in the centre of curvature of the mirror, which was made the cathode. As before, and at 3mm. from the end, was placed the screen Z Z with its aperture of 18mm.; and at 22mm. from it the gauze in immediate contact with the covering of the photographic plate L L. The positive print *b* shows the impression thus obtained, and comparing it with the positive *a*, it is seen that the active rays now proceeded from the glowing mica.

There is a confirmation of this in the print *c* produced by the arrangement shown in Fig. 4, in which the tube was put upright; the mica was on the bottom, as in Fig. 2 but the distances between, the mica and the screen and the plate were the same as those of Fig. 3. These distances being equal the impression is the same whether the mica is on the ring, or on the bottom of the tube.

*5. *Complications of Phenomena and the Necessity for Describing Minutely all the Circumstances in which the Observations are made.*—We must not pay attention in the preceding photographs to the relative intensity of the impressions, since there are too many circumstances which might cause it to vary, and are all not within control. Leaving out of consideration the duration of the action, the sensitiveness of the plate, the manner of developing it, the intensity, frequency and nature of the electric discharge, let us think of the variability of the glass (or, rather, in our case, of the mica which was undergoing disintegration) under prolonged action, of the continually changing condition of the air inside, which may be liberated or absorbed, of the conditions of insulation of the tube at its various points, and above all of the varied distribution of the

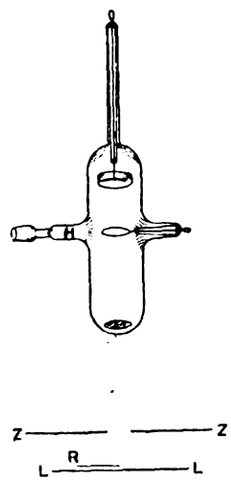


Fig. 4 (One-sixth actual size).

discharge and of the subsequent interrupted discharges which are usually noticed along the external walls of the tube, &c., &c. In view of all these things the diffidence with which at present I regard quantitative determinations in experiments of this kind is justified.

It would be desirable that observers should indicate at least the shape and dimensions of the tubes and electrodes, the stage of the luminosity at the moment of observation and the method of excitation. In this way any contradictory results would probably receive their justification as, for instance, the discrepant observations of Prof. Righi and Profs. Borgmann and Gerchun. The former found that under the Röntgen action an insulated metal sphere tended to acquire or to preserve a positive charge, whilst Borgman and Gerchun found a negative residual charge. In some cases I believe that by the use of an exploring point in the external field opposite effects might be observed even with the same tube excited in the same manner. I will give an example. A tube J (of external diameter 25mm., length 142mm.) had at the top as cathode a cup of 10mm. radius of curvature, height 8mm., and across the the middle for anode a ring coaxial with the cup. When excited with a rapid interruptor and with a large coil which gave a 6cm. spark in the air, it was found in the second stage of luminosity (that is to say, the third band had disappeared), that it showed hardly any trace of cathodic luminosity on the anode, yet it still showed faintly the luminosity of the second band forming the double cone with the vertex much further away from the centre of

* Although one might consider it superfluous, nevertheless for precision I wished to subject the plate, gauze and diaphragm in their relative positions, as in Fig. 2, to the action of a sheet of mica heated red-hot by a jet of flame, in such a way that it might present the same appearance as it did when it was glowing under the effect of the discharge in the inside of the tube. I did not obtain, as is readily supposed, any impression at all, although I prolonged the exposure for a very much longer time.

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the cup. Exploring the field with the cryptoscope, the diaphragm was found to be more luminous in the centre than at the periphery whilst it was near the tube ; but when it was further off it appeared darker in the middle ; and this in any position with respect to the axis of the tube. This fact is hardly in agreement with any other fact, which appears very strange and evidently needs more study.

Some observations made by photography show, it appears to me, that the amount of transparency of certain plates may vary with the variation of their distance from the surface of emission of the X-rays. But I repeat that this fact has not been sufficiently investigated to exclude the possibility of some disturbing circumstance having arisen.

6. *Applications to Petrography.*—Finally, I may say that among the various slices of rock lent to me by the Royal Bureau of Mineralogy, I have met with some peculiarities in the jaspars, and I have begged Prof. Grattarola to study the question from the mineralogical aspect. The other rocks were not in sufficiently thin slices to give noteworthy differences.

The oriental gems, which I have tried in comparison with western ones of the same name, do not show differences of opacity sufficient to enable them to be discriminated in the same way as one recognises with certainty real diamonds from paste.

7. *Additions made on March 5th in Reading over the Proofs.*—During the last few days Signor Calamandrei has prepared for me two tubes similar to Fig. 2, but containing in one case a disc of platinum $\frac{1}{100}$mm. thick, the other a disc of porcelain, which I cut out from a Ginori plate and reduced to the unusual fineness of $\frac{1}{4}$mm. Both the discs were relatively larger than that of mica shown in Fig. 2, for they almost filled the section of the tubes. Both the tubes were excited with the rapid interruptor and the large coil, which gave sparks of 15cm. in the air. They were both kept between the end of the second and the beginning of the third stage of exhaustion, and with the arrangement of Fig. 2 they gave me photographs of a piece of metal gauze. The platinum glowed at the middle, and, becoming volatilised, blackened the lateral walls up to the height of the ring which formed the anode, whilst it left the lower hemisphere transparent.

To glass and aluminium are now to be added mica, platinum and porcelain as substances which emit Röntgen rays when exposed to cathode rays.

## THE UTILISATION OF WATER-POWER, ESPECIALLY WITH A SMALL FALL, WITH SOME EXAMPLES OF PLANTS FOR THE GENERATION OF ELECTRICAL ENERGY.*

BY ALPH. STEIGER.

The cheap production of electrical energy is generally recognised to be one of the chief aims of modern engineering science. Nature has provided us in water-power with one of the best possible agents for realising this object; and I trust that, in bringing the subject of the utilisation of this free gift of Nature before the members of the Institution of Electrical Engineers, I shall be able to convince them that the water-powers of this country, if judiciously utilised, are capable of rendering them great service.

In my own country—Switzerland—the electrical engineer is co-operating cordially with the water-power engineer, and electrical installations are rapidly increasing in number. The successful electrical transmission of power to points far distant from its source has been the chief factor in this development. The idea prevails that considerable fall is required to obtain water-power, but it is my desire to show and to *prove* in the following remarks that excellent results are obtainable also with a very low fall—a fall of even less than 3ft. Small falls are more frequently met with in this country than high falls, and will therefore have more particular attention in this Paper than the high falls found in mountainous districts. The description of a few turbine plants under low falls, some of which are applied to the generation of electrical energy, will be of special interest.

During a long experience in constructing turbines and designing complete plants I have found that the most difficult were always those connected with the utilisation of a low fall. These difficulties consist chiefly in the variation within very wide limits of both the quantity of water and the fall, while a constant power, and in most cases a constant speed, is of great importance.

Generally speaking, the real agent in water power is gravity, and the water is simply the medium to transmit the action of gravity on to the motor which converts it into mechanical work. The action of gravity can take either the form of dead weight, or of pressure, or of velocity, sometimes called kinetic energy. A very high efficiency is obtained from motors in which the water acts by dead weight or by pressure, but the slow speed of the water-wheels and the complicated mechanism of the pressure engines render them unsuitable for the purpose of generating electricity ; moreover, motors worked by weight or by pressure are only advantageous when working under a high fall. The kinetic energy is the only form in which the gravity can be applied advantageously to the performance of mechanical work under a small fall. The motors using it in this form are the common undershot wheel, the Poncelet water-wheel, and the turbines. It will be sufficient for the purpose of this Paper to give the efficiency of the various types of water motors for any fall, without going into a detailed description of those which are unsuitable for driving dynamos. The efficiency of the motors, with the fall for which they are adapted, is as follows :—

| Fall. Feet. | Efficiency of water wheel. | | Efficiency of turbine. |
|---|---|---|---|
| | | Per cent. | Per cent. |
| 1 to 5 | Ordinary undershot ... | 25 to 30 | 70 to 75 |
| | Poncelet ... ... | 65 to 70 | |
| | Sagebien ... ... | 65 to 75 | |
| 5 to 8 | Low breast ... ... | 30 to 50 | 75 to 80 |
| 8 to 15 | High breast ... ... | 60 to 75 | 75 to 80 |
| 15 to 50 | Overshot wheel ... | 55 to 75 | 75 to 80 |
| Above 50 | Pressure engine ... | 75 to 85 | 75 to 80 |

These figures show the interesting fact, that the smaller the fall is, the greater is the gain in power over the old-fashioned water-wheels. Although the smallest fall which would reasonably be utilised by a turbine is at least 2ft. 6in., I will show by some examples that, by a turbine suitably constructed and carefully adapted, useful power is still obtained under a fall of only 1ft. or a little over. The great variety of fall, water supply, local conditions, and special requirements, of necessity demands a variety of types of turbines.

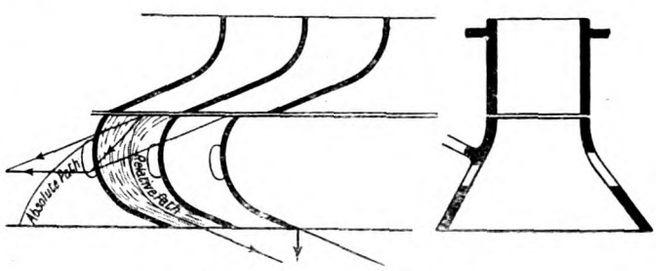


FIG. 1.—Vanes of "Action" Turbine.

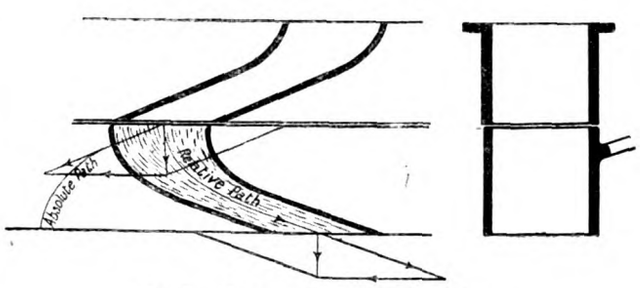


FIG. 2.—Vanes of "Reaction" Turbine.

Turbines are classified, according to the manner in which the water acts in them, into—(*a*) "impulse," or "action," turbines, and (*b*) "reaction" turbines ; and according to their construction, into—(*a*) parallel flow turbines, (*b*) radial flow turbines, (*c*) mixed flow turbines.

There is an essential difference between the "impulse" turbine and the "reaction" turbine, as indicated by the form of vanes illustrated in the diagrams Figs. 1 and 2.

The "*impulse*" *turbine*, as usually constructed, must run clear of the tail-water, its buckets being only partially filled with water. It requires a constant fall, with constant level of the water in the head and tail race, but its efficiency is not affected by the greatest variation of the water supply. On account of this quality, it can be built as partial injection turbine, to utilise high falls with a very small water supply. If constructed as "partial injection turbine," its diameter can be chosen so as to give just the desired number of revolutions. This is extremely convenient for driving dynamos, which can thus be connected direct with the shaft of the turbine, doing away with intermediate gearing or belt drives. An instance of this kind is the turbine plant now being erected by Messrs. Escher, Wyss and Co., of Zurich, at the Falls of Foyers, for the British Aluminium Company (Limited). This plant consists of five "impulse" turbines with vertical shaft, with partial injection, each giving 700 B.H.P., working under a fall of 350ft. The dynamos are required to run at 140 revolutions per minute, and to

* Paper read before the Institution of Electrical Engineers.

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obtain this speed the turbines were given a diameter of a little over 9ft.

Partial injection turbines under a high fall are sometimes fixed on a horizontal shaft, and can thus be coupled direct to the armature spindle of a dynamo by means of an isolating coupling.

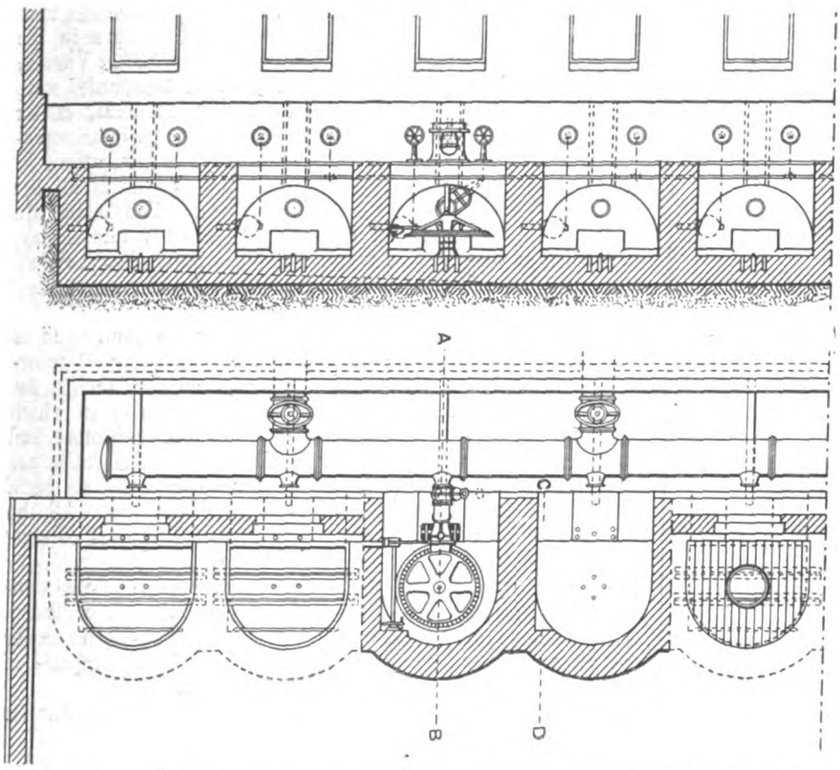

FIG. 3A.—Turbines at the Falls of Foyers, Scotland. (The British Aluminium Co., Limited.)

This mode has been adopted, amongst numerous other plants, for the electric lighting installation of Davos, in Switzerland, which consists of three horizontal patent turbines of 200 B.H.P. each, working under a fall of 330ft., and running at 400 revolutions per minute. The turbines have a diameter of 40in. As a contrast to these turbines of large power and small diameter, and to show the adaptability of the partial injection turbine to special requirements, the 140 H.P. turbines of the waterworks in Chauxdefonds may be mentioned. These work under a fall of only 170ft., but as they are driving pumps at the low speed of 60 revolutions they had to be made of a diameter of 15ft.

Great as the advantages of the "impulse" turbines are under the conditions above mentioned, their use under very low falls is limited, firstly, owing to the reason already given that they must run clear of the tail water—a condition which can seldom be realised in a flat country like this; and, secondly, because they run at a slower speed than a "reaction" turbine under the same fall. Although "impulse" turbines are now built to run in the tail water without considerable loss of efficiency, the reduction of power in proportion to the reduced fall, and the quantity of water accordingly reduced, together with the reduced speed, excludes them in the majority of low and varying falls. The ideal turbines for low and varying falls are *the "reaction" turbines.* They are generally placed on a level with the tail water, or, if local conditions require them to be placed above tail water, connected with it by a suction tube. They run at a higher speed for the same fall, or the same diameter, than an "impulse" turbine, and their efficiency is not affected by the immersion in the tail water. The principal objection raised against "reaction" turbines in general is that their efficiency is greatly reduced when working at part gate. This is indeed the case with many of the reaction turbines known in this country, which give a very poor efficiency at part gate, especially at less than half gate. The continuity of flow of the water through the buckets is essential to a good efficiency. Only in a few reaction turbines is this condition fulfilled to such an extent that within very wide limits of the water supply the efficiency is not perceptibly reduced.

The utilisation of a small and varying fall, with a varying quantity of water, is a very difficult problem for the water-power engineer. The turbine for a given power under a low fall is larger and runs slower than one of the same power under a higher fall; it is, therefore, heavier and more costly, and requires heavier gearing, entailing a greater loss of power through friction. A high speed is desirable, especially for driving dynamos; but attempts to increase the speed of the turbine by reducing its diameter may easily result in an inferior efficiency. The efficiency should be as high as possible in consideration of the greater cost of a water-power plant with a low fall; but the proportion within which such a fall and the quantity of water varies is mostly so great that it is almost impossible to obtain the highest efficiency when the water supplied is diminished, *i.e.*, when a high efficiency is most wanted. The maintenance of a *constant* power with a *constant* speed under variation of fall and quantity of water in large proportion can, if at all, only be attained by sacrificing some efficiency. The hydraulic losses must be reduced to a minimum by the most careful construction of the turbine in its essential parts, and it is needless to say that no standard size or type of turbine will fulfil all these conditions by simply consuming all the available water.

Even the arrangement of the turbine chamber is of influence on the results, and requires special attention. On a careful judgment of the local conditions depend the economy and the success of a plant. Unsatisfactory results in water-power plants are caused just as much, or oftener, by bad judgment of the local conditions as by the inferiority of the turbine. In by far the most cases of low falls incidental to flat countries, an abundance of water corresponds with a reduction of the fall. The power of a turbine calculated for the normal fall would be reduced, for the time, when an abundance of water reduces it, and, as a consequence, water would be wasted, while the power obtained is

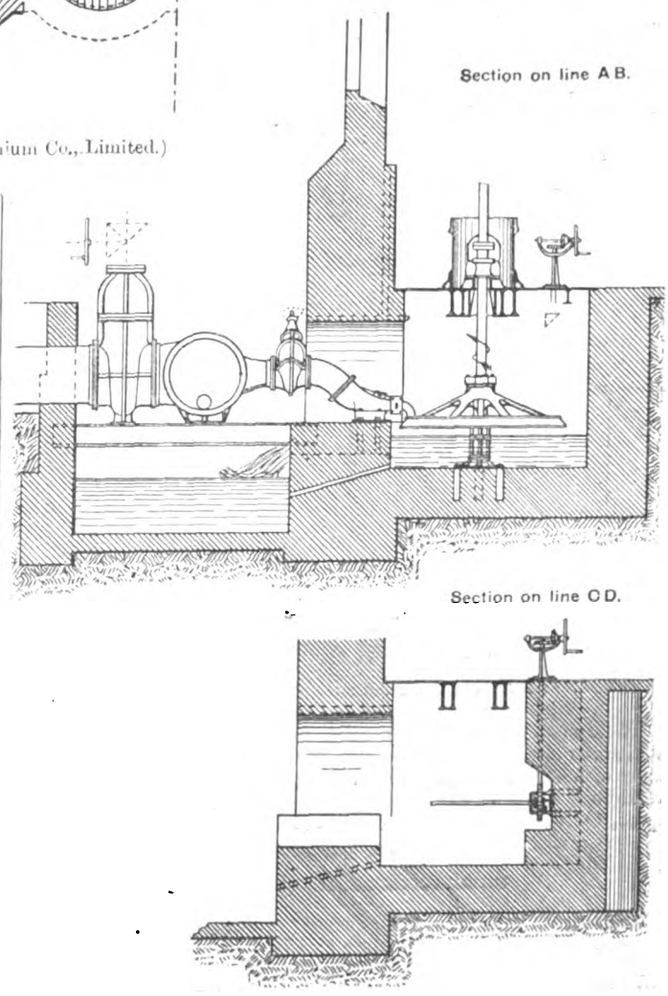


FIG. 3B.—Turbines at the Falls of Foyers, Scotland. (The British Aluminium Co., Limited.)

insufficient. These cases are, unfortunately, of frequent occurrence. On the other hand, if the turbine is constructed to give off the required power under the reduced fall, it must be partially closed for the diminished water supply with the



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normal fall, whereby the efficiency would be reduced just when it should be highest, if economy is at all the chief object of a turbine plant. The manner in which a high efficiency can be maintained for a diminished water supply is to subdivide the turbine into several compartments, each of which represents a complete turbine. This arrangement has been adopted by Fourneyron for his well-known outward flow turbine, and in the modern *Jonval turbine*. The Fourneyron turbine is provided with a cylindrical gate, which is moved vertically, whereby each compartment is opened or closed. This type has been adopted for the large power plant on the Niagara Falls, but on the European continent they are seldom used. Their efficiency is very good, but, owing to the narrowness of the buckets, they are easily choked.

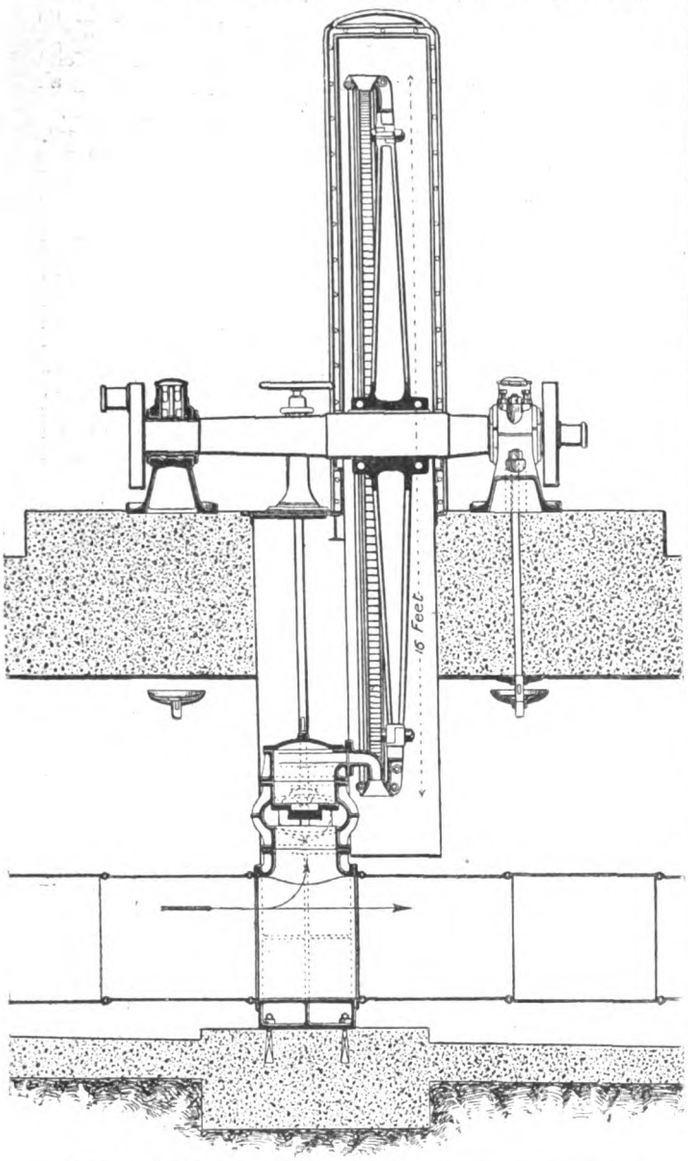


FIG. 4.—Turbines of the Chauxdefonds Waterworks, Switzerland.

The Jonval turbine is a parallel flow turbine, and is, for large variations of the fall and quantity of water, subdivided into two or more concentric compartments. A subdivision in this manner renders it possible to maintain not only the power, but also *the speed*, under a varying fall within very wide limits.

*(To be continued.)*

**ELMORE COMPANIES.**—The financial papers contain communications from shareholders expressing anxiety as to the dividend outlook. In one communication attention is called to the sanguine statement of Mr. W. Elmore, published in October, 1894, as follows :—"The businesses have been cut adrift from wreckers and the shareholders' property and interests made safe. The Companies have practically no trade liabilities beyond the current monthly accounts. They have ample stocks of raw copper, purchased at the bottom of the recently depressed market, and abundance of capital at command to purchase any additional quantities required for the execution of the large volume of orders which the recognised superiority of the product secures."

## THE INTERNATIONAL TELEGRAPHIC CONFERENCE.

The International Telegraphic Conference will be opened at Buda Pesth on June 16th, and as its object and methods are little known outside of telegraph circles, some information on the subject may be interesting. These conferences take place every five years, and have been held in turn in the principal European capitals as follows :—Paris, 1865 ; Vienna, 1868 ; Rome, 1871-72 (at which the cable companies were first represented) ; St. Petersburg, 1875 ; London, 1879 ; Berlin, 1885 ; Paris, 1890. The delegates include representatives of nearly all the Government administrations in the world which work telegraph lines, as well as of all the companies working cables and land lines. The latter are allowed to speak, but not to vote. It is only fair to say, however, that the Government delegates have always shown great consideration for views put forward by the companies' representatives.

The object of the Conference is to draw up from time to time service regulations for the efficient working of international telegraphy, the adjustment of accounts, tariffs, &c. The Director General of Telegraphs of the country in which the Conference is held presides over its deliberations ; and matters of detail, together with the framing of the rules, are delegated to two Commissions, one dealing with all tariff matters and the other with the rules for working. All the decisions of the Commissioners are, however, subject to confirmation by the full Conference.

The chief subjects for discussion at the approaching Conference will probably be the authorised vocabulary lately issued by the International Bureau of Telegraphs at Berne under instructions from the Paris Conference, and the proposal of Germany for a uniform European word rate.

The British representatives to the Buda Pesth Conference are the following :—

| | |
|---|---|
| Post Office ..... | J. C. LAMB, Esq., C.B., C.M.G. |
| Cape Colony..... | H. C. FISCHER, Esq., C.M.G. |
| Natal..... ..... | P. BENTON, Esq., and R. MACKAY, Esq. |
| India ..... ..... | P. LUKE, Esq., and B. T. FFINCH, Esq. |
| New South Wales ... | Sir SAUL SAMUEL, K.C.M.G., C.B., Agent-General. |
| Victoria..... | Hon. DUNCAN GILLIES, Agent-General. |
| South Australia ..... | Hon. T. PLAYFORD, Agent-General. |

The representatives of the Companies are the following :—

The MARQUIS OF TWEEDDALE—
African Direct, Eastern, Black Sea, Europe and Azores, and Eastern Extension Companies.

Lord SACKVILLE A. CECIL—
Eastern, Brazilian Submarine and Pacific and European Companies.

Sir ALBERT A. LEPPOC CAPPEL, K.C.I.E.—
Eastern, Eastern Extension and Brazilian Submarine Companies.

C. W. EARLE, Esq.—
Eastern Extension Company.

J. DENISON PENDER, Esq.—
Eastern, Black Sea, Eastern and South African, Europe and Azores, West African, African Direct, Eastern Extension, Brazilian Submarine and West Coast of America Companies.

M. JULES DESPECHER—
African Direct, Brazilian Submarine, Black Sea, Eastern, Eastern Extension, Eastern and South African and Europe and Azores Companies.

G. DRAPER, Esq.—
Eastern, Black Sea and Eastern and South African Companies.

F. E. HESSE, Esq.—
Eastern Extension Company.

W. HIBBERDINE, Esq.—
Eastern, Black Sea, Eastern and South African, Europe and Azores, Eastern Extension and West African Companies.

W. H. AXWORTHY, Esq.—
African Direct, Brazilian Submarine and Pacific and European Companies.

G. R. NEILSON, Esq.—
Europe and Azores Company.

H. ST. L. SMITH, Esq.—
Eastern, Black Sea, Eastern and South African, Europe and Azores, Eastern Extension and West African Companies.

S. BARBER, Esq., and C. BURT, Esq.—
Anglo-American Company.

GEORGE WARD, Esq.—
Commercial Cable Company.

CH. GERHARDI, Esq., and Senor COROMINA.—
Direct Spanish Company.

E. M. UNDERDOWN, Esq., and O. MOLL, Esq.—
Direct United States Cable Company.

Commodore SUENSON and F. C. C. NIELSEN, Esq.—
Great Northern Telegraph Company.

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W. ANDREWS, Esq., and F. MOLL, Esq.—
Indo-European Telegraph Company.
R. K. GRAY, Esq., J. JEFFERY, Esq., and W. F. O'BRIEN, Esq.—
Spanish National and South American Telegraph Companies.
Major ALEXANDER WOOD and E. S. HODSON, Esq.—
Western and Brazilian Telegraph Company.
R. T. BROWN, Esq —
West India and Panama Company.
G. VON CHAUVIN, Esq.—
Western Union Telegraph Company.

The Conference will probably last about six weeks, and before separating will fix the place at which the next meeting of the International Telegraph Union will be held. It is not believed that any great changes in international telegraphy will be introduced at Buda Pesth, and the work done will be principally in the direction of simplifying and codifying the existing service regulations.

## PHYSICAL SOCIETY.

At an ordinary meeting of the Physical Society held on May 22, 1896, Prof. Ayrton (Vice-President) in the chair, Mr. R. APPLEYARD read a Paper on

### "Dielectrics."

The author has particularly investigated the effect of temperature on the dielectric resistance. He has employed for this purpose condensers insulated with mica and paraffined paper. In order to eliminate some of the effects of surface leakage, Price's guard-ring arrangement was made use of in all the experiments.

The author finds that the capacity of a paraffin condenser varies irregularly with the temperature, but that to within the accuracy attainable with his instruments (1 per cent.) the capacity of a mica condenser is constant between 33°F. and 110°F. If the resistance of paraffin at a temperature $t$ is represented by $R = R\alpha^t$, the mean value for $\log \alpha$ deduced from all the author's measurements is $\bar{1}{\cdot}96344$. Experiments made with a parallel plate condenser with paraffin as the dielectric show that when the temperature reaches within about 20deg. of the melting point the resistance rapidly falls; when melting commences there is a rapid drop, but while melting is in progress the resistance remains constant.

Prof. AYRTON said he would bear witness to the extreme value of Mr. Price's device, as it completely did away with the necessity for the extreme care previously necessary to prevent errors due to surface leakage. He regretted that he had not had an opportunity of comparing the author's results with those obtained some years ago by Prof. Perry and himself (Prof. Ayrton).

A Paper by Prof. VIRIAMU JONES, on

### "The Magnetic Field Due to an Elliptical Current at a Point in the Plane of the Ellipse and within it,"

was taken as read.

Prof. SILVANUS THOMPSON said that this Paper was of interest, not only on account of the application which others might make of the author's method, but also in that the correction when applied to Prof. Jones's results brought the international ohm more nearly into accord with the true ohm.

Mr. J. J. WALKER said he considered that the Paper was more suited to the Mathematical Society. The integration, which the author reduced to elliptic integrals, might be more easily performed by another method.

Prof. AYRTON said that Prof. Jones's value for the true ohm was now 106·302cm. of mercury.

Mr. CAMPBELL read a Paper on

### "New Instruments for the Direct Measurement of the Frequency of Alternating or Pulsating Electric Currents."

The author employs two arrangements, in one of which a steel wire, the tension on which is variable, and the other a steel spring of variable length clamped at one end, are acted upon by an electromagnet through which the periodic current is passed. The tension or length, as the case may be, is varied till maximum resonance is obtained, a small contact piece being employed to detect when this occurs. The instrument exhibited was capable of measuring the frequency of periodic currents of from 40 to 150 cycles per second.

Mr. WATSON said he thought that in the case of the steel spring there would be a considerable temperature correction, and he suggested a method by which this might be compensated.

Mr. BLAKESLEY asked if the author had found that the spring became magnetised and thus gave the octave.

Mr. TREMLETT CARTER asked whether elastic fatigue influenced the results, and said that a synchronous motor and a speed indicator could be used to measure the frequency.

Prof. SILVANUS THOMPSON suggested that it might be better to employ a polarised apparatus, since to avoid the impression of forced vibrations on the spring it was better, as was done in the case of tuning forks, to make it massive. It had been found in other cases, such as in Hughes's telegraph and the telephone, that better results were obtained with polarised apparatus. He (Prof. Thompson) had used a telephone, placed anywhere near a magnet traversed by the periodic current, together with a tuning fork, which gave beats with the note produced by the telephone, to measure frequencies. The variations in frequency ordinarily met with in practice were much greater than was generally suspected.

Mr. BLAKESLEY said he considered that the advantage of the author's instrument over a telephone and tuning fork was that it was continuously variable over a large range.

Mr. ENRIGHT asked if the author had been troubled by the spring or wire breaking into overtones. In some experiments, in which rather long wires were used, he had been troubled in this way.

Prof. AYRTON said that he did not think that it was possible to get the wire or spring to respond to the octave unless the alternating current contained a component of the frequency of the octave. In fact he had himself used such a stretched string as a wave analyser. He had used a telephone to prove that the note given by a hissing alternate-current arc corresponded in frequency to that of the current. In the instrument used by Prof. Perry and himself a polarised arrangement was always employed, since the alternating current was passed either through a wire in a constant magnetic field, or through an electromagnet which acted on a wire through which a constant current was passed.

The AUTHOR, in his reply, said that the instrument responded, though feebly, to the octave, and this response might be made use of to check the accuracy of the scale.

The Society then adjourned till June 12th.

## LEGAL INTELLIGENCE.

### County of London and Brush Provincial Electric Lighting Company (Limited) v. Vestry of St. Leonard, Shoreditch.

An action has been commenced by the County of London and Brush Provincial Company to restrain the Vestry of St. Leonard, Shoreditch from laying down electric lines beyond the area within which the Vestry are authorised to supply energy under the Shoreditch Electric Lighting Order, 1892. It appeared from an affidavit that the Vestry commenced on May 21st to excavate a trench for the purpose of laying down electric lines within the parish of St. Luke, Middlesex, a district for which the County of London Company have a Provisional Order. On the application of Lord Robert Cecil (instructed by Mr. Sydney Morse) Mr. Justice Henn Collins on the 21st inst. gave the Company leave to serve summons with writ for June 2nd, and granted an injunction in the meantime.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

### NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

TENDERS INVITED.—The Corporation of Leeds require tenders for an electrical installation sufficient for working by the over head system a double track of tramway seven miles in length. The work is divided into seven contracts, details of which will be found in our advertisement columns. Tenders have to be sent in to the Town Clerk, Town Hall, Leeds, not later than June 20th, and particulars, plans, &c., can be obtained from the City Engineer, Municipal Buildings, Leeds, or from Dr. John Hopkinson, F.R.S., 5, Victoria-street, Westminster, London, S.W.

——— The Caledonian Railway Company invite tenders for stores for 12 months from August 1st next. These include telegraph and electric appliances, india-rubber, copper rivets, crucibles, galvanised wire, tools, &c. Specifications and forms of tender may be obtained on and after Monday next from the Superintendent of Stores, Mr. Jas. Lorimer, Charles-street, St. Rollox, Glasgow, and tenders must be sent in to the Secretary (Mr. J. Blackburn), 302, Buchanan-street, Glasgow, by Monday, June 15th.

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TENDERS INVITED.—The North Eastern Railway Company require tenders for telegraph apparatus, wires and line stores, for six months. Tenders to the Secretary, York, by June 8th.

——— Tenders are required for the installation of the electric light at the Devon and Exeter Hospital. Tenders to Mr. C. Cole, 50, High-street, Exeter, by June 3rd.

——— The Cork Corporation invite tenders for providing and erecting the necessary plant and apparatus for the electric lighting of the municipal pumping station. Tenders to Mr. D. F. Gilinan, Municipal-buildings, Cork, by June 3rd.

——— The Municipal Authorities of Mako, Hungary, require tenders for the electric lighting of the town.

——— The Municipal Authorities of Nava del Rey (Valladolid), Ronda (Granada), and Torre Vieja (Alicante), Spain, are inviting tenders for electric lighting concessions; in the first and last cases for a period of 20 years. Tenders in each case to El Secretario del Ayuntamiento.

——— The State Small Arms Authorities at Spandau require tenders for the supply of 900 incandescent lamps. Tenders to the Königliche Direktion der Gewehr fabrik, Spandau, Germany, by June 17th.

TENDERS ACCEPTED.—The Brighton Corporation have accepted the tender of the Callender Company for the supply of armoured and unarmoured lead-covered electric light cables for the year ending May 1, 1897.

——— The Forfar Corporation have accepted the National Telephone Company's tender for fitting up fire alarms, &c., for £23. 8s.

TENDERS RECEIVED.—The Bray Town Commissioners received 30 tenders for the supply of additional machinery at the electricity works. These are being considered by a special committee.

SALE BY AUCTION.—Particulars will be found in our advertisement columns of the disposal by public auction by Messrs. Wheatley Kirk, Price and Goulty, on Tuesday, June 2nd next, of the entire contents of the late lighting station of the Reading Electric Supply Company (Limited), situated in Thorn-lane, Duke-street, Reading, Berks. The sale of this plant, &c., is taking place owing to the Company having completed their new central station. It will be seen that the sale includes two Babcock-Wilcox boilers, steam engines by Browett and Lindley, Alley and Maclellan, and Greenwood and Batley; Thomson-Houston dynamos, and a quantity of useful electric plant and apparatus, instruments, &c. Catalogues can be obtained from the auctioneers, or direct from the Reading Company.

APPOINTMENT.—The Electric Lighting Committee of the Blackpool Town Council have decided to appoint Mr. Quinn borough electrical engineer, at a salary of £300 per annum, in succession to Mr. Hesketh, who was recently selected to fill the position of electrical engineer to the Queensland Government. Mr. Quinn has been engaged as chief assistant engineer at the Brighton Corporation Electricity Works for the past five years. Mr. A. T. Cooper will continue to act as assistant at Blackpool.

APPOINTMENTS VACANT.—The Corporation of Lincoln, who intend to establish electricity supply works, invite applications for the position of electrical engineer. Salary £300 per annum. Applications must be sent in to Mr. H. K. Hebb, Clerk to the Urban Sanitary Authority and Deputy Town Clerk, by Saturday, June 6th. Some additional particulars are given in our advertisement columns.

——— A principal is required for the new technical schools at Swindon. Commencing salary £250 per annum. Applications to the Swindon and North Wilts Technical Education Committee, Technical Schools, Swindon.

REMOVAL.—Messrs. Eugen Conrady and Co. inform us that they have removed their works and offices from Keighley to 35, Charles-street, Hatton-garden, London, E.C.

WORKS EXTENSION.—The Brush Electrical Engineering Company have decided, in consequence of the active demand for the "Raworth" universal steam engine, to considerably extend their works at Loughborough. The new tool shop, which will be exclusively devoted to the engine trade, is to be 160ft. long by 48ft. wide. Building operations have already been commenced, and will be pushed forward with all despatch, so as to avoid delay in execution of orders.

BANKRUPTCY.—The examination of C. G. Stewart, jun., electrician, takes place at the Court House, Edinburgh, on June 8th.

LIQUIDATIONS.—At a meeting of the United Gutta Percha and Rubber Company (Limited) on April 30th it was decided to wind up the Company voluntarily. The decision was confirmed on May 19th, when Mr. D. S. Carson, 209, West George-street, Glasgow, was appointed liquidator. All claims must reach the liquidator by July 6th.

LIQUIDATIONS.—A meeting will be held at 30, Moorgate-street, E.C., on June 30th, at 3 p.m., to receive an account of the winding-up of the District Messenger Company of Paris (Limited).

——— At a meeting of the proprietors of the British Thomson-Houston (Limited) on the 1st inst., it was resolved that, for the purposes of reconstruction, it was advisable to wind up the company voluntarily. This resolution was confirmed on the 18th inst., and Mr. J. Devonshire, 38, Parliament-street, Westminster, S.W., was appointed liquidator. Particulars of the registration of the new Company are given in another column.

——— A meeting is to be held at the office of Mr. R. Innes, 10, Norfolk-street, Manchester, on June 23rd, at 3 p.m., to receive an account of the winding-up of Hargreaves and Shaw (Limited), electrical and mechanical engineers.

WOODHOUSE AND RAWSON UNITED, LIMITED (IN LIQUIDATION).—A sequel to the meeting of the principal trade creditors in this concern, which was held on April 21st, and particulars of which were given in our issue of the 24th ult., comes in the form of a circular issued by Messrs. Pilling and Co., chartered accountants, of 2, Clarence-buildings, Booth-street, Manchester, inviting those of the creditors who are disposed to authorise the Official Receiver and Liquidator of the Company to tender for the interest of the debenture holders and debenture-stock holders in moneys alleged to be recoverable from the Directors and officers of the Company, which are now offered for sale under an order of the Court, to send in their names with the amount they are prepared to subscribe towards the venture—we had almost written gamble. The position is certainly a most peculiar one. Counsel has advised that there are certain sums clearly recoverable from the persons referred to, and the First and Second Debenture holders and others have been asked to subscribe the necessary funds to indemnify the Official Receiver from all liability in taking action in the matter. It has now come to the turn of the trade creditors to have this offer placed before them, and it remains to be seen whether this body will feel more disposed than others who have been approached to take steps to bring the Directors and other officials before the Courts. The unsecured creditors' claims amount to about £15,000, and the committee appointed by the creditors to consider the matter suggest that an all-round contribution should be made of 10 per cent. of the creditors' claims, which, it is considered, would provide sufficient funds to contest the points raised by counsel's opinion.

CABLE-MAKING MACHINERY.—Messrs. Johnson and Phillips remind us that in August last when their special catalogue of cable-making and wire-covering machinery was issued, it was foreshadowed that an important and comprehensive addition would shortly be made to it. This department of the firm's business has, however, been too busily employed to give attention to the matter, and those interested are therefore informed that a number of illustrated sheets giving particulars of some of the machines manufactured since the catalogue was published can now be obtained. The list of special machines made shows about 20 different kinds of which full particulars can be obtained on application. As Messrs. Johnson and Phillips are not only makers of these machines but are also users, purchasers have the great advantage of the experience gained in the development of the machines for practical use.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from May 20th to May 27th, with the ports of destination:—

*Australasia*—Albany, £2,108 (including £1,310 telegraph material); Fremantle, £257 (including £180 telegraph material); Launceston, £131 (including £56 electric lighting apparatus); Melbourne, £624 (including £201 telegraph material); Rockhampton, £80 (electric lighting apparatus); Sydney, £123; Wellington, £216. *Brazil*—Rio de Janeiro, £5,285 (telegraph material). *Burma*—Rangoon, £31. *Canada*—Montreal, £30. *Ceylon*—Colombo, £25 (telephone). *Chile*—Valparaiso, £1,010 telegraph material). *China*—Shanghai, £9,436 (including £9,434 telegraph material). *Egypt*—Alexandria, £135 (telegraph material); Port Said, £7. *France*—Boulogne, £33. *Germany*—Borkum, £2,199 (telegraph cable). *Holland*—Amsterdam, £80; Flushing, £32. *Hong Kong*—£39 (telephone stores). *India*—Bombay, £213 (including £42 telegraph material); Calcutta, £92. *Japan*—Yokohama, £221. *Malta*—£62 (telegraph material). *North Borneo*—Labuan, £17 (telegraph apparatus). *Russia*—Odessa, £465 (including £436 telegraph material); St. Petersburg, £93. *South Africa*—Cape Town, £39; Delagoa Bay, £66 (telegraph material); Durban, £30; East London, £513; Lourenco Marques, £73 (telegraph material); Port Elizabeth, £31. *Straits Settlements*—Singapore, £267. *Sweden*—Gothenburg, £44 (telegraph material); Stockholm, £164 (telegraph material).

MACHINERY CATALOGUE.—A useful list reaches us from Messrs. John Turner and Sons, electrical engineers, of Denton, near Manchester, whose London agency has just been placed in the hands of Mr. C. F. Quicke, M.I.E.E., of 72, Finsbury-pavement, E.C. The list is illustrated and contains full particulars of dynamos, motors, and coupled plants, manufactured at Denton. Several of the

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machines are specially constructed for different classes of work. The apparatus described includes main and standard switchboards and switches, and on page 26 a useful type of motor fan, which is claimed to be a most efficient ventilator for ships, public buildings, &c., and is built in a variety of sizes. In addition to the construction of machinery and apparatus, Messrs. Turner and Sons undertake the carrying out of complete light and power transmission installations, and stock various kinds of arc and incandescent lamps, cables, and wires, measuring instruments, &c. The catalogue contains a brief account of the Denton works, which were established 36 years ago, and of the firm's works at Danbury, Conn., U.S.A., which, though more recently established than the English factory, are equipped up to the high standard of excellence which the American market demands. The management on both sides is identical, and the Danbury works being situated within easy reach of New York and Boston, facilities for handling large contracts are at the firm's command.——The Blymyer Ironworks Company, of Cincinnatti, U.S.A., forward us a handsome catalogue of machinery chiefly designed for sugar cane, coffee, and rice plantation work. Included in the catalogue are particulars of the portable and stationary steam engines, boilers and fittings, waterwheels, &c., manufactured by the Company.

"Electric Wiring."—We have received from the General Electric Company, of Queen Victoria-street, London, a reprint in pamphlet form of the Paper on "Electric Wiring" read by Mr. F. Bathurst before the Institution in November last, together with Mr. Bathurst's reply to the discussion upon the Paper. The discussion itself is omitted. Copies can be obtained from the General Electric Company on application.

Guide Book.—The Immisch Electric Launch Company (Limited) have just issued a handy little guide to the Thames valley, entitled "Electric Launches on the Thames." The book contains, among other things, a calendar of river fixtures, railway time tables for the summer months, a descriptive guide to the Thames between Richmond and Oxford, two or three maps, and plenty of information about electric launches.

Scotland.—Those contemplating a journey to the Highlands are certainly well provided with literature. We have previously referred to two popular guides issued with the object of meeting the demand for information on this subject, and now have to acknowledge the receipt of a useful handbook issued by the Aberdeen Steam Navigation Company, of London and Aberdeen, which takes the tourist from London Bridge to the Highlands and back, describing the scenery and points of interest *en route*.

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Amazon Cable.—A number of additional telegraph offices have just been opened in the Amazon cable districts, including Cametá, Chaves, Breves, Itacatiara, Macapá, Monte Alegre, Monsquiers, Obidos, Parintins, Pinheiros and Souré.

Asylum Lighting.—The Cheshire County Council have decided to introduce the electric light into the Upton Lunatic Asylum at an estimated cost of £3,000.

Bath.—At a special meeting of the Urban Sanitary Authority on Friday it was decided to borrow £45,000 for the purchase of the City of Bath Company's undertaking and for providing capital for extensions of the plant and mains.

Birmingham.—The National Telephone Company are fitting up a very complete system of telephonic communication at the new General Hospital. The arrangements will comprise a miniature telephone exchange. A switchboard will be fitted up in the porter's office, from which wires radiate to sixty-one different parts of the building, and communication can be effected between any part of the hospital and the porter's inquiry office. An electrical annunciator will be erected at the entrance lodge, to enable indication to be made of the presence in the building of any particular doctor or nurse.

Bury.—The Bury, Rochdale and Oldham Tramway Company have asked the permission of the Bury Town Council to the introduction of the overhead system of electric traction on their lines, and for the terms upon which they would supply the necessary electrical energy for working the trams.

Chelmsford.—The Town Council have decided that, in view of the considerable expenditure on other public works, the question of the purchase of the Chelmsford Electric Light Company's undertaking must stand over for the present.

Cheltenham.—The Town Council have received sanction to borrow £23,430 for electric light extension purposes. Application was made for £25,000, but the Local Government Board have declined to sanction the loan of £70 for a proposed extension outside the lighting area, and an item of £1,500 has been held in suspense for further particulars.

Coventry.—From the quarterly statement just presented by the Electric Light Committee it appears that 10,642 units were sold during the three months ending March 31st, and the total income for this period amounted to £284. 1s.

Country House Lighting.—Cairnbulg Castle, near Fraserburgh, is to be fitted up for the electric light.

Dover.—Councillor Fry, who is endeavouring to get the Town Council to establish electric tramways in Dover, has succeeded in inducing the Council to appoint a deputation to visit Rouen or Hamburg for the purpose of inspecting the system of electric traction employed in those towns and of collecting information. In the course of a lengthy speech he gave details of a scheme which included the construction of tramway lines from the pier to Folkestone-road, Maxton and Buckland, to be worked on the overhead system.

Edinburgh.—On Tuesday last the Town Council formally approved the recommendation of the Electric Light Committee to reduce as from the 15th inst. the price of electric energy from 6d. to 5d. per unit, the charge for each arc lamp to £18 per annum, and to abolish meter rents. Mr. Mackenzie, in support of the recommendation, said their station was opened on April 11, 1895, with 48 customers and with an equivalent of 2,000 8 c.p. lamps connected, and after 13 months' working they had 425 customers representing 54,360 8 c.p. lamps, and including the arc lamps the total was 58,860 8 c.p. It was thought that the original plant, which was designed to supply 40,000 8 c.p. would meet their requirements for two or three years, but so great was the demand that at Christmas, 1895, every engine and boiler in the station was fully loaded, and in order to avoid a breakdown they were compelled to borrow an engine from one of the London companies, the demand having come on so suddenly that there was no time to get one of their own. In order to cope with the increased demand during next winter they had ordered five boilers, six low-tension machines of 360 H.P. each, a number of high-tension machines and other plant, which would be ready to run at the end of September, thus more than doubling the capacity of the station. The necessary extensions of the mains were being carried out, and new consumers were being connected daily. The condition of the undertaking was very promising, not only from the engineering and demand points of view, but last year's financial results and the current year's prospects were equally good. For the first five and a half months the station was being worked at a loss, but by the end of last September the position had so improved that the income just balanced expenditure. From September, 1895, to the middle of April they were working at a profit, but during the last two months the load was very light, and the station was again being operated at a loss. The total income from private lighting for the 13 months of their existence was £13,220. 18s., and from public lighting £3,604. They had supplied 550,000 units to private consumers, and 320,000 units for public lighting, a total of 870,000 units, representing an income of £16,824. The station expenses, including carbons, trimming arc lamps, and upkeep of mains, amounted to £4,700, and the standing charges, interest, and sinking fund to about £8,100, making a total of £12,800, leaving a profit balance of about £4,024. Mr. Mackenzie thought this was a highly satisfactory condition of affairs, and he claimed it as a "record" for a first year's working. Reckoning the price of the current at 6d. per unit, the engineer had estimated the income for the present year at £28,100, and the expenditure at £21,122, leaving a balance of £6,978. The Committee, however, had decided that it would be advisable to reduce the charge for current, and had, therefore, fixed the charge to private consumers at 5d. per unit, and the charge for current for motors, &c., at 3d. Owing to these changes, the abolition of meter rents and the reduction in the charge for arc lamps, the estimated revenue would be reduced by about £4,100, leaving an anticipated balance of £2,878. Mr. Mackenzie referred in eulogistic terms to the services rendered by their consulting engineer (Prof. A. B. W. Kennedy), and their late resident engineer (Mr. E. W. Monkhouse), and, in conclusion, said it was his intention to give notice of motion to establish a depreciation fund. The report was unanimously adopted.

Electricity in Mining.—In our issue of March 27th we referred to a statement made by the Directors of the Moodie's Fortuna Mining Company, that the work of crushing by electric power at the mine had not proved successful. This statement was challenged at the time by Mr. W. B. Esson and Mr. H. K. Baynes; and now Mr. H. J. S. Heather, the electrical engineer in charge at Moodie's electrical works, Barberton, in a communication to the *Financial News*, further contests the point, and says:—

"In your issue of March 24th there appeared an article which has exercised the minds of many with regard to the application of electricity to mining, the statement having been made that attempts to crush by electric power at Moodie's Fortuna have not been a success. If this were so, does it not appear strange that the United Ivy Reef, who have been dependent on power supplied from the same installation, have found it a success, and with it have been able to declare a dividend, though crushing ore of no greater value? The fact is that the power is a success; but it would appear that the management of the Fortuna mill has not been; for we were asked by them to shut down a considerable number of times, owing to something or other going wrong with the battery. Would anyone say that Fraser and Chalmers' mills are not a success because

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one of them has had to shut down so often? We have frequently had to complain of the stonebreaker being started when filled with stone, and being put on and off without the arranged signals being given. If, moreover, the power were not a success, how came it that no complaint was ever made to me on the many occasions of my visiting the mill? I never heard any, and I am authorised by the manager of Moodie's Company to say that he received none from the manager of the Fortuna. As to the attempts to crush by means of the power, I have to point out that these attempts succeeded in using up all the available ore. With regard to the installation itself, I must admit that Moodie's Company have not for use as much power as could be obtained from the same source under a different system. It has been arranged to make the necessary modifications, and the requisite material has been ordered, and will, on arrival, be erected without delay. Meantime, all those who have contracted to take power from the Company are being supplied according to their requirements."

ELECTRIC TRAMWAYS IN WEST AUSTRALIA.—In the interim report recently issued by the Directors of the Town Properties of West Australia (Limited) reference is made to the necessity for tramways, and it is stated that a scheme for the construction and equipment of a system of electric tramways is being formulated by Sir Douglas Fox. An electrical engineer has been despatched to the colony for the purpose of collecting information.

ESTON.—A committee of the whole Council are considering the question of establishing electric light works in this town.

FLEETWOOD.—The Urban District Council have decided to transfer their Provisional Order to Messrs. Bennett and Druce.

FOLKESTONE.—After a lengthy discussion the Town Council have decided to dispose of their Provisional Electric Lighting Order to Mr. W. B. Hopkins, of Parliament-street, Westminster.

GLASGOW.—The deputation which recently visited Portsmouth, Blackpool, and Brighton for the purpose of examining and reporting upon the systems of electric lighting in these towns, have presented a report, which states that "for the purpose of giving the most effective illumination, and diffusing the light over the largest area without shadows, the overhanging lamp adopted at Brighton is the best," and recommends its adoption in Glasgow.

HAMPSTEAD.—The Electric Lighting Committee presented their accounts from the inauguration of the electricity station in October, 1894, to December, 1895, at yesterday's meeting of the Vestry. The total capital expenditure at the end of December last amounted to £56,552; the total revenue was £4,606. 8s. 7d. (including £3,432. 5s. 9d. from private lighting); expenses amounted to £5,608. 17s. 9d. (£2,035. 16s. 9d. for coal, £947. 15s. for wages and £1,114. 17s. 7d. for management expenses), and interest and sinking fund charges came to £1,934. 19s. 3d., leaving a net deficit of £2,916. 5s. 3d. The number of units sold was 177,300.

HASTINGS.—The contract with the Hastings and St. Leonards-on-Sea Electric Light Company for lighting the sea front expires on July 1st, and as the Company had expressed their intention of not renewing, except at a much higher figure per lamp than is now paid (£25), the Public Lighting Committee have discussed the question of putting down an independent generating plant. Mr. P. H. Palmer, the Borough Engineer, has prepared a report on the matter, recommending the Town Council to undertake their own street lighting, and to carry out the terms of the Hastings Provisional Order (1890). The old pumping station in Waterworks-road is given as a site for the generating station, and the Council are recommended to put down plant capable not only of supplying current to the present arc lamps, but also of lighting the Town Hall, Brassey Institute, and other public buildings. Mr. Palmer puts the cost of equipping the station with duplicate machinery and buying the Company's arc lighting plant at £7,560. The scheme has been submitted to Mr. P. M. Grenville, electrical engineer, of Old Queen-street, London, who has reported favourably on the proposals. The estimated cost of running 50 arc lamps, including interest, sinking fund, &c., was put at £1,639, or £32. 15s. 7d. per lamp per annum. The Company's figures represented £35 per lamp per annum if current were supplied till 11:30 p.m., or £47 if supplied all night. The Committee therefore recommended that the Council's scheme be proceeded with, and that application be made to borrow £7,560 for the purpose. These recommendations have been adopted.

KINGSTON-ON-THAMES.—From the last statement of the Electric Light Committee it appears that the department continues to make steady progress. The revenue from private customers has increased from £1,116 in 1894 to £1,617; 66,000 units were supplied to the public lamps at 2½d. per unit. The net result is a deficit of £1,283 on the year's working. Arrangements have been made for charging electric launches during the summer months, and the Committee anticipate a good demand for energy for this purpose. Various extensions of the mains were ordered to be carried out at the last meeting of the Council. Negociations for the extension to the Coombe and Malden districts are still in progress.

MILL LIGHTING.—Messrs. Humphries and Bobbett's new flour mill, Castle-street, Bristol, is to be lighted electrically.

POLICE.—At the Marlborough-street Police Court on Wednesday a journalist named MacLeod was charged with obtaining credit to the extent of £35. 10s. from Mr. R. Aylmer, of 47, Victoria-street, Westminster, without informing him that he was an undischarged bankrupt. The prosecutor was slightly acquainted with the prisoner, and received an order from him for installing the electric light at a house in Jermyn-street. The work was duly executed, but payment had not yet been made. As the result of inquiries it was found that the defendant was an undischarged bankrupt and therefore these proceedings were taken. For the defence it was stated that the order was given on account of the committee of a club which was being promoted, and MacLeod was prepared to pay the money immediately. The defendant was remanded for a week in two sureties of £25 each.

PORTSMOUTH.—The accounts for the first year's working of the electricity works to March 31st last have been published, and are of a satisfactory character. The revenue amounted to £7,387, and the expenses, to £4,010, leaving a gross profit of £3,377. £3,330 has been applied towards the payment of interest and sinking fund (which together absorb £3,749), so that the net deficiency only amounted to £419. During the last quarter of the period under review the station was being operated at a profit, and as numerous extensions of the mains are being made the Electric Lighting Committee anticipate being able to present an even more favourable balance sheet at the end of the present year.——In order to create a demand for current for lighting places of worship on Sunday the City Council are advised to advance the funds for wiring and fitting up the buildings at 5 per cent., the capital to be repaid by quarterly instalments.

POSTAL TELEGRAPH CLERKS.—The annual conference of the Postal Telegraph Clerks' Association is now being held at Exeter. The proceedings commenced last evening.

PRESENTATION.—Mr. John Hesketh was at Blackpool last week presented with two illuminated addresses, one by the members of the Electric Lighting Committee of the Blackpool Corporation (including the Mayor), and one by the staff at the station. The former address sets out the esteem in which Mr. Hesketh is held by the Committee, and points to the satisfactory progress of the electric lighting under Mr. Hesketh's management.

SHOREDITCH (LONDON).—The National Telephone Company have agreed to pay half the cost of opening and closing the trenches where the telephone lines are put down side by side with the electric light cables in this district, have further agreed to pay a yearly sum of 1s. per pipe per 100 yards for wayleave, and to put the Vestry upon the telephone exchange free of charge. A formal contract has, we understand, been entered into upon these terms and conditions.

WREXHAM.—As the Board of Trade have revoked the Provisional Order of the Wrexham Electric Light and Power Company, the Lighting Committee of the Town Council are considering the question of the establishment of electricity supply works.

## COMPANIES' MEETINGS AND REPORTS.

### West Coast of America Telegraph Company (Limited).

The report of the Directors of this Company for the year ended December 31st last, to be presented at the meeting to be held at Winchester House, London, E.C. to day (Friday), states that the gross income for the year 1895 was £32,930. 5s. 9d., against £21,753. 12s. 2d. in 1894. The traffic receipts were adversely affected by the stagnation in the nitrate industry, and other local causes; but, owing to a readjustment of the proportions of the international traffic receipts for the year, the income of the Company was sufficient to pay the expenses and the interest on the debentures. The total expenses were £20,930. 5s. 9d., against £20,154. 4s. 11d. in 1894. The Company's repairing steamer "Retriever" has been fitted with a new steel main boiler, the cost of which, £1,978. 0s. 3d., has been charged to the reserve fund. The steamer is now in first-class condition. The Company's cables and land lines are maintained in good working order. Mr. J. Denison Pender and Mr. Frederick Walters both offer themselves for re-relection as Directors, and Mr. John Francis Clarke (the auditor) also seeks re-election at the meeting.

### Bournemouth and District Electric Supply Company (Limited).

The following is the report of the Directors for the year 1895, to be presented at the meeting to be held at Bournemouth, on Tuesday next:—

The capital account shows an expenditure of £20,845. 8s. 7d., chiefly upon buildings, machinery, and mains, the funds for which were borrowed from the County of London and Brush Provincial Company. Notwithstanding the reduction in the price of current from 8d. to 7d. per unit, made in April, 1895, the total income amounted to £7,431. 3s. 10d., an increase of £458. 13s. 8d. over 1894, and the expenditure to £5,272. 12s. 7d., a reduction of £57. 15s. 10d. The gross profit amounted to £2,153. 11s. 3d., compared with £1,642. 1s. 9d. in 1894; but owing to increased charges

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for interest on sums borrowed for capital expenditure, there is a debit balance of £237. 15s. 9d. to be carried forward. On December 31st last there was an equivalent of 20,978 8 c.p. lamps, connected to the Company's mains, an increase of 1,798 lamps, or 9½ per cent. During the period under review, 243,816 units of current were sold, against 214,374 in 1894, an increase of nearly 14 per cent., whilst the total cost per unit was reduced from 5·91d. to 5·19d. The generating station has been rebuilt and rearranged during the past year, and, with the advantage of the many improvements which have been adopted, the Directors anticipate a considerable further reduction in cost of generation during the present year.

## Southampton Electric Light and Power Company (Limited).

The Directors' report to the meeting of shareholders, to be held on June 1st states that the business of the Company for the year 1895 steadily increased, and after paying interest on loans and debentures and debiting Directors' fees and writing off preliminary expenses, there is a net profit, including the £35. 14s. 1d. brought forward, of £94. 14s. 9d. The revenue and expenses from 1891 are as follows :—

| | Lamps (equiv. 8 c.p.) | Units sold. | Revenue. £ s. d. | Expenses. £ s. d. |
|---|---|---|---|---|
| 1891 (part only) | ... ... | 5,469 ... | 350 5 11 ... | 535 2 1 |
| 1892 ..... | 2,200 ... | 35,537 .. | 1,153 4 10 ... | 1,152 0 4 |
| 1893 ..... | 3,162 ... | 53,848 ... | 1,606 14 8 ... | 1,121 4 8 |
| 1894 ..... | 5,396 ... | 85,501 ... | 2,491 6 7 ... | 1,676 14 4 |
| 1895 ..... | 6,887 ... | 100,473 ... | 2,862 6 1 ... | 1,895 10 8 |

A Provisional Contract has been signed for the sale of the Company's undertaking to the Southampton Corporation for the sum of £21,000. No dividend is to be paid out of the profits of 1895, but the "Preliminary Expenses" item is to be written off. Formal resolutions for the winding-up of the Company and the distribution of the assets will be submitted to the meeting.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**BRITISH THOMSON-HOUSTON (LIMITED)**.—This Company was registered on May 18th with a nominal capital of £240,000 in 4,000 "A" and 20,000 "B" shares of £10 each, to carry into effect an agreement with the liquidator of the British Thomson-Houston (Limited), in liquidation, to construct, repair, maintain and run installations, wires, cables, and other works for the supply and distribution of electricity for lighting, heating or motive power purposes, and for working by electricity any railways, tramways, or other works, to work, maintain and carry on electric railways or tramways, telegraphic or electric light systems, and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, and manufacturers of and dealers in all apparatus required for or capable of being used in connection with the generation, distribution, supply, accumulation and utilisation of electricity. The subscribers with one share each are C. Burrell, banker ; E. Lazarus, bank manager ; W. A. McArthur, colonial merchant ; J. T. Merz, chemical manufacturer, T. T. Thompson, merchant ; E. Thurnauer, engineer, and H. Lee, accountant.

**LONDON ELECTRIC OMNIBUS COMPANY (LIMITED)**.—This Company was registered on May 18th with a capital of £250,000 in £1 shares, to carry into effect agreements with Radcliffe Ward and the Solar Accumulator Company, and to carry on the business of an electric omnibus company in all or any of its branches, electricians, electrical and mechanical engineers, suppliers of electricity, manufacturers of electrical apparatus, coach, omnibus and carriage builders, &c.

**MANCHESTER ELECTRICAL WORKS (LIMITED)**.—This Company was registered on May 18th with a nominal capital of £1,000 in £1 shares, to carry on business as manufacturers of and dealers in electrical, telegraphic and scientific instruments, contractors for the sale, erection and maintenance of, and dealers in and suppliers of electrical engineering apparatus, electrical and mechanical engineers, and to carry on the business of an electric light company in all or any of its branches. The first subscribers with one share each are W. Pirrie, W. Brown, F. C. Sanders, A. W. Smedmore, F. G. Phillips, F. Weeks, and F. Johnson.

**COUNTY OF LONDON AND BRUSH PROVINCIAL ELECTRIC LIGHTING COMPANY (LIMITED)**.—The annual return to May 6th has been filed. The nominal capital is £800,000, in 40,000 Preference and 40,000 Ordinary shares of £10 each ; 10,000 of the former and 22,475 of the latter have been taken up, and the full amount called ; £324,346 has been paid.

**EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED)**.—The annual return of this Company, made up to May 13th, has been filed. Out of a nominal capital of £3,000,000, in £10 shares, 250,000 have been subscribed for, the full amount called, and £2,500,000 received.

**EDISON-GOWER-BELL TELEPHONE COMPANY OF EUROPE (LIMITED)**.—The annual return of the above-named Company, made up to April 9th, has been filed. The nominal capital is £500,000, in £1 shares, of which 385,009 have been taken up. 370,000 of these have been issued as fully paid, and the full amount has been called on the remainder.

**SCOTTISH HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED)**.—The annual return of this Company, made up to April 30th, has been filed. The capital of £100,000 is divided into 19,900 Ordinary shares of £5 each and 100 Founders' shares of similar value ; 730 of the former and all of the latter have been taken up, and the full amount per share has been called ; £4,258 has been received, and £162 is still in arrears. The sum of £108 has been received in respect of 54 forfeited shares.

## CITY NOTES.

**MEMORANDA**.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31½d. per oz. (May 28th). Consols (2¾ per cent.) 113¼—113½ for money, 113¼—113½ for account ; 2½ per cent. 106¼—106¾ (May 28th). Stock Exchange Settling Days : Consols, June 1st ; Stocks and Shares Continuation Day, June 10th ; Ticket Day, June 11th ; Pay Days, May 29th and June 12th ; Mining Share Carry-over Day, June 9th.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED)**.—The traffic returns of this Company for the week ended May 24th were £893, against £884 in the corresponding week of 1895, an increase of £9. The total receipts for the half-year amount to £19,693, against £19,604 for the corresponding period of 1895, an increase of £89.

**CONTINENTAL METROPOLITAN TRAMWAYS COMPANY (LIMITED)**.—The Directors of this Company announce that they are in negotiation with a French syndicate for the sale of their Paris undertaking.

**JAMES HICKS AND SON (LIMITED)**.—At the recent annual general meeting of this Company (gas, &c., lamp manufacturers, Birmingham), the Chairman, in the course of his speech, stated that they had suffered severely from the competition of the electric light, as the best class of their customers were those who were ready to adopt electric lighting.

**LIVERPOOL ELECTRIC SUPPLY COMPANY (LIMITED)**.—The Directors of this Company have issued a Circular to their shareholders, stating that the Act of Parliament confirming the sale of their undertaking to the Corporation has received the Royal assent, and that the actual transfer will take place on July 1st next, on which date the Directors propose to pay £8. 5s. per share, being £8 2s. in respect of capital and 3s. for dividend at the rate of 6 per cent. for the half-year to July 1st.

**LIVERPOOL OVERHEAD RAILWAY COMPANY**.—The traffic receipts of this railway for the week ended 24th inst. amounted to £1,178. The amount for the corresponding week last year was £1,135 ; increase, £43.

**LONDON ELECTRIC OMNIBUS COMPANY (LIMITED)**.—Letters of allotment have, it is stated, been posted for the recent issue of capital in this Company.

**MIDDLESBOROUGH ELECTRIC LIGHT, HEAT AND POWER COMPANY (LIMITED)**.—The condition of this Company, the capital of which is chiefly held in this country, is stated to show steady improvement.

**REUTER'S TELEGRAM COMPANY (LIMITED)**.—The annual general meeting of this Company was held at the offices, Old Jewry, E.C., on Wednesday, the Chairman (Admiral Sir J. C. D. Hay) presiding. In moving the adoption of the report and accounts, the Chairman said that though the Company's prospects continued bright he wished to point out that their present satisfactory state could only be counted upon so long as business remained good. The increased profit in 1895 was due to the extension of commercial enterprise. In view of the encouraging reports from Colonial agencies the Directors had decided to retain the advertisement branch of their business, for which no further outlay would be necessary A dividend of 2½ per cent., making 5 per cent. for the year, was declared.

**STOCK EXCHANGE NOTICES**.—The Stock Exchange Committee have ordered the undermentioned securities to be quoted in the official list : 22,500 Six per Cent. Cumulative Preference shares (Nos. 30,001 to 52,500) and 22,500 Ordinary shares (Nos. 1 to 22,500) of Willans and Robinson (Limited) ; and £300,000 Four per Cent. First Mortgage debentures (Nos. 1 to 3,000), in lieu of the £200,000 Four and a-Half debentures now quoted, of the India Rubber Company. Application has also been made to the Committee to appoint a special settling day and to grant a quotation to the Chelsea Electricity Supply Company (Limited) for the recent issue of 12,000 ordinary £5 shares.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED)**.—This Company's traffic receipts for the week ended May 22nd, after deducting 17 per cent of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,710.

**WILLANS AND ROBINSON (LIMITED)**.—From our advertisement columns it will be seen that this Company invite applications for £100,000 Four per Cent. First Mortgage Debenture Stock, payable—£10 on application, £10 on allotment, £40 on July 31 next, and £40 on January 31, 1897. The capital of the Company is £300,000, divided into 30,000 Six per Cent. Preference Shares and 30,000 Ordinary Shares of £5 each, of which 22,500 Preference and a similar number of Ordinary Shares have been issued and are fully paid. The present Debenture issue is secured by a charge upon the whole of the property and assets of the Company, and is required for completing the Company's extensive new works at Rugby, for providing additional plant and machinery and for further working capital. The prospectus states that the rate of increase in business is so rapid that the horse-power ordered during the first four months of the present year exceeds that of the whole of 1895 (27,883 I.H.P.), which showed a remarkable increase on the preceding year's figures. In addition to the Willans engine, the Company propose to manufacture the Niclausse water-tube boiler on a large scale at the new Rugby works. The profits of the Company for 1894 and 1895 (after allowing for interest on debentures and mortgages taken over from the old Company, all of which have since been paid off) were £15,708 and £23,275 respectively. Dividends have been paid at the rate of 7 per cent. per annum on the Ordinary shares, and, in addition, handsome reserve and depreciation accounts have been established. Application is to be made in due course for a Stock Exchange quotation. Prospectuses and forms of application can be obtained at the Company's temporary London offices, 14, George-street, Mansion House, E.C., as well as from the Company's bankers, solicitors, and brokers, and at the Thames Ditton works. The subscription list opens on Monday, and will be closed at 4 p.m. on Tuesday. Everything points to the continued prosperity of the Company, and there can be no doubt that a valuable home investment is here offered. We look forward to the subscriptions to this issue being much in excess of the amount of the issue.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name | Previous Week's Price, May 20. | Price Wednesday, May 27. | Rate per Cent. Yielded. | Dividend Due | Business Done During Week Ending May 23. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 48 50 | 48 50 | 5 2 0 | Jan., Apr., July, Oct. | 49 | .. |
| £2,993,560 | Stock | 24 0 | Do. Preferred | 91½ 92½ | 91½ 92½ | 5 8 1 | " " | 92½ | 91½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9¼ 9¾ | 9 9½ | .. | .. | 9½ | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 18 3 | January and July .. | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10 11 | 10 11 | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 14¾ 15½ | 15 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15½ | 15⅛ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 117 | 113 117 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | $13½ | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 2 10 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 13 | 12 13 | 6 3 1 | February and August | 12¾ | 12½ |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 19½ 20½ | 19½ 20½ | 4 17 7 | " " | 20½ | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 4 5 | 4 5 | 4 0 0 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 15 3 | " " | 10½ | .. |
| £80,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 106⅞ 109⅞ | 106⅞ 109⅞ | 4 4 1 | .. .. | 107½ | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10 | 9½ 10 | 4 0 0 | Jan., Apr., July, Oct. | .. | .. |
| 400,000 | 10 | 2/6 | Eastern | 17 17½ | 17 17½ | 3 14 4 | " " | 17⅛ | .. |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18 18½ | 18½ 18¾ | 3 4 0 | " " | 18½ | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 130 133 | 130 131 | 3 0 3 | May and November | 133 | 131 |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 109 | 106 109 | 4 13 0 | February & August | .. | .. |
| 250,000 | 10 | 6/6 | Eastern Extension | 17⅞ 18½ | 17⅞ 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅛ | 17⅞ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 131 134 | 131 134 | 3 0 3 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 101 105 | 101 105 | 4 17 1 | January and July .. | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 17 1 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 108 | 105 108 | 3 14 11 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 110⅞ 113⅞ | 110⅞ 113⅞ | 3 10 11 | May and November | .. | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust | 10½ 11 | 10½ 11 | 4 1 10 | Jan., Apr., July, Oct. | 10½ | 10½ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17 17½ | 17 17½ | 3 8 7 | " " | 17⅝ | 17⅛ |
| 150,000 | 10 | 10/0 | Great Northern | 23 24 | 23 24 | 4 3 4 | Jan., April, and July | 24½ | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 14 7 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 52 55 | 52 55 | 4 10 11 | May and November | 54 | 53 |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 109 112 | 5 8 7 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 11 | .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 6 7 | 6½ 7½ | .. | April and October | 6½ | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 135 140 | 135 140 | 4 5 9 | " " | .. | .. |
| 15,609 | 10 | 2/0 | West African Telegraph | 6 7 | 7½ 8½ | .. | January and July .. | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 105 | 103 106 | 4 15 6 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. | January and July .. | 1⅜ | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 97 102 | 99 104 | 7 19 3 | June and December | .. | .. |
| 88,321 | 10 | 1/3 | West India and Panama | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | .. | 1⅛ | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 11⅝ | 11½ 11⅝ | 5 2 2 | May and November | 11⅞ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 11 9 | June and December | 110½ | .. |
| 64,248 | 15 | 3/9 | Western and Brazilian | 9¼ 9¾ | 9¼ 9¾ | 4 12 4 | May and November | 9½ | 9¼ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6¾ 7¼ | 6¾ 7¼ | 5 3 8 | " " | 7⅛ | 6⅞ |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 3 | 2½ 3 | .. | .. | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 104 108 | 104 108 | 5 13 2 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 104 108 | 104 108 | 5 13 2 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 2 3 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 105 | 102 105 | 5 15 11 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chill Telephone (fully paid) | 3 3½ | 3 3½ | .. | .. | .. | .. |
| 224,850 | 10/0 | 1¼d. | Consolidated Telephone Const. & Manufacturing | ⅞ 1 | ⅞ 1 | .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅞ 1⅛ | ⅞ 1⅛ | .. | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7⅜ 7⅝ | 7½ 7¾ | 3 13 4 | June and December | 7⅞ | 7⅞ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 18 | 16 18 | 3 6 8 | " " | 17⅛ | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16½ 17½ | 16½ 17½ | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅜ 6⅝ | 6⅜ 6⅝ | 3 12 9 | .. | 6⅝ | 6⅜ |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 4½% (red.) | 107 110 | 107 110 | 3 4 6 | January and July .. | 108½ | 107½ |
| 58,000 | 5 | 3/0 | United River Plate | 3½ 4 | 3½ 4 | .. | " " | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 98 103 | 99 104 | 4 18 0 | " " | 100½ | 100½ |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ 15½ | 14½ 15½ | 3 4 6 | .. | 15¾ | 14½ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ 17 | 16½ 17 | 3 10 7 | .. | 16½ | 16½ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 138 | 134 138 | 3 13 6 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | .. | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 8 8½ | 8¼ 8¾ | .. | .. | .. | .. |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | .. | .. | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8½ 9½ | 8¼ 9¼ | .. | .. | 9⅛ | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ 13½ | 12½ 13½ | .. | .. | 13 | 12⅞ |
| 8,322 | £5 | .. | House-to-House Electric | .. .. | .. .. | .. | .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. .. | .. .. | .. | .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. | January and July .. | .. | .. |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 8 8½ | 8 8½ | 3 12 9 | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | .. .. | .. .. | .. | .. | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 14 15 | 14 15 | 2 13 4 | .. | 14⅛ | 14⅛ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 123 | 120 123 | 3 14 5 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9 9½ | 9 9½ | .. | .. | .. | .. |
| .. | .. | .. | Rand Electric | ⅜ ½ prem. | ⅜ ½ prem | .. | .. | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 10½ 11 | 10½ 11 | .. | .. | 10½ | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 3 6 | .. | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9½ 10 | 9½ 10 | 3 8 4 | .. | 9⅞ | 9½ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1⅝ 1⅞ | 1⅝ 1⅞ | 5 8 8 | .. | 1⅞ | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅝ 1⅞ | 1⅝ 1⅞ | 3 4 0 | .. | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 114 | 111 114 | 3 19 9 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1½ 1⅝ | 1½ 1⅝ | 8 10 11 | February & August | 1⅝ | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 104 107 | 104 107 | 4 5 9 | January and July .. | .. | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. .. | .. .. | .. | .. | .. | .. |
| 110,000 | 2 | .. | Electric Construction | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | .. | 1⅛ | .. |
| 12,845 | 2 | 2 9⅞ | Do. 7 per Cent. Cumulative Pref. | 2½ 3 | 2½ 3 | 4 13 4 | September | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ ⅞ | ⅝ ⅞ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. | .. | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23½ 24½ | 23 24 | 4 3 4 | February & August | 23⅝ | 23½ |
| £200,000 | 100 | 4½% | * Do. 4½ per Cent. Debentures, 1896 | .. .. | .. .. | .. | March & September | .. | .. |
| 15,995 | £10 | .. | International Okonite Ordinary | .. .. | .. .. | .. | .. | .. | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. .. | .. .. | .. | December and June | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ⅛ ¼ | ⅛ ¼ | .. | .. | .. | .. |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 41 | 38 41 | 4 7 10 | March and July | 40 | 38½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 105 | 102 105 | 4 17 1 | January and July | .. | .. |
| 37,514 | £5 | .. | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. .. | .. .. | .. | .. | .. | .. |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. .. | .. .. | .. | .. | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16 17 | 16 17 | 3 8 7 | March & September | .. | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 17 18 | 17 18 | 3 17 9 | .. | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 114 | 109 114 | 3 19 9 | February & August | 113½ | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 42 44 | 42 44 | 2 16 10 | January and July .. | 42¾ | .. |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15½ | 15 15½ | 3 4 6 | .. | 14⅞ | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 133 135 | 135 137 | 2 18 5 | May and November | .. | .. |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway | 14 14½ | 14½ 14½ | 2 2 6 | .. | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 17⅞ 17⅞ | 17⅞ 17⅞ | 2 16 10 | .. | .. | .. |
| 135,000 | Stock | 4% | Do. 4% Debenture | 114½ 116½ | 114½ 116½ | 3 10 10 | January and July | .. | .. |

In calculating the yield on this security, allowance has been made for accrued interest but *not* for redemption.

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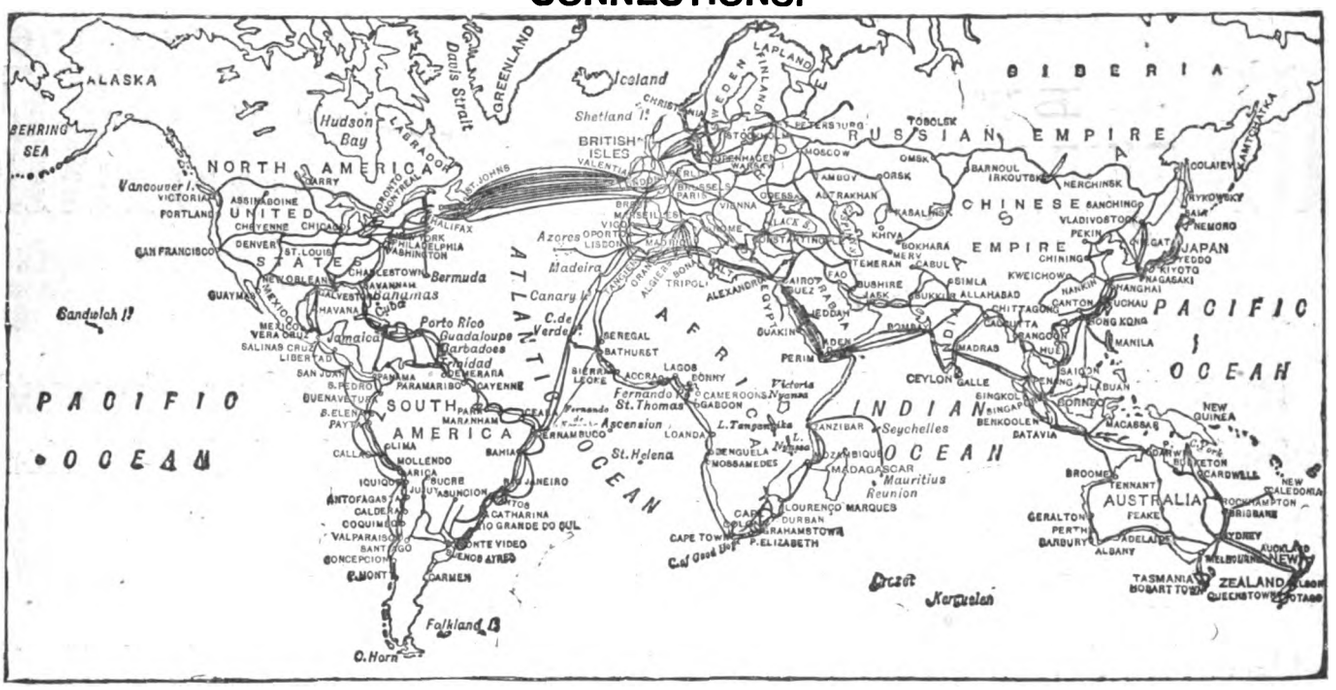


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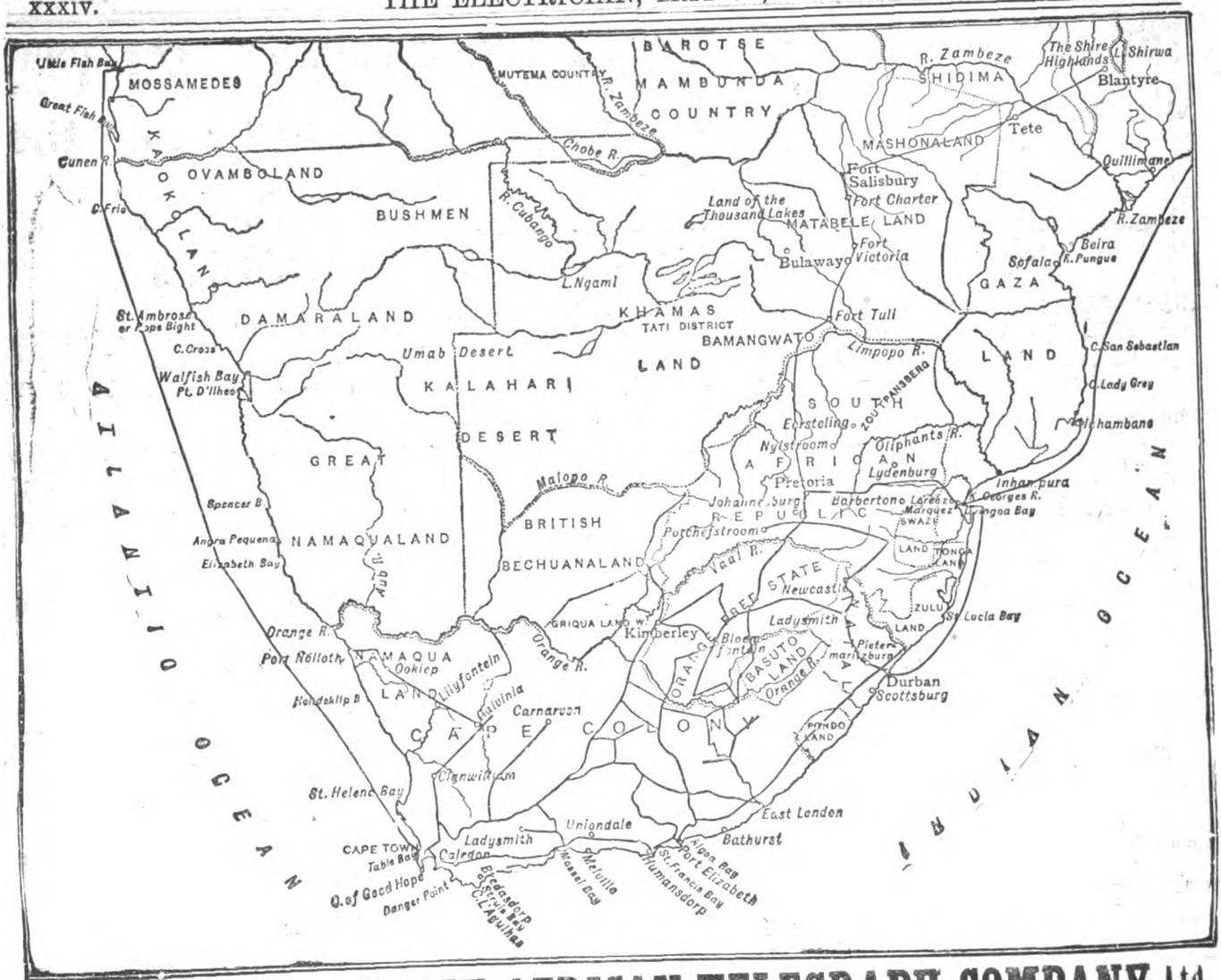


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J. CAMBROOK, *Secretary*, WEST AFRICAN TELEGRAPH COMPANY.

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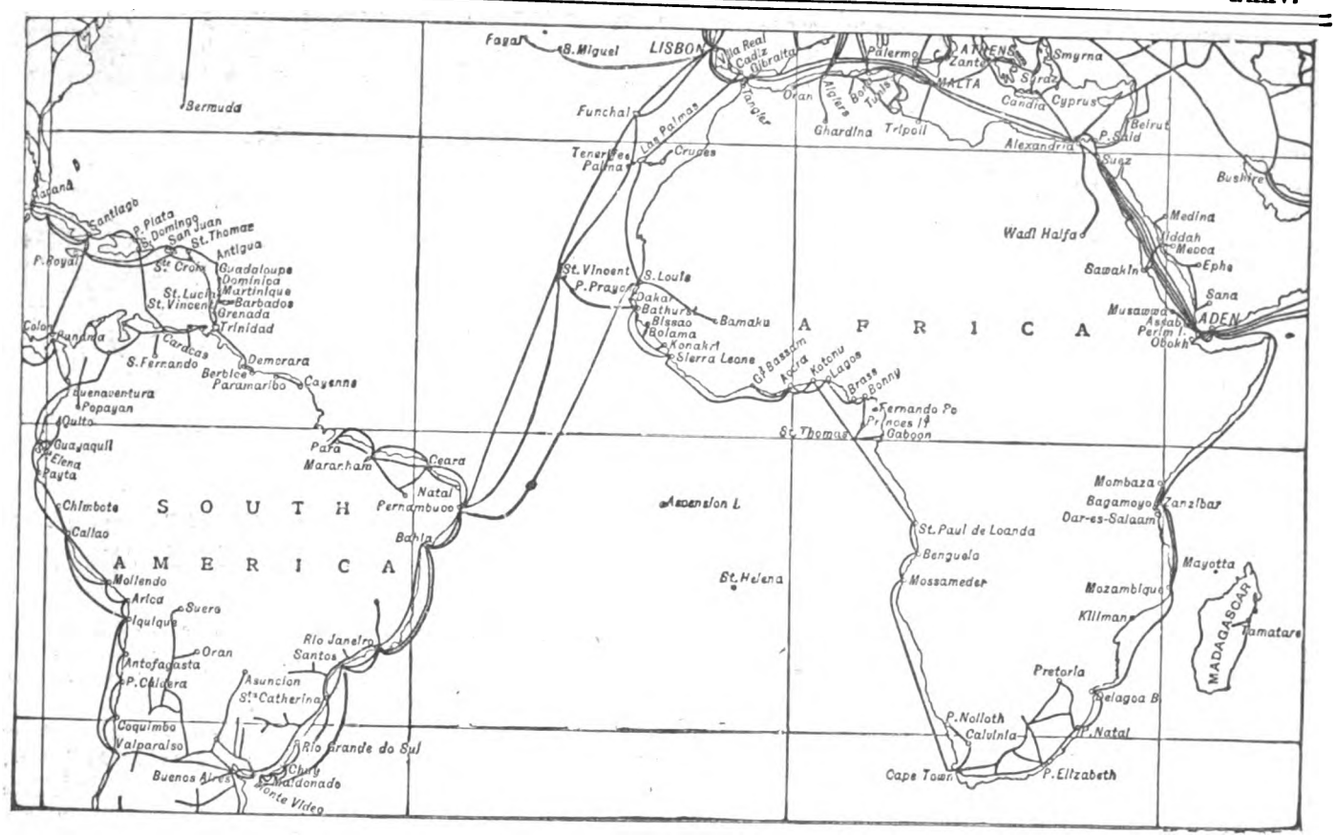


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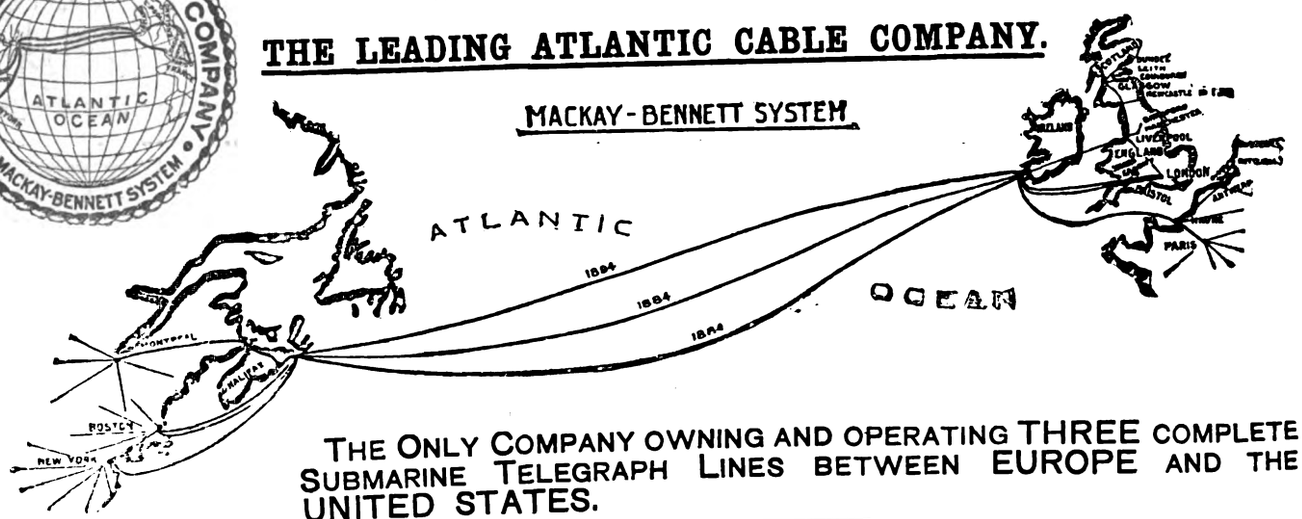


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GENERAL OFFICE, LONDON,
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109, FENCHURCH STREET, LONDON, E.C.
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A5, EXCHANGE BUILDINGS, LIVERPOOL.
BACKHALL CHAMBERS, BALDWIN ST., BRISTOL.
99, GORDON STREET, GLASGOW.
10, FORSTER SQUARE, BRADFORD.
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TRIPLE-EXPANSION ENGINES

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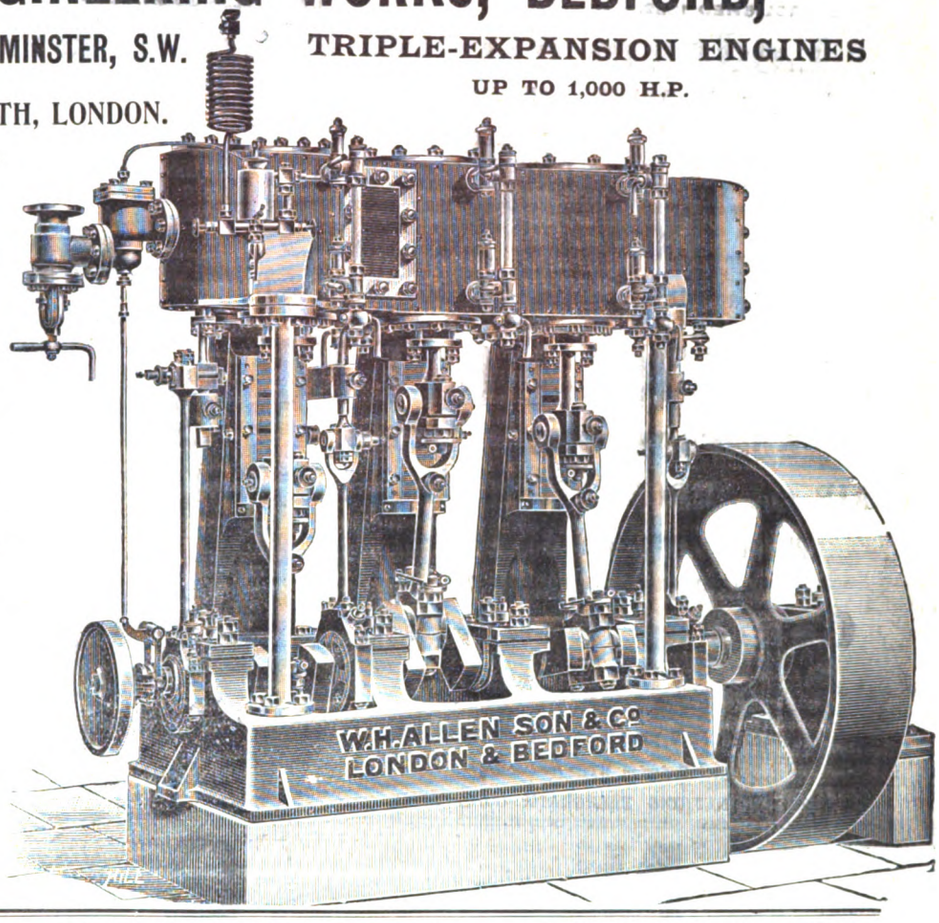


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For Forced Draught and Ventilating.

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# HIGHER VOLTAGE DEMANDS BETTER INSULATION.

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PRACTICAL APPARATUS OF EXCELLENT QUALITY AT REASONABLE PRICES.

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SWITCH AND DISTRIBUTING BOARDS
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HIGH TENSION SWITCHES AND FUSES
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Electric Light Contractors, Wiring Contractors, AND Central Station Authorities ALL DERIVE **SATISFACTION** from the use of this Company's Manufactures.

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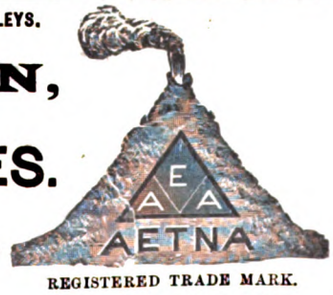


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SIMPLE and COMPOUND, OPEN and ENCLOSED,

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**SURFACE CONDENSERS,**

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*Before Ordering, Write for Catalogue.*

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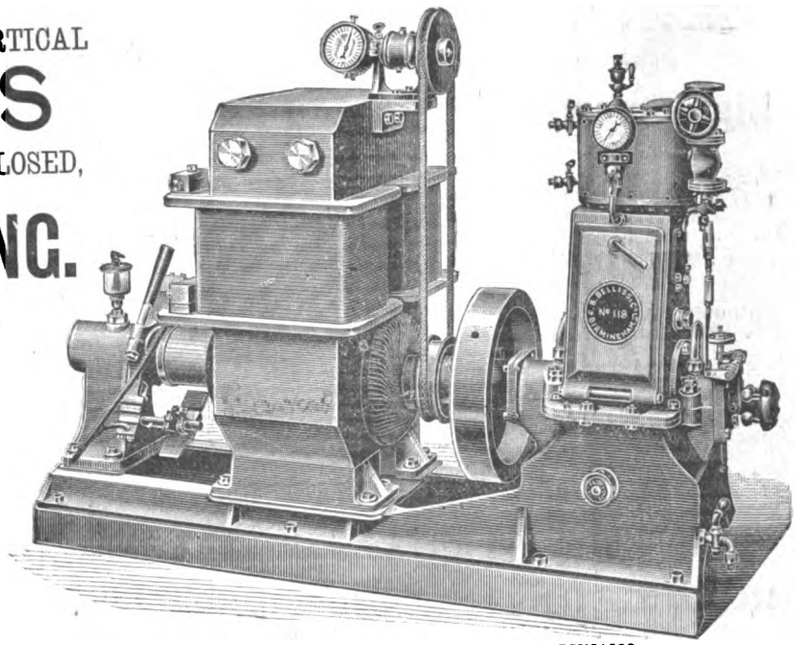

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# AMMETERS & VOLTMETERS

***NOW READY.***

6in. METAL DIAL.
BRASS COVER.
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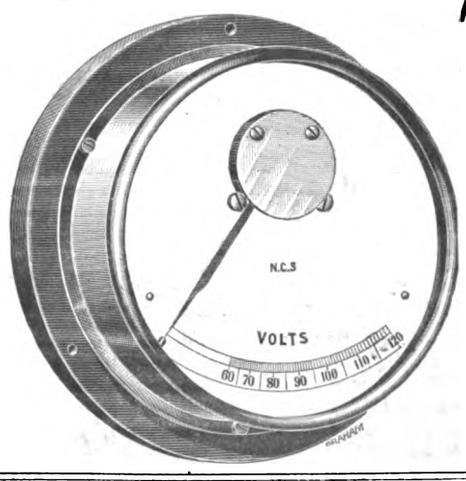
TERMINALS AT BACK.

**£1 17 6**

**Up to 100 Amps.**




ACCURATE.
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**Electrical Auctioneers, Valuers, AND ARBITRATORS.**

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**SALES BY AUCTION, &c.**

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**ACME AND IMMISCH ELECTRIC WORKS,**

**FERDINAND STREET, CHALK FARM, LONDON, N.W.**

MESSRS. PERCY HUDDLESTON & CO.

WILL SELL BY PUBLIC AUCTION,

**On TUESDAY, JUNE 16, 1896,**

At TEN for ELEVEN o'clock precisely, the

*ENTIRE CONTENTS OF THE ABOVE WORKS.*

Comprising: 25-H.P. SEMI-PORTABLE UNDERTYPE ENGINE, by Robey and Co. 10-H.P. LOCO. BOILER, by Marshall, Sons and Co. 20-H.P. HIGH SPEED ENGINE, by Bellis and Co. Twenty Screw-Cutting and other Lathes, from 4 to 19in. centres. Boring, Drilling, Planing, Slotting, Sawing, Milling, Punching and Shaping Machines, 7-ton Overhead Crane, Gauges, Stocks and Dies, Lathe and other tools, Belting, Shafting, Pulleys, &c. CONTENTS OF BRASS FOUNDRY. Also the VALUABLE ELECTRICAL PLANT, comprising Dynamos, Motors, Volt and Ammeters, Galvanometers, Wheatstone Bridges, Meters, Resistances, Switches, 15 miles of Vulcanised Cable, Telephones, Cast Iron Poles, Stays, Standards, Insulators, &c. Also the OFFICE FURNITURE, including two Safes, Typewriter, Desk, Tables, &c.

On view day preceding and morning of Sale. Admission by Catalogue only, which may be obtained from the Auctioneers, PERCY HUDDLESTON & CO., 72, Finsbury Pavement, LONDON, E.C.; 20, Chapel Works, LIVERPOOL; and 47, Grand Parade, BRIGHTON.

## TENDERS INVITED.

### BOROUGH OF SHOREDITCH.

ELECTRIC LIGHTING OF DUST DESTRUCTOR AND ELECTRICITY SUPPLY STATION, SHOREDITCH.

CONTRACT No. 6.

The SHOREDITCH VESTRY INVITE TENDERS FOR:—

The SUPPLY and FIXING of INSULATED CONDUITS, CABLES, SWITCH and FUSE BOARDS, and all SUNDRY FITTINGS and MATERIALS for INSTALLING the ELECTRIC LIGHT in their new Dust Destructor and Electricity Supply Station, Coronet-street, Shoreditch.

Specifications, with Forms of Tender, can be obtained, on and after June 5th, from the Consulting Engineers, Messrs. Kincaid, Waller and Manville, 29, Gt. George-street, Westminster, on payment of Three Guineas, which sum will be returned on receipt of a bona fide tender.

The Vestry do not bind themselves to accept the lowest or any tender; and Contractors whose tenders are accepted shall enter into a formal agreement under seal with sufficient sureties for the due fulfillment of their respective Contracts.

Trade Union rates of wages and hours to be observed.

Sealed Tenders, endorsed "Electric Lighting Tender for Wiring," to be sent at or before 4 p.m. on Tuesday, June 16th, 1896, to

H. MANSFIELD ROBINSON, Clerk and Solicitor.

Town Hall, Old-street, E.C.

### COUNTY BOROUGH OF BURNLEY.

TENDERS FOR ELECTRIC CABLES.

The CORPORATION of BURNLEY invite TENDERS for the SUPPLY and DELIVERY at their Electric Lighting Station, Burnley, of ARMOURED CONCENTRIC UNDERGROUND CABLES. Specification, Schedule of Quantities and Forms of Tender may be obtained on application to Mr. W. R. Wright, the Borough Electrical Engineer, on payment of a deposit of £1. 1s., which will be returned on receipt of a bona fide tender. Sealed tenders endorsed "Tender for Cables" and addressed to the "Chairman of the Electric Lighting Sub-Committee, Town Hall, Burnley," must be delivered on or before Wednesday, the 24th instant.

By Order,

WM. T. FULLALOVE, Town Clerk.

Town Hall, Burnley.
3rd June, 1896.

THE

**BRITISH ELECTRIC TRACTION (PIONEER) CO.,**

LIMITED.

**1 and 2, GREAT WINCHESTER STREET, LONDON, E.C.**

*Chairman*—Sir CHARLES RIVERS WILSON, G.C.M.G., C.B.

This Company has been formed to DEVELOP ELECTRIC TRACTION in the United Kingdom and elsewhere, on the most approved methods and according to the requirements of each locality.

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LIMITED,

**GUARANTEES FIDELITY.**

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— *PRICE LIST POST FREE.* —

Address: **GREAT TURNSTILE, HOLBORN, LONDON, W.C.**

Telegrams, "Turnstile London." Telephone, 65188.

## TENDERS INVITED.

### CALEDONIAN RAILWAY COMPANY.

CONTRACTS FOR STORES.

The DIRECTORS of the CALEDONIAN RAILWAY COMPANY are prepared to receive TENDERS for the SUPPLY of the undermentioned STORES, for Twelve months, from 1st August, 1896:—

| Class No. | |
|---|---|
| 1 | Barrows. |
| 2 | Bolts and Nuts. |
| 5 | Bricks, Clay, Lime, &c. |
| 6 | Brooms, Birch and Heather. |
| 7 | Brushes. |
| 9 | Candles and Soap. |
| 10 | Canvas. |
| 11 | Carriage Furnishings. |
| 12 | Carriage Laces |
| 13 | Carriage Trimmings. |
| 17 | Colours. |
| 18 | Copper Rivets, &c. |
| 19 | Cotton Waste and Sponge Cloths. |
| 20 | Crucibles. |
| 21 | Drysalteries. |
| 24 | Gas and Water Fittings. |
| 25 | Glass. |
| 27 | Hammer Shafts. |
| 28 | Hardware. |
| 29 | India-Rubber. |
| 32 | Iron Chain. |
| 33 | Iron Rivets. |
| 34 | Galvanised Wire and Wire Fencing Requisites. |
| 37 | Lamps and Lamp Furnishings. |
| 38 | Lamp-Wick Cottons. |
| 39 | Leather. |
| 40 | Locks. |
| 41 | Nails, Sprigs and Tacks. |
| 42 | Oils and Grease. |
| 47 | Rail Chair Spikes and Fish Bolts. |
| 48 | Ropes, Cordage and Twines. |
| 49 | Screws. |
| 50 | Shovels, Spades and Graips. |
| 52 | Spelter, Tin and Lead. |
| 59 | Sundries. |
| 60 | Telegraph and Electric Appliances. |
| 64 | Timepieces. |
| 65 | Tinwork. |
| 66 | Tools. |

Specifications and Forms of Tender, and any other necessary information, may be obtained, on and after the 1st June, from Mr. Jas. Lorimer, Superintendent of Stores, Caledonian Railway, Charles-street, St. Rollox, Glasgow.

Patterns may be inspected on and after Monday, 1st June, from 9 a.m. till 5 p.m., at the Company's Stores, Charles-street, St. Rollox. (Saturday, 9 a.m. till 1 p.m.)

Tenders, endorsed "Tender for Stores," to be lodged with the Secretary, 302, Buchanan-street, Glasgow, not later than MONDAY, 15th June, 1896.

The Directors do not bind themselves to accept the lowest or any offer.

J. BLACKBURN, Secretary.

Company's Offices, 302, Buchanan-street, Glasgow.
29th May, 1896.

### CITY OF LEEDS.

TO ELECTRICAL ENGINEERS, CONTRACTORS AND OTHERS:—

The COUNCIL require TENDERS for an ELECTRICAL INSTALLATION sufficient for the working by the overhead system of haulage, a double track of Tramway seven miles long. The work will be divided into the following Contracts:—

1. POLES for supporting Trolley Wire.
2. UNDERGROUND CONDUITS and CONDUCTORS.
3. TROLLEY WIRE and attachments.
4. MOTOR CARS.
5. ACCUMULATORS and SWITCHES.
6. STEAM ENGINES.
7. DYNAMOS, SWITCHBOARDS and ACCESSORIES.

Tenders endorsed with the number of the contract must be sent in, addressed to the Town Clerk, Town Hall, Leeds, not later than JUNE 20th next.

Particulars, plans and forms of Tender may be had (on payment of a deposit of £2 2s. for each contract, which will be returned on receipt of a bona fide Tender) from the City Engineer, Municipal Buildings, Leeds, or from

DR. JOHN HOPKINSON, F.R.S.,
5, Victoria-street, Westminster, S.W.

A COLONIAL FIRM with OFFICES and WAREHOUSES in NEW ZEALAND and AGENCIES thoughout AUSTRALASIA, is open to REPRESENT a few good ENGLISH and CONTINENTAL HOUSES in ELECTRICAL MACHINERY and SUPPLIES (Mining Machinery preferred).

TRAVELLERS CONSTANTLY AT WORK.

*(Sole Agencies only accepted.)*

Address:

HADLEY & CO., Auckland, New Zealand.

**DOULTON & CO.,**

MANUFACTURERS OF

**PLUMBAGO CRUCIBLES**

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Brass, Copper,
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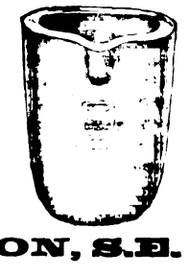

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## APPOINTMENT VACANT.

TO ELECTRICAL ENGINEERS.

THE LEYTON URBAN DISTRICT COUNCIL are prepared to receive applications for the post of RESIDENT ENGINEER to the Electric Lighting Installation now in course of construction. For particulars apply by letter to the undersigned.

R. VINCENT, Clerk to the Council,
Town Hall, Leyton, Essex.

---

THE ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).

NOTICE is Hereby Given that the TRANSFER BOOKS and REGISTER of Members of the Company will be CLOSED from the 5th JUNE to the 18th JUNE, 1896, both days inclusive, for the purpose of preparing the dividend warrants.

By order,
J. CECIL BULL, Secretary.

1 and 2, Great Winchester-street, London, E.C.,
4th June, 1896.

---

**CHEAP PREPAID ADVERTISEMENTS** *relating to* **SITUATIONS VACANT AND WANTED, MISCELLANEOUS PLANT WANTED, FOR SALE, AND FOR EXCHANGE,** *are inserted in* **"THE ELECTRICIAN"** *at the following low rates:*

*Three Lines and Under* .. .. .. .. **1s. 6d.**
*Per Line After* .. .. .. .. .. .. **6d.**

Nine Words to the Line.

## SITUATIONS VACANT AND WANTED.

A LARGE Continental Manufacturing Joint Stock Company in the electrical line, intending to open a London branch, seeks the services of a MANAGER; liberal terms. Must be thoroughly acquainted with the trade, and have good introductions. Guarantee required.—Address "P. C.," Buecker's Hotel, Finsbury-square, London, E.C.

MANUFACTURER of good Incandescent Lamp requires AGENTS in all important towns in the United Kingdom.—Apply by letter to "LAMPS," care of *Electrical Review*, 22, Paternoster-row, London.

COIL-WINDING, LACQUERING and POLISHING GIRLS WANTED, used to lacquering and polishing small electrical instruments.—State wages required and experience to "TELEPHONE," *Electrician* Office Salisbury-court, Fleet-street, E.C.

ELECTRICAL ENGINEER seeks ENGAGEMENT, capable of estimating for and carrying out electrical wiring. Good general experience, moderate salary.—Address, "G. S.", *Electrician* Office, Salisbury-court, Fleet-street, E.C.

ENGINEER, nine years' experience in factory, installation and station work, well up in designing and estimating, highest references, seeks ENGAGEMENT.—2217, *Electrician* Office, Salisbury-court, Fleet-street, E.C.

WANTED, situation as INVENTOR'S MODEL MAKER, used to small mechanical work.—Address, W. WATSON, Green Dragon Hotel, Beverley.

ELECTRICAL ENGINEER seeks ENGAGEMENT. Capable of estimating and carrying out installations. Good experience.—Address "G. S.," *Electrician* Office, Salisbury-court, Fleet-street, E.C.

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PLATINUM UTENSILS, SCRAP, LAMP TOPS.—Best prices given by Derby and Co., 44, Clerkenwell-road, London, E.C. N.B.—Platinum sold

WANTED good SECONDHAND 100 HORSE-POWER STEAM ENGINE and 75-UNIT ALTERNATOR.—Price and particulars to "X. X.," *Electrician* Office, Salisbury-court, Fleet-street, E.C.

TO CYCLE, MOTOR CAR, ELECTRIC COMPANIES AND OTHERS.

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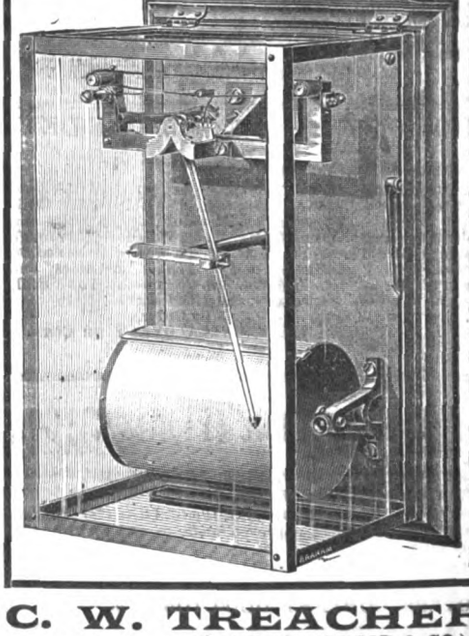

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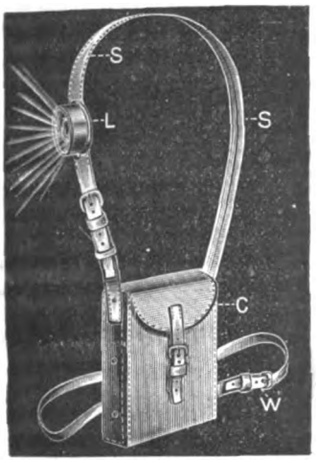


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The book will be found of quite exceptional interest, and the illustrations assist the text in an unusual degree.

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**CHAPTER I.—The Cable Ship on Repairs.**

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**APPENDICES.**

Appendix to Kennelly's Break Test—Appendix re New Japanese Cable Steamer.

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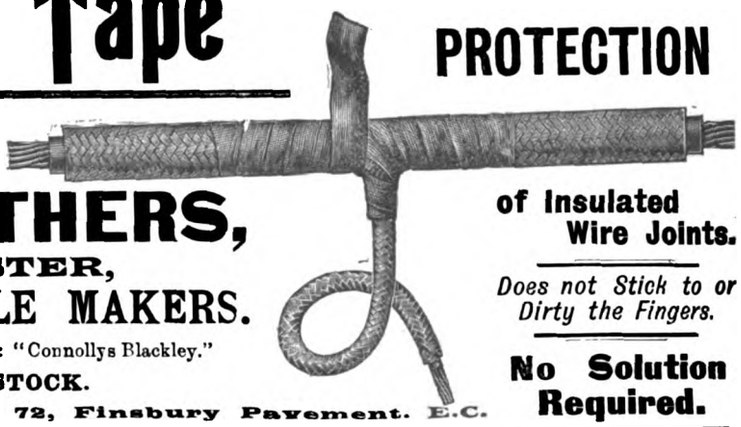

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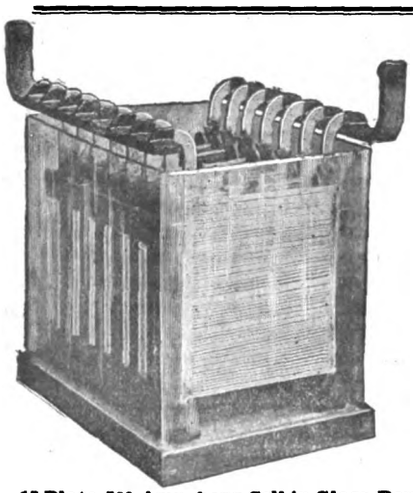

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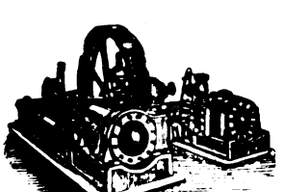

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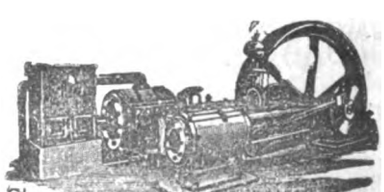

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 942. [Vol. No. 6. XXXVII.] FRIDAY, JUNE 5, 1896. PRICE SIXPENCE.

## NOTES.

A VERY lucid little article, by Dr. OLIVER LODGE, to be found elsewhere in the present issue, describes a few of his more recent experiments on Röntgen rays. Dr. LODGE finds that a *positive* charge has a peculiar reinforcing action upon the ray-emitting powers of a surface exposed to the cathodic radiation, but wisely refrains from hazarding an explanation of the phenomenon. Of greater interest are the experiments made in connection with the influence of magnetic lines of force. M. LAFAY (see *The Electrician*, Vol. XXXVI., April 3rd, p. 750) asserted that X-rays after passage through an electrified plate become amenable to the magnetic influence. As Dr. LODGE very truly remarked, this result would, if true, be profoundly important, since it would tend to the belief that X-ray phenomena were due to something in the nature of flying particles. Not a trace of the deflection or of the twist observable with *cathode* rays was found in the case of X-rays.

AN interesting letter which we publish this week, from the pen of M. BLONDEL, supplies us with a further *quotum* of historical notes relative to the action of the electric arc in distorting the wave form of the alternating current supplying it with power. M. BLONDEL shifts the date of the earliest indication of this effect back to 1881, and attributes to JOUBERT the distinction of having been the first to observe it. As will also be seen, M. BLONDEL's own subsequent contributions to the literature of this interesting line of research were many of them made at an early date, the question of the distortion of waves by the alternate-current arc having been analysed by him in a Paper which appeared in *La Lumière Electrique* of September 16, 1893. Basing his argument upon the researches which are described in that Paper, our correspondent now alleges that both Mr. FRITH's and Mr. STEINMETZ's opposing conclusions are erroneous, owing to the fact that these investigators do not appear to have taken account of the influence exerted by the nature of the carbons. Thus the plot thickens, and things resolve themselves into an interesting triangular duel.

LET us briefly review the positions of the three contending parties. In the first instance, Mr. FRITH brought before the Physical Society some curves which he had already, in 1891, communicated to the Manchester Literary and Philosophical Society. These curves represented the influence of an alternating arc upon the wave form developed by a "Wilde" iron-cored alternator, and Mr. FRITH ventured to state that the curves showed "the great effect that the arc has on the wave form, and also how this effect can be destroyed by placing resistance in series with the arc." The general conclusion drawn by Mr. FRITH was that when the arc is permitted to have a preponderating influence it will alter the wave to the form required for the maximum efficiency, that is to say, the flat-topped wave. Now we come to Mr. STEINMETZ. In our issue of May 22nd, we published a letter in which he described some experiments performed by Messrs. TOBEY and WALBRIDGE, in 1890, these investigators running arcs in series on a Stanley alternator. The wave form, which ordinarily was sinusoidal, became distorted into "the most exaggerated form of a flat-topped wave—that is, a sharp double peak with a deep hollow between." Mr. STEINMETZ states that this effect was satisfactorily explained by Prof. PUPIN, who attributed it to "the periodically varying resistance of the arc, which is extremely high at or near zero value of current, low near the maximum value." The Stanley machine used possessed very high internal reaction, and Mr. STEINMETZ asserts that, had a machine possessing very low internal reaction been used, the wave of current would have been "distorted to single peakedness, that is, to the shape undesirable for arc lighting." How Mr. STEINMETZ knows this he does not say; but the assertion is one of vital importance to the question at issue. Here we have, then, M. BLONDEL stating that the nature of the influence of the arc depends upon the quality of the carbons, and Mr. STEINMETZ stating that it depends upon the internal reaction of the alternator. What is the general law? Are both these conclusions right, or are they both in some way incorrect? In fact, what are the general conditions under which an alternating arc can distort the wave into the most efficient form, as we know from Mr. FRITH's researches it sometimes does?

THE Fourth Report of the Royal Commission on Electrical Communication with Lighthouses and Light-Vessels, which will be found in another column, contains some exceedingly interesting particulars with regard to the experience obtained in connection with various solutions of this peculiarly difficult problem. As will be seen by the Report, the experience is not altogether satisfactory, and it is proposed to try the induction system, supplemented by Mr. SYDNEY EVERSHED's

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ingenious call-relay. Not the least valuable feature of the Report is the information relating to and the success attained with the Fastnet discontinuous system of communication. This system has proved an unqualified success, and may confidently be recommended for all rock lighthouses in exposed positions. Notwithstanding the great attention which was at one time called to the Danish system, it is evident that the members of the Royal Commission do not think very highly of it, nor does it appear to offer many suggestions of first-class importance applicable to this country.

THE principle of Mr. EVERSHED's call-relay is as follows: A rectangle of copper wire, one end of which is clamped to an insulating support, is placed between the poles of a powerful permanent magnet. This rectangle is timed to vibrate when traversed by the special calling current, the frequency (20 to 40 ∿) of which is regulated by a tuning fork. In its excursions it comes in contact with a second rectangle timed in unison with it, and, closing a local circuit, rings a call bell. Two similar rectangles are used to prevent accidental contacts due to mechanical jars. The Royal Commission propose to give this pretty device an early trial on the East Goodwin lightship. The vessel is, of course, surrounded at the bottom of the sea by a huge ring main, which forms the primary coil of the induction system, the secondary coil being wound round the outside of the vessel, the iron frame of which forms a suitable core. A rapidly driven contact-breaker sends an intermittent current through the primary line, giving rise to a buzzing in the telephone connected to the secondary circuit, the regular interruption of which when signalling is effected by a Morse key.

IT has been said that "history might possibly miss most of its striking episodes if every actor could know the work to which he was putting his hand." We doubt it. Individuals to whose lot it falls to make history are not in the nature of things likely to be deterred from so doing by the possible miscarriage of their schemes. And still less does the remark apply to inventors. The world, we feel sure, has not missed any striking invention by reason of the inventor's fears as to its possible abuse or misuse. At the same time it is not without interest and instruction to compare the glowing anticipations with which great discoveries are so frequently hailed with the business-like estimate of profit—and loss, of a subsequent generation. MORSE's famous first message, "What hath GOD wrought," and the messages exchanged between the Queen and the President of the United States, celebrating the successful laying of the Atlantic cable of 1858, sanguine and sonorous as they were, were no exaggerated expression of contemporary feeling; yet before the century which has witnessed these truly tremendous events has fully run its course, the very sober, not to say sombre, estimate contained in Mr. LECKY's ponderous work on "Democracy and Liberty" does not strike the average reader as unduly pessimistic. Below we quote in full the verdict of Mr. WILLIAM EDWARD HARTPOLE LECKY on the telegraph, considered as a factor in social and political evolution. It will be seen that almost the sole unqualified gain which he is willing to admit is the development of an influential provincial Press—an important item to the credit of telegraphy, no doubt, but not precisely the result contemplated by President BUCHANAN when he ecstatically telegraphed on August 16, 1858: "May the Atlantic Telegraph, under the blessing of Heaven, prove to be a bond of perpetual peace and friendship between the kindred nations, and an instrument destined by Divine Providence to diffuse religion, civilisation, liberty and law throughout the world. . . ."

The growth of an independent provincial spirit has been much accelerated by the telegraph. The political influence of this great invention, though various and chequered, has been scarcely less powerful than that of the railway. It has brought the distant dependencies of the Empire into far closer connection with the mother country; but it is very doubtful whether the power it has given to the Home Ministers of continually meddling with the details of their administration is a good thing, and there have been times of disagreement when a rapid communication between foreign countries might have led rather to war than to peace. Government by telegraph is a serious, dangerous thing; and it has been often said that if an Atlantic telegraph had connected England with the United States in the first excitement of the "Trent" affair, enabling the two nations, when their blood was still hot, to exchange their impressions, a war could scarcely have been averted. The telegraph, on the other hand, has greatly strengthened the central Government in repressing insurrections, protecting property, and punishing crime. It has, at least, modified the Irish difficulty by bringing Dublin within a few minutes' communication of London. It has had enormous economical consequences: equalising prices, stimulating speculation, destroying, in a great measure, the advantage of priority of time which the inhabitants of great centres naturally had in many competitions. The effect, however, on which I would now specially dwell is its great power in decentralising politics. The provincial Press, no doubt, owes much to the repeal of the stamp duty and the paper duty; but the immense development and importance it has assumed within the lifetime of men who are still of middle age are mainly due to the existence of telegraphic communication.

A SOBER summing-up in all truth, but, even so, more flattering than Lord DUFFERIN's recent pronouncement at the annual banquet of the British Chamber of Commerce of Paris. "Thanks to the telegraph," said this authority, "the globe itself has become a mere bundle of nerves, and the slightest disturbance at any one point of the system sends a portentous tremor through its morbidly-sensitive surface."

IF we are to judge by the programme of the First Annual Convention of the Municipal Electrical Association, the municipal electrical engineer hath an inordinate appetite. On the first day four Papers and a Presidential Address are to be read, or taken as read, and discussed, between 10:15 and luncheon time, and the remainder of the bill of fare apparently presupposes a digestive apparatus scarcely less Gargantuan. The quantity of matter to be dealt with is not less abnormal than its variety and interest; if the contents of the Papers bear out their titles, the municipal electrical engineers will have exhausted all possible topics of discussion at their very first meeting. The word "convention" has, it is true, many meanings and shades of meaning; it may denote "a meeting or an assembly of persons, especially of delegates or representatives, to accomplish some specific object, civil, social, political, or ecclesiastical"; or it may be "an extraordinary assembly of the Parliament or estates of the realm, held without the King's writ." But the term does not strike us as exactly appropriate to a modest gathering of hard-working English engineers. There is a certain grandilo-

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quent sound about the word "convention" when so applied, which seems to come to us from across the broad Atlantic. It is to be hoped that the use of this little word is not symptomatic of any other transatlantic importations.

**Society of Arts.**—The annual *conversazione* of this Society will be held at the South Kensington Museum, on Wednesday, June 17th.

**Röntgen Rays.**—On Wednesday next, June 10th, Prof. J. J. Thomson will deliver the Reade Lecture at Cambridge. The subject will be "Röntgen Rays."

**Cable Interruptions and Repair :—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Brest– St. Pierre ..... ..... | June, 1895 ... | May 21, 1896 |
| Puerto Plata—Martinique..... | Dec. 19, 1895 ... | — |
| Ceara—Maranham ..... | April 28, 1896 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |

**A Parisian "Metropolitan" Railway System.**—A notice emanating from the Prefecture of the Seine, and published in the *Bulletin Municipal Officiel* of May 19th, announces that the plans of a proposed autonomous narrow-gauge *electric* railway will be on view in each of the 20 mairies of Paris from May 18th to June 18th, where objections may be lodged.

**Proposed Electric Light and Power Supply at Leeds.**—An offer has been made to the Leeds Corporation by the Yorkshire House-to-House Company to supply the energy required for running the proposed electric trams between Roundhay and Kirkstall.

**Electric Mountain Railway at Zermatt.**—With reference to our note in last week's issue on the electric rack railway which is to connect Zermatt with the Gornergrat, we can now add that the system to be employed will be the polyphase overhead trolley system, similar to that employed at Lugano. The contract for the whole electrical equipment has been given to Messrs. Brown, Boveri and Co., of Baden, Switzerland.

**American Institute of Electrical Engineers.**—The annual meeting for election of officers of the American Institute of Electrical Engineers was held on May 19th, when the following were elected :—President, Louis Duncan ; Vice-Presidents, Charles P. Steinmetz, Harris J. Ryan, Wilbur M. Stine ; Managers, John W. Lieb, jun., F. A. Pickernell, William L. Puffer, L. B. Stillwell ; Secretary, Ralph W. Pope ; Treasurer, George A. Hamilton.

**The Guernsey Authorities and the Telephone Wires.**—The High-street at Guernsey was temporarily closed on Wednesday whilst workmen removed all telephone wires, which, it is alleged, the National Telephone Company put up without the permission of the authorities, who object to lines crossing streets. The Company having failed to acknowledge the notice to remove the lines the authorities took the matter into their own hands.

**An Historical Patent.**—But that the patent had already lapsed, Tuesday next, June 9th, would witness the expiry of the historically interesting patent No. 2,712, of 1882, granted to Franz Krizik and Ludwig Piette, of Pilsen, for "Improvements in Electric Lamps." The invention relates to the use of a tapered iron core for the solenoids of arc lamps, and the form of lamp in which this invention was embodied has been known commonly as the Pilsen lamp.

**Jungfrau Railway.**—In connection with the international competition for the best solution of a number of questions connected with the construction and working of an electric railway up the Jungfrau, details of which we published in *The Electrician* of March 13th last, 130 schemes have so far been received as follows :—From Switzerland there came 43 schemes, from Germany 42, Italy 10, England and America 9, France 6, Austria 5, Holland 2, and Belgium, Servia, Russia and Algeria 1 each.

**Royal Society.**—Yesterday the annual election of Fellows took place, and was followed by the reading of Papers, among others one by Prof. Dewar and Dr. Fleming : (1) "On the Electrical Resistivity of Bismuth at the Temperature of Liquid Air," (2) "On the Electrical Resistivity of Pure Mercury at the Temperature of Liquid Air" ; another by Prof. F. G. Baily, "The Hysteresis of Iron and Iron and Steel in a Rotating Magnetic Field" ; and another by Mr. C. Chree, "Observations on Atmospheric Electricity at the Kew Observatory."

**Institution of Electrical Engineers.**—At the special general meeting held on Friday last the proposed alterations in the Articles of Association, which we reprinted in our last issue, were, with the exception of a few minor amendments and additions, approved of. The proposals now await confirmation at a special general meeting to be held shortly.——The annual conversazione of the Institution will be held in the galleries of the Royal Institute of Painters in Water Colours on Thursday evening, June 25th.

**University College of South Wales and Monmouthshire.**—On Monday last the new engineering laboratory of this college was opened by Mr. F. W. Harries, master of the Drapers' Company. For the purpose of this laboratory the Government granted £20,000, local subscribers got together another £20,000, and the Drapers' Company gave £10,000. Prof. Viriamu Jones, Principal of the College, in proposing a vote of thanks to the Drapers' Company, said that the conditions upon which the grant was made would most certainly be fulfilled.

**American Criticism of European Practice.**—The tendency of American practice, says the *Street Railway Review*, "is towards standardisation and simplification and cheapening of manufacture and maintenance, and to this is partly due, no doubt, the rapid growth of the electrical business in this country. The European engineer, on the other hand, must have everything technically correct and suited to each particular case, thereby giving rise to a great diversity of practice and complication of apparatus. An example of the latter was furnished the other day, when an examination of a trolley base sent from Germany, and considered the proper thing over there, revealed the fact that it had something over 100 parts."

**The Pacific Cable Conference.**—Lord Selborne (Under-Secretary for the Colonies) and Mr. G. H. Murray (of the Treasury) have been appointed British delegates to the Colonial Office Conference which is about to be held to consider the Pacific Cable scheme. Lord Selborne will act as chairman. The Conference, when it meets to-day, will therefore be constituted as follows : Lord Selborne and Mr. G. H. Murray (England), Sir Saul Samuel (New South Wales), Mr. Duncan Gillies (Victoria), Sir Donald Smith and Sir Mackenzie Bowell (Canada), and Mr. Fleming, Canadian expert on telegraphy, with Mr. W. H. Mercer, secretary. Mr. Chamberlain, it is understood, will occasionally attend the meetings.

**Institution of Civil Engineers.**—At the annual general meeting on Tuesday the Council for the Session 1896-97 was duly elected, when several members were placed on the governing body as representative of the profession outside the United Kingdom. The full list of the new Council is :—*President*, John Wolfe Barry, C.B., F.R.S. ; *Vice-Presidents*, W. H. Preece, C.B., F.R.S., Sir Douglas Fox, James Mansergh and William Anderson, C.B., D.C.L., F.R.S. ; *Other Members*, A. R. Binnie, Henry Deane, W. R. Galbraith, George Graham, J. H. Greathead, J. C. Hawkshaw, Charles Hawksley, John Hopkinson, jun., D Sc., F.R.S., A. B. W. Kennedy, LL.D., F.R.S., John Kennedy, G. Fosbery Lyster, Sir Guildford L. Molesworth, K.C.I.E., Sir Andrew Noble, K.C.B., F.R S., William Shelford, B. B. Stoney, LL.D., F.R.S., F. W. Webb, Sir. W. H. White, K.C.B., F.R.S., and Sir E. Leader Williams. Of these gentlemen Mr. Henry Deane represents Australia and Mr. John Kennedy Canada.

**Magnesium.**—In an article published in *Machinery*, an American technical journal, Prof. Thurston gives an account of some of the physical properties of magnesium. In the first place, its specific weight is as only about two-thirds that of aluminium, viz., 109lb. per cubic foot. It melts at 811°F., and has electrical conductivity equal to 41·2 per cent. that of pure copper. Its tenacity ranges from 22,000lb. up to 32,000lb. per square inch. Its elastic limit in the shape of wire is about 8,770lb. per square inch, and its elastic modulus about 1,945,000lb., or less than that of most stones. The cast metal has a much lower tenacity, ranging from 9,640lb. to 13,600lb. per square inch. Alloyed with aluminium up to 10

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per cent. of magnesium, it increased the strength and elastic modulus of the former metal, but greater additions yield a weak and brittle alloy. Prof. Thurston further states that all attempts made at the Sibley College to form an alloy of copper and magnesium have completely failed, though much time and trouble were spent on the matter.

**American Pacific Cable.**—Those who favour the construction of a Pacific cable under the control of the American Government, says the *Western Electrician* of Chicago, "may well feel encouraged by the advancement of the movement lately. It was feared that the controversy over the Spaulding and Scrymser Bills under consideration in the Senate would result in the defeat of the project, as the friends of each measure refused to give way to those of the other. On May 6, however, a compromise was effected in the Committee on Foreign Relations which had both measures under consideration. The measure which Senator Frye was directed to report is in the shape of a Bill directing the Postmaster-General to contract with the lowest bidder for the construction of a telegraphic cable between the United States and Japan by the way of Hawaii and the Medway Islands. It is stipulated that the price shall not be in excess of $160,000 a year for a period of 20 years, during which time and for ever afterward the Company shall carry Government messages free of all cost. It is hoped that this will prove a practical solution of this perplexing question."

**The Tramway System of Chicago.**—From statistics just issued it appears that ten years ago there were but four tramway companies in Chicago, capitalised at 2¼ million sterling, and working a street mileage of 90 miles (average capital cost therefore about £25,000 per mile). To-day there are 29 distinct concerns, having an aggregate capitalisation of 37½ millions sterling, and operating 342 miles of street mileage (nearly £110,000 per mile). Of the four systems in existence ten years ago three were worked entirely by horses, the fourth using both cable and horses. Now the horse car has practically disappeared from Chicago, the motive power at present being:—Surface roads—electric, 255 miles; cable, 42 miles; horse, 18 miles. Elevated roads—electric, 15 miles; steam, 11 miles. In addition to the roads now completed, construction work is rapidly progressing upon five surface and elevated roads, all to be worked by electricity and which will, when completed, increase the total city mileage to 400 miles. London has less than three miles of mechanically worked tramways, while the total street length of tramways is only 136 miles, all worked by horse power.

**An Exhibition of Galvanometers.**—The sixty-eighth general meeting of the Society of German Physicists and Physicians will be held at Frankfort-on-the-Main from September 21st to September 26th. There will be no general exhibition in connection with the meeting as hitherto, but several separate exhibitions by different branches are proposed. The sections of physics, meteorology and instrument making are arranging for an exhibition of galvanometers and another one of Röntgen ray apparatus, and they invite the co-operation of all who are interested in the different subjects. The programme for the galvanometer section is as follows: 1. Historical galvanometers up to the fifties; original instruments or good copies of the same by Schweigger, Poggendorff, Fechner, Nobili, Weber-Gauss, &c., are specially wanted, the instruments to be accompanied, if possible, by complete historical data. 2. Galvanometers of later date, up to the eighties, of Meissner-Meyerstein, G. Wiedemann, Werner Siemens, E. Dubois-Reymond, Lord Kelvin, Edelmann, F. Kohlrausch, Rosenthal, &c., also with historical remarks, but especially with information as to sensibility. 3. Galvanometers of the latest design. 4. Apparatus for steady mountings and indicating devices. The terms employed by Messrs. Ayrton, Mather and Sumpner for denoting sensibility are recommended for adoption.

**The Electrical Transmission of Sound.**—One of the truly novel features of the Electrical Exhibition in New York was, says our Niagara Falls correspondent, the transmission of the roar of Niagara Falls by telephone. After investigation it was decided that some point near the Cave of the Winds would be the best point at which to gather the sound. Here one can get closer to the falls than at almost any other place. To reach this point, one descends the Cave of the Winds spiral stairway and walks toward the Centre Fall about 200ft. There on the rocky ledge a wooden box, about 3½ft. long, 3ft. high, and 1½ft. wide, was placed. In this box a telephone with a "solid-back" transmitter was placed, and a sheet-iron funnel, 20in. long and about 14in. in diameter at the fall, was fitted to the transmitter. Three standard batteries were placed in the box, but two only were used. About the box white canvas was wrapped to protect the apparatus from the constantly falling spray. At the point where the telephone is placed there are two distinct sounds produced by the falling water. One is a sharp hissing sound, like escaping steam, made by the water as it curls over the rocks below, and goes sweeping out into the river. The other is the deep pounding roar made as the fall strikes the rocks or water below. The first experiments were made with the telephone placed some 12ft. or 15ft. further away from the falling water than was finally the case, and were successful in catching the sharper hiss of the waters. This sound was plainly heard in New York, but the deeper roar was not caught. It was for this reason that a change in location was made, and the roar as heard in the world-famed Cave of the Winds was electrically transmitted to New York, 462 miles distant.

**Repair of the Pouyer-Quertier Cable.**—The Pouyer-Quertier cable, laid in 1879, between Brest and St. Pierre, broke in deep water near the Flemish Cap in June, 1895. Several attempts have been made to effect a repair. First, the cable steamer "Faraday" went out in August last, but although the cable was grappled successfully several times and raised to the surface, a considerable length of new cable being spliced on and laid in, she was compelled to return to England in October, having failed to restore communication. The "François Arago," belonging to the Compagnie Industrielle des Téléphones, next essayed the repair in the winter, leaving Havre early in January. In spite of almost continuous gales and bad weather, she succeeded in getting up the St. Pierre end and buoying it in 563 fathoms. She also got the Brest end in 1,800 fathoms, but lost it again whilst attempting to splice on to it in a heavy sea. Still, every effort was made to recover this end until the middle of March, when a hurricane swept the ship's deck, broke her steering gear, and carried away some of her boats and standing rigging. Having lost nearly all her buoys, ropes and other gear, and having sustained damage to her machinery, she was compelled to suspend further work, and returned to Havre on March 30th, leaving the St. Pierre end buoyed, and a gap of about 30 miles to where the Brest end was lost. During these last operations another break occurred in the cable nearer Brest. The Telegraph Construction and Maintenance Company's ss. "Seine" was then engaged to repair both these breaks, and left Havre on April 29th. Having taken tests from Brest, which made the distance of the break to be 234 miles off, the ship went to that position on May 1st, and hooked the cable the same day, but it broke in lifting. During that and the four succeeding days, the cable was hooked and brought to the bows fourteen times before the repair was finally effected, the cable being very much decayed and breaking every time a short distance from the ship. On May 5th this repair was completed, and the ship made for the western break, arriving at the position (where the "François Arago" had buoyed the end) on May 12th. The weather was rough until May 15th; a careful search was made for the buoy, which, however, was not found; but the position given by the "François Arago" was so accurate that the buoy moorings were hooked on the first drive made by the "Seine," and the end was recovered. The tests proving good to St. Pierre, new cable was spliced on and the end buoyed. On May 17th the Brest end was hooked in 1,800 fathoms, and raised to the bows with a strain of 6 tons on the grapnel. The cable was found good to Brest, and new cable was spliced on and paid out towards the buoyed end. A thick fog necessitated buoying the Brest end before the other buoy was reached. The fog did not clear away until May 21st, when the two buoyed ends were joined up and the repair completed. The "Seine" was ten days occupied on this deep-sea repair, on only four of which was it possible to work.

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## RÖNTGEN RAY EXPERIMENTS.

BY PROF. OLIVER J. LODGE, F.R.S.

In continuation of the experiment recorded on page 784 of the issue of April 10th (Vol. XXXVI.) the following facts may be reported:—

A vacuum tube was made with three terminals, two aluminium cups facing each other, and one platinum disc at 45deg. half-way between them, with its terminal coming out at right angles to the other two. Section shown in figure below.

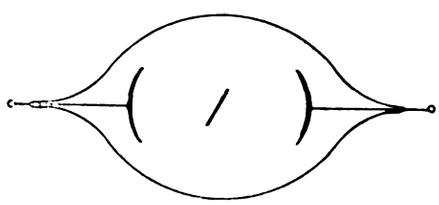
1. The cups being cathode and anode respectively, the insulated platinum disc acted as a moderately weak source, chiefly, of course, on the side facing the cathode. (The other side acts probably only by reason of the partial transparency of platinum.)

2. The platinum being now connected to the cathode, its ray-emitting power practically ceased.

3. The platinum being connected to the anode, it acted as a much more powerful source.

4. Connecting it to the anode through a Wimshurst machine in action, when the machine charged the disc positively it acted as a strong ray source; when the machine was reversed so as to charge the disc negatively it acted as only a very feeble source.

5. Shunting out the machine by short-circuiting its terminals, so as thereby to connect the disc direct to the anode, sometimes improved, sometimes enfeebled, the action. With a low vacuum, such that the induction coil can readily discharge through the tube, the action is best without the Wimshurst; but with a high vacuum, such that the coil has a difficulty in discharging, the intervention of the continuous-action machine greatly improves matters.



In other words, the continuous discharge may be said to maintain a supply of dissociated atoms able to convey the current, and thus dispenses with the heating otherwise frequently necessary.

6. If the machine is interposed between disc and cathode it does good only when it maintains a positive charge on the platinum disc.

7. Without the machine the coil usually acts best when connected so that one cup is cathode and the platinum disc sole anode, so that the charge is concentrated and not shared with any larger surface (though under extra high vacuum conditions a larger anode may become preferable).

8. The addition of the machine, between the disc and the other cup, may readily be made to strengthen the action still further.

9. It is desirable to force up and maintain the positive potential of the platinum disc in every way, *e.g.*, by avoiding any brush discharge or other leak, and by putting the machine in series with the coil when the vacuum gets over high. The usual hasty hook mode of connection for low-vacuum tubes is unsuitable for high vacuum-tubes.

10. When the coil is connected to the two cups, and is in action, the insulated platinum disc in the middle becomes charged, so that a wire attached to it can emit minute sparks The sign of this charge is, in my experience, always positive, no matter how the connection or current be reversed. Doubtless the cause of this is some brush discharge of negative electricity from other terminals; but whatever the cause, the effect is that the disc acquires the positive charge which appears necessary, and is certainly advantageous, to its action as an X-ray source, even when insulated; though, as previously said, it acts better if connected to or made the anode, or otherwise electrified strongly.

So much as a summary of some experiments with this tube. I next pass to a different matter. It has been asserted in France, I believe by M. Lafay, that although the X-rays are not ordinarily affected by a magnet, they become so if they be passed through an electrified plate; as if they were flying particles which could be first electrified and then, of course, magnetically deflected.

This result is profoundly important if true, but I have failed to find it true. Experiments on magnetic deflection are liable to disturbance, owing to the action of a powerful magnet in displacing the cathode rays in even a distant bulb, and so changing the position of the source. My most careful experiments have therefore been made on the *twisting* of rays travelling *along* the lines of magnetic force. For instance, if a Crookes' tube, say the well-known one which casts a shadow of a cross on the glass end, be encased in a helix conveying a current, the shadow of the cross will be notably twisted, and the twist will reverse with the direction of magnetisation. In other words, cathode rays travel spirally along a magnetic field. Do the X-rays the same? Answer, in my experience, they do not: not even when passed through a highly electrified plate first, as in M. Lafay's experiment.

The magnet used was a Faraday magnet with perforated pole-pieces 5·6cm. apart, giving a field, at the middle, of 5,600 C.G.S. lines per square centimetre, when excited for use by 15 or 20 storage cells. At the centre of this field was placed a hemisphere of aluminium with its edges thoroughly protected by an incrustation of molten paraffin, and this was electrified so as to be on the verge of sparking from its convex surface towards one of the poles.

The Röntgen bulb was placed so as to send rays through the tunnel in the first pole-piece, then through the aluminium hemisphere and out at its charged convexity, thence through the 2·8cm. of air magnetised to 5,600 C.G.S., then half-way through the second tunnel, where they encountered a disc of sensitive plate, and impressed themselves upon it.

On the inside of the hemisphere were fixed a couple of parallel copper wires, which the rays encountered before entering the electric field, thereby throwing a shadow of them on the plate. A third wire, parallel to the other two, was fixed in the tunnel (out of either field) close to the plate itself; and when everything was right, on developing the plate, the three shadows came out sharply as three clear parallel lines close together.

The experiment consisted in noting micrometrically whether this parallelism of the shadows was preserved in successive experiments with the electrification or the magnetisation reversed. Not the slightest angular twist of the pair of wires with respect to the single one could ever be seen.

The potential to which the aluminium surface was kept charged was about 40,000 volts, but it is not really a matter of volts, it is a matter of electric density, and this is best specified by saying that it was nearly, not quite, as high as air can stand. It could not be quite as high without risk of the hemisphere giving off an actual spark, which might damage the sensitive plate. Sparks to the pole-piece were obtained *before* inserting the plate, and then the potential was slightly reduced by aid of a safety spark-gap elsewhere. This, which was 2·3cm. wide, was kept sparking during an experiment.

But although the result was thus negative in an electrical field in *air*, it was possible that there might be a positive result in some other medium,—an experiment akin to that of the Faraday magnetic rotation. Accordingly a thick glass plate, 7·3mm. thick, was coated on each side with a small patch of aluminium foil heavily coated all over with slabs of molten paraffin, and the pair of foils were kept electrified. The difference of potential that could thus be maintained across this thickness of glass was much higher than was possible with air, being maintained by a machine which was constantly giving a spark 7·5cm. long between its knobs (2·34cm. diameter), or over 100,000 volts.

This sort of Leyden jar was then placed in the same magnetic field as before, so that the electric and magnetic lines coincided, and the three shadow-throwing parallel wires were again adjusted, two on one side of the glass, and a

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third, between them, on the other side. The X-rays were now passed through the glass, along the electric and magnetic lines, so as to throw a shadow of the wires on to a sensitive plate (or sometimes on a fluorescent screen); but still no trace of twist could be detected.

Other experiments were made of similar general character, with a greater thickness of air between oppositely charged curved plates, &c., but this record may serve. I conclude, therefore, that until the details of a positive experiment are forthcoming it is apparently not feasible to electrify X-rays by passing them through an electrified surface, whether that surface have a plus or a minus electric density, and whether the medium entered be air or glass.

Mr. Benjamin Davies was my assistant in performing these experiments.

## THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 73.*)

**Example VI.**—Ammeter of 10 ohms resistance connected between middle wire and earth; $d_1 = 1{\cdot}38$ ampere. Ammeter is shunted with 10 ohms resistance; $d_2 = 0{\cdot}91$ ampere.

$$\therefore\ F = \frac{1{\cdot}38 - 0{\cdot}91}{1{\cdot}82 - 1{\cdot}38} \times 10 = \frac{0{\cdot}47}{0{\cdot}44} \times 10 = 10{\cdot}7 \text{ ohms.}$$

**Example VII.**—Voltmeter of 300 ohms resistance is connected between middle wire and earth; $d_1 = 3{\cdot}74$ volts. Shunted with 300 ohms resistance; $d_2 = 2{\cdot}54$ volts.

$$F = \frac{3{\cdot}74 - 2{\cdot}54}{5{\cdot}08 - 3{\cdot}74} \times 300 = 269 \text{ ohms.}$$

The fault resistance of a network whose middle wire is permanently earthed through an ammeter of very low resistance can unfortunately not be determined by Methods 2 or 3, owing to the instrument resistance being small compared with the fault resistance to be measured. Theoretically, this does not matter, but the readings and values of the resistances would have to be taken to an impossible degree of accuracy.

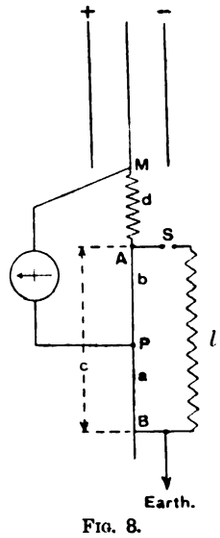


FIG. 8.

*Method 4.* (*Wheatstone's Bridge Method*).—The connections are as in Fig. 8, or 9A and 9B, the point M being connected to the network.

Fig. 8 represents the connections when a bridge of the stretched-wire pattern is used. $d$ is a coil of known resistance; the test is most accurate when this resistance is about equal to the insulation resistance of the network, as then the sliding contact P will, at its balance position, be near the middle of the stretched wire AB. If, however, the insulation resistance of the network be low, $d$ must be chosen of a greater value, as otherwise the stretched wire will be unduly heated by the current flowing through it. The galvanometer should be a fairly sensitive one, and $l$ may be a few lamps connected in parallel. S is a key or switch.

The position of the sliding contact P is adjusted *until the same current flows through the galvanometer whether the contact at* S *is open or closed*, not until no current passes through the galvanometer, as in an ordinary Wheatstone's bridge test. Then the insulation resistance is

$$F = \frac{a}{b} d.$$

If a stretched-wire bridge with two sliding contacts* be used, the bridge is so connected that the end B is the movable end

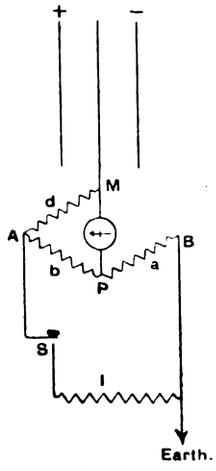


FIG. 9A.

connection and A the fixed one. Then P is fixed at the reading equal to $d$ (or ten times, or one-tenth, or any convenient multiple or fraction of $d$), and the sliding connection B is moved until balance is indicated by the two galvanometer deflections being equal. Then $a$ (that is $c - b$) will give the insulation resistance on the same scale as that on which $b$ represents $d$. When making a measurement just for once in a way this adjustment of the two sliders is not worth the trouble; it is then best simply to fix B at the end of the scale, and to balance by adjusting P, as in an ordinary stretched-wire bridge. But if the apparatus is to be used frequently to test the same insulation resistance it may be a convenience to have it almost direct-reading.

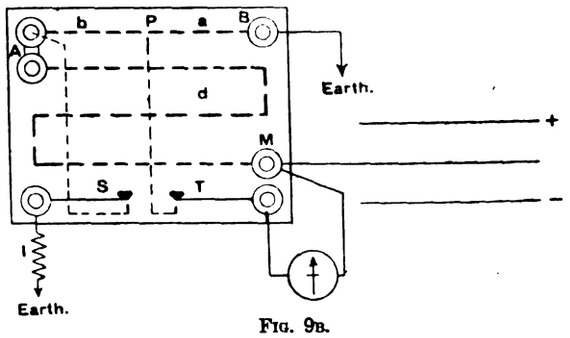


FIG. 9B.

When a bridge of the resistance-box pattern is used for the test we have slightly different conditions. Figs. 9A and 9B represent the connections in this case; Fig. 9A is a "lozenge-shaped" diagram of the bridge, and Fig. 9B shows a Post Office portable pattern bridge connected up for the test. The ratio $b : a$ should be taken as large as circumstances will permit so that $d$ has also to be large, and only a small current passes through the bridge coils. The resistance $l$ may be a few lamps connected in parallel, as before. The key T of the galvanometer circuit must be held permanently depressed, and

* From a forthcoming work to be published by *The Electrician* Printing Publishing Company. All rights are reserved.

* For localising faults, a stretched wire bridge with two sliding contacts has certain advantages. These will be discussed in another place, and suggestions as to the construction of such a bridge will be given.

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$d$ must be adjusted until the condition of balance is fulfilled—viz., that the same current should pass through the galvanometer, whether the key S is up or down. Then, as above,

$$F = \frac{a}{b} d.$$

There is a possibility, though the case rarely occurs, that the fault resistances on the positive and negative side of the network fulfil the conditions for the potential of the middle wire to be 0, so that no current could be obtained for the bridge when it is connected to the network at the middle omnibus bar. In such a case, point M might be connected to another main instead of to the middle wire, as theoretically the bridge may be connected to any point of the network. But in practice it is to be preferred to leave M connected to the middle 'bus bar, and to insert a battery of a few cells in series with $l$; this avoids the danger of too large a current passing through the coils or stretched wire of the bridge. If the deflection of the galvanometer is to the end of the scale before the key S is depressed, this deflection must be reduced by shunting the instrument either with a resistance coil or with a length of fine wire; or else, if the current causing the deflection is not very large, and the instrument is not of the d'Arsonval type, the needle may be brought back to zero by moving the controlling magnet, or by placing another magnet near to the instrument in such a position as to neutralise the effect of this current.

*General Conclusions and Comparison of Methods 1 to 4.*

Whatever method be employed, it is always advantageous to have a high-resistance recording voltmeter permanently connected between one (or each of) the outer mains and earth. Besides indicating the nature of faults, as already explained, it also gives a clue to which of the mains is faulty, and acts as a sort of check on the daily insulation test. A substitute for this is a high-resistance or electrostatic voltmeter, from which readings are noted every hour by the switchboard attendant.

Of the four methods described, No. 4 is undoubtedly the most accurate, but it has the disadvantage of giving no indication of the relative fault resistances of the mains. It is true that if a recording voltmeter be employed one can see whether a fault has occurred on the positive or negative side of the network; but it requires some judgment, and there is always some uncertainty as to whether the fault is on the middle wire or on the outer wire. There is just the general rule to go by, that a drop in the insulation resistance effects more change in the absolute potentials of the mains (*i.e.*, in the difference of potential between each main and earth) if it occurs on the outer wire than if it occurs on the middle wire. The same rule is a guide in the case of a five-wire network. A fault in one of the extreme mains affects the absolute potentials more than the same fault would had it occurred in the adjacent main; and much more than it would had it occurred in the middle wire. For three and five-wire networks, therefore, Method 4 may be used occasionally to measure the insulation resistance accurately, but one of the other methods should be used for the daily test. For two-wire networks the above objection to Method 4 does not hold, as, by connecting almost any voltmeter or ammeter momentarily between each main and earth, it is immediately apparent on which main the fault is. The connections of the bridge are not terribly complicated, though it is well to refer to the diagram the first time they are made.

Some central-station engineers have an unconquerable objection to momentarily increasing the leakage from one of their mains, especially from one of their outer mains. Then the choice of methods is very limited, and in many cases an accurate test is out of the question. Method 2 is then the best test to choose, but in some instances mentioned it would be necessary to use adjustable resistances of known value and capable of standing moderately strong currents; such coils are costly and decidedly a luxury. Method 1 may be used with voltmeters of fairly high resistance; the disadvantages of this method, when the resistance of the voltmeter is high compared with the insulation resistance of the network, have already been pointed out. Method 3 is also not sensitive under these circumstances.

In most cases Method 3 is the test to be recommended. It is not quite so sensitive as Method 1, but it has the advantages of partially earthing the middle wire only, and of needing an instrument with a much shorter range than that required for Method 1. Where the fault resistances of the mains are so balanced that no current is ordinarily to be obtained between the middle wire and earth, it is perhaps preferable to use Method 1 than to complicate Method 3 by the introduction of an artificial fault.

Method 1 has the advantage of being the oldest method and the one most used hitherto. It was first employed in Vienna by Mr. Gustav Frisch in 1889, and is at present used daily at several central stations, including the Westminster and Liverpool stations, both of which employ low resistance ammeters for the test.

It should be mentioned that, in all tests described, the insulation resistance that is measured is in reality the insulation resistance of the network, generating plant, switchboard, &c., in parallel. In well-managed stations the normal earth-leakages from the latter are nothing compared to the earth-leakage from the network, and if an earth occur in a dynamo or in the battery room it is at once detected.

It is always advisable to insert fuses between the mains and the testing instruments. The resistance of the fuse always being insignificant compared with the fault resistance of the main, it need not be allowed for.

As before stated, ammeters and voltmeters giving readings to both sides of zero are the most convenient to use. Some instruments give readings to one side only, but are provided with an extra pointer, which indicates in which direction the current is flowing; these, of course, answer the same purpose. Other types will only measure currents flowing through them in one direction; such instruments are inconvenient to use for these tests.

*Alternating Current Low-Pressure Networks.*

The four methods as above described are not suitable for measurements on alternating current networks. Method 4 may, however, be used, if a galvanometer is chosen that will not deflect for alternating currents, by putting a few battery cells in the arm $l$. A fuse should be inserted at M or B, or both, to protect the slide wire or bridge coils; and the galvanometer circuit between M and P should also include a delicate fuse.

The daily test of such networks should be the measurement of the potential difference between each main and earth; this test will give a comparative indication of the condition of the network from day to day, but will not enable one to calculate with accuracy its insulation resistance. The reader is referred to the remarks on the value of the potential of the respective mains in the article on high-pressure networks which follows.

*(To be continued.)*

## PATENTS IN 1895.

In his Thirteenth Report the Comptroller General of Patents states that in 1895, for the first time since the year 1885, the number of applications for patents showed no increase upon that of the preceding year, but, on the contrary, a decrease of 321. This decrease, however, was entirely due to a falling off of 676 in the number of applications accompanied by *provisional* specifications, those accompanied by *complete* specifications having increased, in even more than the usual proportion, by 355; 2·3 per cent. of the total number of applications were made by women. Six applications were made to the Privy Council for extensions of patents—of these, three applications were refused, two applications were withdrawn, and one case remained undecided. The number of readers frequenting the Patent Office Library during the year was 108,285, or a decrease of 5,089 as compared with the previous year.

The total receipts of the Patent Office for the year ending December 31, 1895, amounted to £187,012, as against £182,000 for the preceding year. Of this sum £168,428 was

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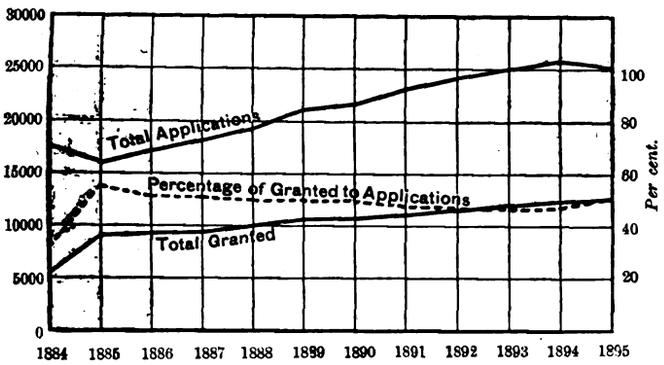
derived from patent fees. The expenditure last year amounted to £100,671, against £96,000 for the year 1894. A surplus of £86,341 was thus realised by the operation of the Patent




Curves showing total number of Patents applied for each year since 1884, also percentage ratio of Patents granted to Patents applied for, and total number of Patents granted.

Office during 1895. The two principal items of expenditure were—salaries, £54,853, and printing £24,650. The sum of £10,161 was expended on new works.

## THE EVOLUTION OF MODERN SCIENTIFIC LABORATORIES.*

BY PROF. W. H. WELCH.

The scientific discoveries of the present century have had such a profound influence upon inventions, upon industries, and upon the comfort, health, and welfare of the people in general, that there is widespread, even if not always adequate, appreciation of the value of scientific study and investigation. But it may be doubted whether there is any proper understanding, in the minds even of the educated public, of the material circumstances which surround scientific discovery, and which make it possible. The average man, if interested at all, is interested that the discovery is made, not how it is made. In America, where men of science rely mainly upon enlightened private beneficence, and not upon governmental aid, to furnish the pecuniary resources which are essential for scientific progress, it is important that there should be some general information, not only regarding the results of scientific work, but also regarding the external material conditions necessary for the fruitful prosecution of such work.

At the present day the systematic study and advancement of any physical or natural science requires trained workers who can give their time to the work, suitably constructed work-rooms, an equipment with all of the instruments and appliances needed for the special work, a supply of the material to be studied, and ready access to the more important books and journals containing the special literature of the science. All of these conditions are supplied by a well-equipped and properly organised modern laboratory. Such laboratories are, with the partial exception of the anatomical laboratory, entirely the creation of the present century, and for the most part of the last fifty years. They have completely revolutionised during the past half century the material conditions under which scientific work is prosecuted. They are partly the result, and in larger part the cause, of that rapid progress of the physical and natural sciences which characterises the era in which we are living.

The evolution of the modern laboratory still awaits its historian. It is not difficult to find incidental references to historical facts bearing upon this subject. The development of the chemical laboratory has been traced with some fulness. But it is curious that there is no satisfactory monographic treatment of the general subject of the historical development of scientific laboratories. The subject seems to me an attractive one. It would surely be interesting to trace the development of the teaching and the investigating laboratory back to its beginnings, to learn about the material circumstances under which the physicists, the chemists, the morphologists, and physiologists of former generations worked. What share in the development of laboratories had the learned academies of the Renaissance and of the subsequent centuries? What share had public and private museums and collections of instruments of precision? What share had the work of the exact experimentalists, beginning with Galileo, of physicians, of the alchemists, and of the apothecaries? What individuals, universities, corporations and governments were the pioneers in the establishment of laboratories for the various physical and natural sciences? The detailed consideration of these and many other questions pertinent to the subject would make an interesting and valuable historical contribution.

There is evidence that in Alexandria, under the early Ptolemies in the third century before Christ, there existed state-supported institutes, in which students of man and of Nature could come into direct personal contact with the objects of study, and by the aid of such appliances as were then available could carry on scientific investigations. The practical study of anatomy, physiology, pathology and other natural sciences was here cultivated. We are very imperfectly informed as to the results and the material circumstances of this remarkable period in the history of science. We know that after about a century of healthy activity the Alexandrian school gradually sank into a place for metaphysical discussions.

Fifteen hundred years elapsed before we next find any record of the practical study of a natural science. In 1231 the great Hohenstaufen, Frederick the Second, who has been called the most remarkable historic figure of the Middle Ages, commanded the teachers at Salernum diligently to cultivate the practical study of anatomy. After the passage of this edict occasional dissections of the human body were made, but it cannot be said there was any diligent cultivation of anatomy on the part either of teachers or of students during the following two centuries. In the latter half of the fifteenth century there developed that active interest in the practical study of human anatomy. For over 600 years there has been at least some practical instruction in anatomy, and for over 300 years there have existed anatomical laboratories for purposes of teaching and of investigation, although only those constructed during the present century meet our ideas of what an anatomical laboratory should be. It is a matter of no little interest, both for the history of medicine and for that of science in general, that the first scientific laboratory was the anatomical laboratory. Private laboratories for investigation must have existed from the earliest times. Doubtless Aristotle had his laboratory. But the kind of laboratory which we have on this occasion in mind is one open to students or investigators, or both. There was no branch of physical or natural science, with the exception of anatomy, which students could study in the laboratory until after the first quarter of the present century. Only in anatomy could students come into direct contact with the object of study, and work with their own hands, and investigate what lay below the surface.

The famous Moravian writer on education, Amos Comenius, over 250 years ago, gave vigorous expression to the conception of living, objective teaching of the sciences. He said: "Men must be instructed in wisdom so far as possible, not from books, but from the heavens, the earth, the oaks and the beeches—that is, they must learn and investigate the things themselves, and not merely the observations and testimonies of other persons concerning the things." "Who is there," he cries, "who teaches physics by observation and experiment, instead of by reading an Aristotelian or other text-book?" But how little ripe were the conditions then existing for the successful carrying out of ideas so far in advance of his times is illustrated by the very writings of the author of "Orbis Pictus" and "Lux in Tenebris."

It would lead too far afield to trace in detail on this occasion the development of physical and of chemical laboratories, but a few words on this subject will not be out of place. Methodical experimentation in the sciences of Nature was definitely established by Galileo, and was zealously practised by his contemporaries and successors in the seventeenth century. It was greatly promoted by the foundation during this century of learned societies, such as the Academia dei Lincei and the Academia del Cimento in Italy, the Collegium Curiosum in Germany, the Académie des Sciences in Paris, and the Royal Society in England. Much of the classical apparatus still employed in physical experiments was invented at this period. Experimental physics from the first acquired a kind of fashionable vogue, and this aristocratic position it has ever since maintained among the experimental sciences. These sciences must concede to physics that commanding position which it has won by the genius of the great natural philosophers, by the precision of its methods and the mathematical accuracy of its conclusions, and by the fundamental nature and profound interest and importance of its problems. The debt of the medical sciences to the great experimental physicists, from Kepler and Galileo and Newton down to Helmholtz is a very large one.

There existed in the last century cabinets of physical apparatus to be used in demonstrative lectures, but they were very inadequate, and suitable rooms for experimental work scarcely existed. It was not until about the middle of the present century that we find the beginnings of the modern physical laboratory. Lord Kelvin, then William Thomson, established a physical laboratory in the University of Glasgow about 1845, in an old wine cellar of a house. He

* Abstract of an address delivered at the opening of the William Pepper Laboratory of Clinical Medicine, Philadelphia, December 4, 1895.

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tells us that "this, with the bins swept away, and a water supply and sink added, served as a physical laboratory for several years." It was as late as 1863 that Magnus opened in Berlin his laboratory for experimental physical research. Since 1870 there has been a rapid development of those splendid physical institutes which are the pride of many universities.

Humbler, but more picturesque, was the origin of the chemical laboratory. This was the laboratory of the alchemist searching for the philosopher's stone. In the painter's canvas we can still see the vaulted, cobwebbed room with its dim and mysterious light, the stuffed serpent, the shelves with their many-coloured bottles, the furnace in the corner with the fire glowing through the loose bricks, the fantastic alembics, the old alchemist in his quaint arm-chair reading a huge, worm-eaten folio, and the assistant grinding at the mortar. Fantastic and futile as it all may seem, yet here was the birth of modern chemistry. The alchemists were the first to undertake the methodical experimental investigation of the chemical nature of substances. No more powerful stimulus than the idea of the philosopher's stone could have been devised to impel men to ardent investigation. But search for gold was not all that inspired the later alchemists. Paracelsus, the alchemist, said, "Away with these false disciples who hold that this divine science, which they dishonour and prostitute, has no other end but that of making gold and silver. True alchemy has but one aim and object—to extract the quintessence of things and to prepare arcana, tinctures and elixirs which may restore to man the health and soundness he has lost." And again he says of the alchemists: "They are not given to idleness, nor go in a proud habit or plush or velvet garments, often showing their rings upon their fingers, or wearing swords with silver hilts by their sides, or fine and gay gloves upon their hands, but diligently follow their labours, sweating whole days and nights by their furnaces. They do not spend their time abroad for recreation, but take delight in their laboratory. They wear leather garments, with a pouch and an apron wherewith to wipe their hands. They put their fingers among coals and into clay, not into gold rings."

During the seventeenth and eighteenth centuries the doctrines and work of the alchemists had profound influence upon medicine. Alchemy was not completely overthrown until Lavoisier gave the death-blow to the phlogistic theory of Stahl. But for a considerable time before Lavoisier introduced the new spirit into chemistry its methods and its problems were gradually approaching those of modern times. It was, however, over thirty years after the tragic death of Lavoisier before the first chemical laboratory in the modern sense was established. One cannot read without combined feelings of wonder and pity of the incommodious, forlorn, and cramped rooms in which such men as Scheele and Berzelius and Gay-Lussac worked out their memorable discoveries. Liebig has graphically described the difficulties encountered by the student of that day who wished to acquire practical training in chemistry. With some of the apothecaries could be obtained a modicum of practical familiarity with ordinary chemical manipulations, but Sweden and France were the centres for those with higher aspirations.

It was the memory of his own experiences which led Liebig, immediately after he was appointed professor of chemistry in Gissen in 1824, to set about the establishment of a chemical laboratory. Liebig's laboratory, opened to students and investigators in 1825, is generally stated to be the first modern public scientific laboratory. Although, as we shall see presently, this is not quite correct, it is certain that Liebig's laboratory was the one which had the greatest influence upon the subsequent establishment and organisation not only of chemical laboratories, but of public scientific laboratories in general. Its foundation marks an epoch in the history of science and of scientific education. This laboratory proved to be of great import to medical science, for it was here, and by Liebig, that the foundations of modern physiological chemistry were laid. The significance of this memorable laboratory of Leibig is not that it was a beautiful or commodious or well-equipped laboratory, for it possessed none of these attributes—indeed, it is said to have looked like an old stable—but that here was a place provided with the needed facilities, and under competent direction, freely opened to properly-prepared students and investigators for experimental work in science.

The chemical laboratories of to-day are, in general, the best organised and the best supported of scientific laboratories. The need of establishing physiological laboratories was recognised several years before the foundation of Liebig's laboratory. The important results to be derived from the application of the experimental method to the study of vital phenomena had been demonstrated first and most signally by Harvey, and after him by many experimenters. The fecundity of exact experimentation by physical and chemical methods applied to the phenomenon of life had been shown by the classical researches of Lavoisier on respiration and animal heat. Magendie had entered upon that remarkable scientific career which entitles him to be regarded as the founder of modern experimental physiology, pathology, and pharmacology. With two or three exceptions, all of the separate physiological laboratories worthy of the name have been established since the middle of the present century. Bernard, that prince of experimenters, worked in a damp, small cellar, one of those wretched Parisian substitutes for a laboratory which he has called "the tombs of scientific investigators." There can be no greater proof of the genius of Bernard than the fact that he was able to make his marvellous discoveries under such obstacles and with such meagre appliances. France was long in supplying her scientific men with adequate laboratory facilities, but no more unbiassed recognition of the value and significance of the German laboratory system can be found than in the reports of Lorain, in 1868, and of Wurtz, in 1870, based upon personal study of the construction and organisation of German laboratories.

It is apparent, from the brief and imperfect outline which I have presented of the evolution of modern scientific laboratories, that the birthplace of these laboratories, regarded as places freely open for instruction and research in the natural sciences, was Germany. Such laboratories are the glory to-day of German universities, which possess over two hundred of them. By their aid Germany has secured since the middle of the present century the palm for scientific education and discovery. Great scientific investigators are not limited to any country or any time. There are those of surpassing ability who will make their own opportunity, and will triumph over the most discouraging environment. This country and every civilised country can point to such men, but they are most exceptional. The great majority of those even with the capacity for scientific work need encouragement and opportunity. We now have sufficient knowledge of the workings of scientific laboratories to be able to assert that in general where the laboratory facilities are the most ample and the most freely available, there are developed the largest number of trained workers, and there the discoveries are the most numerous and the most important. At the present day no country, no university, and no medical school can hold even a respectable place in the march of education and progress unless it is provided with suitable laboratories for scientific work.

A properly equipped and properly conducted scientific laboratory is a far more expensive institution than is usually conceived. It must be suitably domiciled either in a separate building or in rooms commodious and well lighted. The outside architectural features are of secondary importance. The instruments and appliances necessary for exact observation and experiment, even in those sciences which apparently require the least, are numerous and costly. A working library, containing the books and sets of journals most frequently consulted, is most desirable, if not absolutely indispensable. The director of the laboratory should be a man of ability and experience, who is a master in his department of science. He must have at least one assistant, who is preferably a young man aiming to follow a scientific career. A person of no small value in the successful working of the laboratory is the intelligent janitor or "diener," who can be trained to do the work of a subsidiary assistant, and can be entrusted with the care and manipulation of instruments. There must be funds for the purchase of fresh supplies and new instruments when needed. The running expenses of a first-class laboratory are not small. But, costly as may seem the establishment and support of a good laboratory, the amount of money expended for laboratories would seem to us ridiculously insignificant if we could estimate the benefits to mankind derived from the work which has been done in them. Wurtz has truly said of the money required for laboratories, "It is a capital placed at a high rate of interest, and the comparatively slight sacrifice imposed upon one generation will bring to following generations increase of well-being and knowledge."

The educational value of the laboratory cannot well be overestimated. For the general student this is to be found primarily in the development of the scientific habit of thought. He learns that to really know about things it is necessary to come into direct contact with them and study them. He finds that only this knowledge is real and living, and not that which comes from mere observation of external appearances, or from reading or being told about things, or, still less, merely thinking about them.

## THE DEVELOPMENT OF ELECTRICAL TRACTION APPARATUS IN THE UNITED STATES.*

BY H. F. PARSHALL.

In this Paper I propose to discuss and illustrate the more important details of the machinery especially developed for use in electrical traction. At the commencement of my experience, about six months was taken to construct 40 street car motors. At the present day, in the same works, there are constructed regularly 150 street car motors per week, and, in some cases of extreme demand, as many as 500 have been constructed in the same length of time.

* Abstract of a Paper read before the Society of Arts, February 18th, 1896.

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The difficulties experienced with the apparatus as first designed were largely confined to the motor and motor regulator, this latter being now commonly called the controller. After these had been brought into a better state of perfection, refinements were introduced in the power station and in the switching appliances. This being the order of development, it will also be taken as the order for discussion.

The tramway motors first constructed in the United States were but little suited for the work of electrical traction. Engineers but little understood the great strain, both mechanical and electrical, to which this machinery would be subjected. In general, the motors were designed on much the same lines as central station dynamos and stationary motors had previously been. The speed and the torque at different speeds of the motors, in general, did not agree with the speed and resistance of the car at different speeds. Special attention was paid to the efficiency at full load, but, inasmuch as the mean working point was much less than the full load of the motor, efficient results were not obtained until power measurements as to the average work required for the propulsion of a car were made, and the motor so designed that the efficiency was towards a maximum at the average working point of the motor.

Another point that was not clearly recognised related to the torque per ampere best suited to such a motor. In starting the car, the torque per ampere should be a maximum. As the car becomes accelerated, the torque per ampere should be less, and should fall off according to the maximum speed to be attained. In the first motors the torque per ampere, owing to the proportions of the motor, was approximately constant, so that an excessive starting current was required, this being so great that, frequently, there was great heating of the windings, and the durability of the motor was greatly impaired. At the present day, in well designed street car motors, the effort at the car wheel is about forty pounds per ampere in the armature, and, when running at full speed, from twenty to twenty-five pounds. In thus varying the range of torque per ampere the efficiency of the motor has been increased, and, likewise, the durability of the parts in which the electrical losses occur.

The mechanical improvements found necessary to make were numerous and important. The diameter of the shaft had to be increased so that the factor of strength was some six times greater than in ordinary station motors and dynamos; the bearings had to be increased in length and diameter; and the face of the gear had to be increased, and also the pitch. The fine pitch that had previously been found satisfactory in machine construction was found to be altogether unsuited for tramway motors. Improvements were also made in the method of holding the armature conductors, since it was found that the conductors, when held in the ordinary way, would shift in respect to each other, and so injure the insulation as to impair the durability of the armature.

In order to lessen the deterioration of the controlling mechanism, which was either a commutating switch or a rheostat, it was found necessary to design the motor so that the torque per ampere, at a given speed, coincided with the resistance of the car for a given acceleration and speed. Increasing the efficiency of the motor, that is, lessening the amount of current for which a given torque and acceleration is produced, greatly lessened the deterioration of the controlling apparatus, so that advancement in the design and efficiency of the motor was accompanied with a corresponding durability of the controlling apparatus.

The next more important step in this direction was the substitution of the multipolar motor and the dispensing with one set of gears. This was found practicable, when the manufacture of steel had advanced so that castings of high permeability, and of the complex form required for tramway motors, could be made. The earlier types of motors were made of forgings of simple shape, which were not of such form as could be made into multipolar motors. This last change was accompanied by numerous other mechanical improvements. The gears, shaft and bearings were again increased in size. The method of lubrication was improved, the gears being placed in an oil-tight box, so that their durability was increased some three or four times. A steel gear will now wear for three years and a pinion nine months, in an equipment making 100 miles a day. The pinions usually have 13 to 16 teeth and the gear from 60 to 70. The pitch commonly used is that known, in the United States, as the No. 3 pitch, *i.e.*, the diameter of the gear divided into the number of teeth=3. By making the shaft more rigid, and by studying the form and clearance of the teeth, a gear has now been produced that makes comparatively little noise.

Another improvement relates to the method of suspending the motor in the so-called "nose-suspension" manner, in which the motor is carried by a lug and cross bar. The top axle lining lasts about six months, and the bottom axle lining about twelve months. *With the side bar suspension*, in which the motor is suspended in a line vertically underneath its centre of gravity, the axle linings last twice as long.

Great mechanical improvements have also been made in the construction of the commutator, which is subjected to hard usage, owing to the necessity of carbon brushes (set at a very considerable pressure on account of the vibration of the motor). A well constructed commutator may now be expected to last two years.

A further improvement has been to completely house the motor in a steel casing so that it is now entirely waterproof. The force with which water penetrates a tramway motor in a wet street is remarkable, since the joint between the upper and lower halves of the motor have to be especially larded to keep the water from oozing through even when the surfaces are as perfectly milled and fitted together as possible.

The electrical features of the motor have also received decided mechanical improvement. The armature coils are formed and interchangeable, and insulated, first with abestos, and, secondly with mica and tape, so that it will withstand a very high temperature. The method of securing the armature coils has also formed the subject of study and improvement. The coils are now held upon a conical surface, and securely clamped by a nut so that any shifting is prevented.

Another improvement is in reference to the magnet coils, which are insulated with asbestos, and made entirely waterproof. It would seem perhaps that this was unnecessary, considering that the motor itself was made waterproof, but condensation of water frequently occurs in an encased motor, and renders it necessary for good results that both the coils of the field and of the armature should be waterproof.

Another improvement that has been found of great importance in practice is the diminution of the weight of the motor for a given power. This has been done by the use of steel, and by studying, particularly, the mechanical construction, and the nature of the work to be done. A motor nominally rated as 25 H.P., complete with the gearing, now weighs about 1,500lbs. Such a motor cannot, of course, do 25 H.P. permanently, but it is rated on its capacity for doing this work for a limited period of time—generally two hours—this being a more satisfactory manner of rating for electrical traction. With this diminution of weight it has been found that the deterioration of tracks, trucks and bearings, has been greatly lessened. Great improvements have also been made in the construction of trucks for tramway purpose.

The motor that has heretofore been illustrated, and particularly discussed, is what is known as the "standard tramway motor," *i.e.*, a motor capable of exerting 800 to 1,000lbs. horizontal effort on the car wheel, when running 10½ miles per hour and delivering 25 H.P., when mounted on 33in. wheels and loaded to its rated capacity. It differs only in the point of size from the larger motors that are used in what may be termed "light railways," along which trains, weighing from 60 to 100 tons, are moved at a speed of 15 to 45 miles an hour, and, in some cases, to 60 miles an hour.

In the standard motor the diameter of the car axle is 3⅜in., the pinion is seated with paper bore, the axle gear is of cast iron, and the gear reduction is 4·78 to 1. This motor is suited for all ordinary city tramways. It has been frequently wound for a higher speed and different output, but the consumption of energy in a given time is increased according to the increase of speed, that is, the consumption of energy per car mile in a given motor remains practically the same so long as the magnetic conditions remain constant. In high speed or suburban railway work, where heavy grades and heavy loads have to be met with and drawn from 20 to 30 miles an hour, a motor having a rated horizontal effort of 1,200lb. when running 12 miles an hour and delivering 40 H.P. under the previously-mentioned conditions is commonly used. For a still heavier class of work two or four motors are used per train, each giving 2,000lb. horizontal effort when running 20 miles an hour and delivering approximately 120 H.P. under the previously-mentioned conditions. Two such motors will operate three ordinary passenger cars at a speed of 30 to 40 miles an hour, and four of them operate six passenger cars. It is interesting to note that, in the design of these motors, the maximum rated horizontal effort is not varied by varying the number of turns on the armature so long as the weight of the copper and the magnetic flux remain the same. I give herewith a table that shows the general results and traction coefficients that have been obtained in the United States with the forms of equipment with which I am familiar.

Referring next to the controller, I may state that this has undoubtedly required as much attention and invention to perfect as the motor. The controller now generally used is known as a series-parallel controller—*i.e.*, the motors are started in series with each other. This lessens the starting current for a given horizontal effort to half of that when the motors started together in parallel. It has been found that, in cities where the number of stops are frequent, by the use of the series-parallel controller, the consumption of energy per car is lessened 40 per cent. Of course, there would no such gain in suburban districts where the stops are less frequent.

The different steps gone through in the starting of two motors by the series-parallel method are as follows:—

The two motors are started in series and with an external resistance, which is gradually turned out of circuit. One of the motors

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*Table of Horizontal Efforts and Traction Coefficients.*

| Output at Full Load. | | | | | | |
|---|---|---|---|---|---|---|
| Turns per coil on armature..... | 3 | 4 | 2 | 3 | 4 | 2 |
| Horizontal effort for equipment in lb. | 1,600 | 1,600 | 2,400 | 2,400 | 2,400 | 4,000 |
| Speed in miles per hour .. ..... | 10·5 | 10·5 | 17·5 | 12·0 | 9·5 | 10·5 |
| Total horse-power of equipment..... | 60 | 50 | 110 | 80 | 60 | 110 |

| Output Required to Drive Loaded Train on a Level. | | | | | | |
|---|---|---|---|---|---|---|
| Horizontal effort for equipment in lb. | 220* | 220* | 450† | 450† | 450† | 600 |
| Speed in miles per hour ..... | 26 | 23 | 28 | 20 | 18 | 18 |
| Total horse-power of equipment..... | 16 | 14 | 34 | 24 | 22 | 29 |

is shunted with a varying resistance until short-circuited. It is then open circuited, with respect to the other motor, and, by means of varying resistances, the motor is finally brought into parallel with the second motor.

The most salient features of the developed controller are as follows:—Magnetic blow-out, placed wherever the circuit is to be broken, and which practically eliminates the burning of the contacts and greatly increases their durability; copper contacts used instead of brass contacts, it having been found that brass is less durable. Separate cut-out switches are used, so that either motor may be cut out of circuit at the will of the operator. An interlocking reversing switch is used so that motors can only be reversed when the current is turned. Safety braking switches are placed on the reversing switch, so that, in case of emergency, the power may be turned off and the motors short-circuited, so that they act as generators, in which case the car is speedily brought to a standstill. This method of braking is what is known as the emergency method, since it is not suitable for general use on account of the great strain put upon the motors.

A method that is coming into use in the United States is that of connecting the motors, with their fields reversed, through the coils of a magnetic brake. This is effected from the main handle of the switch and the braking power regulated according to the position of the controlling cylinder.

Many of the features above mentioned in connection with the standard type of controller are incorporated in the controllers for the larger motors, but, owing to the greater contact surface, and the greater amount of friction, special means have to be provided for turning the cylinder. In some controllers for four motors two separate switches are used, the two being operated by a single shaft by means of gears.

Referring next to the progress made in electrical locomotives, I will call your attention to a locomotive recently constructed by the General Electric Company of America for the Baltimore tunnel of the Baltimore and Ohio Railway. The particulars of this locomotive are as follows:—Number of trucks, 2; number of motors, 4; weight of driving wheels, 192,000lb.; number of driving wheels, 8; drawbar pull, 42,000lb.; starting drawbar pull, 60,000lb.; gauge, 4ft. 8½in., and diameter of driving wheels, 62in.; length over all, 35ft.; height to top of cab, 14ft. 3in.; wheel base of each trunk. 6ft. 10in.; extreme width, 9ft. 6½in.; diameter of sleeve bearings, 13in. On this locomotive the particular form of overhead construction is worthy of notice. It consists of a shoe in an inverted channel. It was first intended to use the ordinary trolley, but it was found that the current density was too high for this work. The motor of this locomotive has a rated output of some 300 H.P., and may be reversed at full load without any sparking at the brushes. The armature is, in this case, series wound. The fields are of six poles, three of them being long and carrying the larger magnet coils (this being made necessary on account of the space in which the motor has to be put), and three of the poles being shorter. These poles are wound with a number of turns consistent with the armature reaction. The thought will probably come to some as to whether or not it is necessary to put coils on these poles. I will state that it is, and that the construction shown is the best, since specific experiment has shown that the distribution of the field is better, and, likewise, the tendency to spark is greatly lessened, when all the poles of such a motor are excited. The armature is constructed on a hollow sleeve, the internal diameter of which is some 2in. greater than the diameter of the axle. Motion is transmitted from the armature to the axle by means of a spider carried on a hollow sleeve, the extremity of the arms of this spider engaged with cushioned lugs carried the locomotive wheels. This construction removes the dead weight of the motor from the axles and transmits it through the springs of the trucks. This is a great advantage, mechanically, in preventing hammering on the rails, and also a great protection to the windings of the motor from shock. A locomotive thus driven is remarkable for its smoothness and quietness in running.

* 20lb. per ton for 11 ton train.

† 15lb. per ton for 30 ton train. 10lb. per ton for 120 ton train. The output required by train on a level will vary within wide limits, with cars of varying weights and track in varying conditions.

Both the electrical and mechanical problems involved in the construction of such locomotives are most difficult, but the experience has been ample to show that they have been fairly met and that a successful and, in all ways, satisfactory electric locomotive has been produced. The magnetic densities in the air gap of such a machine and in the projections have to be extremely high, being from 80,000 to 90,000 C.G.S. lines per square inch in the air-gap, and from 150,000 to 180,000 C.G.S. lines per square inch in the projections, not allowing for the leakage between them, which is of course considerable.

Turning next to the appliances in the station, I would say that these also have been subjected to great improvement. Perhaps the most noticeable improvement is that of the substitution of direct connected generators for the belt-driven machinery at first used, and I may here state that I do not consider large belt-driven dynamos suitable for electric traction work. The average work is greatly below the maximum work, if the driving belt is given sufficient tension to avoid slipping at the maximum load, the loss in the bearings is excessive for the average load. This objection, however, is entirely secondary to the mechanical objections of a belt connecting an engine with a dynamo subject to rapidly fluctuating loads. The largest belt-driven dynamo that has been constructed in the United States is of 500 kilowatts output. The use of this machine is, however, becoming exceptional. The trouble experienced with the bearings, together with the considerable floor space and the greater cost of the machine as a whole, with no compensating feature in its operation, has led to the substitution of direct connected machines. From 150 kilowatts capacity and larger, the belt-driven dynamos should not be used. In the extreme case, dynamos of not more than 200 kilowatts capacity should not be driven by belts or ropes.

At the Exposition in Chicago was exhibited a machine of 2,000 E.H.P. output, designed by me. The specification for this machine was that it should not heat more in any part than 30° C, should be subjected to variations of load, equal to its rated capacity, without sparking, and should carry 50 per cent. overload without dangerous heating or sparking. Owing to the short time at the disposal of the makers, the dynamo was first assembled and tested in Chicago, and was found to perfectly comply, in all respects, with the specification. The diameter of the armature is 10½in., diameter of commutator 7ft., number of segments 696, length of commutator 18in., field magnets 12 poles, magnet frame constructed of steel, the use of steel being found most economical. The construction of the commutator is worthy of special attention, the segments being held so as to equally expand along their length, and in such a manner that different parts of the commutator may be taken out without disturbing the remaining parts. Eleven of these machines have now been constructed from the original designs, and are working satisfactorily in the United States. Numerous smaller machines have also been constructed. In the commutator of the 1,500-kilowatt machine there are 7,000lb. of copper. The weight of the armature is 86,000lb., and the weight of the machine complete is 180,000lb. The design of these machines to a given specification required very considerable study, both as to the density of the air-gap, the armature reaction and the number of commutator segments; this problem has been accurately solved.

The transmission of power to a distance by means of multiphase currents and the distribution by means of motor-generators, and by so-called rotary converters (which is a machine running as a synchronous motor but with closed circuit armature windings, the conductors being arranged so that commutation is effected) is now receiving considerable attention. The source of power at Portland, U.S.A., is from turbines. The shaft is vertical and the weight of the armature is carried by a hydraulic bearing. The current is generated at a pressure of 6,000 volts and at a frequency of 33. This frequency is as high as the use of large rotary converters used in the sub-stations will permit. On account of the problems connected with the commutation of the currents the maximum size of a rotary converter is limited to the periodicity, *i.e.*, for comparatively high periodicities only rotary converters of small output can be constructed.

In a sub-station are operated two 500-kilowatt rotary converters, the current being transformed down to suit the E.M.F. in the rotary converter. The ratio of the three-phase voltage to the continuous voltage of the machine is fixed by the extent of pole arc of the field magnets. The ratio is generally about 0·612. It may, however, be varied by varying the percentage of the pole arc of the field magnets. Experience with such machines shows that best results are secured when the currents are delivered in phase with the E.M.F. Either a lagging or leading current with respect to the E.M.F. of the rotary converter occasions more or less sparking. The distribution of the current among the armature conductors is a fit subject for a mathematical investigation, since the armature receives energy in the form of alternating currents, and delivers energy in the form of continuous currents. An examination as to the current distribution in a commutating machine with that of the current distribution in a synchronous motor, under many conditions, shows that the average



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effective current strength in the armature conductors is less than would be inferred from a separate examination of each. Thus, under some conditions of running it is found that the cross section of the conductors in such machines may be less than those of an ordinary commutating machine or of an ordinary synchronous motor. An investigation of the properties of this machine was recently carried out at Niagara Falls by me and other engineers of the General Electric Company of America. It was found, however, that owing to the condition of supply and the nature of the currents, that is, quarter phase currents, the feature was but of little importance in practice.

Recently I have designed the multiphase system for the distribution of power to electric tramways in Dublin. The object of the use of the three-phase in this particular case is to comply with the Board of Trade requirements as to the drop of voltage in the earth return. In this case I have preferred to use synchronous motors driving commutating machines, the particular advantage in this being that the phase of the current, in respect of the E.M.F., may be regulated by the excitation of the synchronous motor. In the case of the rotary converter this may not be done without varying the pressure in the consumer's circuit. There is also, in my opinion, some advantage in the use of a synchronous motor over an ordinary static transformer, the one being more easily repaired, and less liable to give way under the overloads that are frequent in tramway systems. It is not necessary to mention that the three-phase system is only used as a convenient means of transmitting power at a high tension. The three-phase synchronous motors have the advantage of being self-starting, and there is also another advantage in that the amount of copper required is about three-quarters of that required in a simple alternating-current system of transmission.

Recently, both in the United States and in England, the subject of underground systems, such as conduits or systems in which the line is divided into sections, current being switched on in succession, or by the passage of the car over the sections, has received a good deal of attention. A conduit has been successfully used in New York. The plough consists of a central web of insulating material carrying two contact pieces forced out against the conductors by springs. It has been a difficult problem to make this plough so that it is sufficiently durable. This plough seems to fairly meet the requirements. The cost of such a plough does not exceed £3. The maintenance in New York does not exceed 0·0005d. per car mile. Such a plough lasts six months, making 100 miles per day. The maximum speed is 17 miles an hour. The average high speed is about 12 miles an hour. The cost of this conduit is £17,000 per mile of single track. It has been stated that a conduit could be constructed that would be equally as good for less, but, in making this statement, the severe climatic conditions in New York had not been properly considered, and it is also to be borne in mind that former experience with conduits has indicated that, for anything like satisfactory results to be expected, the structure must be so laid that perfect alignment is maintained. Some similar conduits, but of less rigid mechanical structure, have been used in other American cities, but in no case is there encountered such severe climatic conditions as are to be met with in New York. The depreciation and maintenance of this particular conduit is less than any overhead system with which I am acquainted. The fact, however, remains that it is laid in a broad street, where there is perfect drainage and but little vehicular traffic across the rails, and that it is laid in a new part of the city, where troubles in laying from water pipes and gas pipes are largely avoided.

The sectional rail, and other systems in which there are switches at frequent points along the line so that a portion of it, less than the length of the car, is in circuit, are in an experimental stage. While I have seen some very successful models of such systems, the difference between a successful model and a perfectly working tramway appliance is so great that I shall not now discuss such underground systems.

I would call your attention to one of the details of the switchboard that has received great attention, and which has now attained to a very high degree of perfection, that is, the automatic circuit-breaker. I have seen a circuit-breaker open 6,000 amperes at 500 volts repeatedly, without burning the contacts, or making a serious flash. The circuit-breaker is reliable in its action, that is, it can be set to open for any desired current with accuracy. It has been frequently observed by tramway engineers of experience that there is a great difference in the quality of short circuits, that is, when these circuit-breakers are set for a given current the flashing is greater under some conditions than under others. This has sometimes been attributed to self-induction. The writer, however, does not hold this opinion; but a study of the switch will show that to maintain the necessary contact the weight of the moving part is appreciable, and it has, therefore, an appreciable time of movement. A short circuit may occur near the station, so that the current that would flow in the circuit, were it not interrupted, would be much greater than from a short circuit taking place in some other part of the system. This, together with the fact that the circuit breaker requires a certain appreciable time for operation would explain the different results observed.

In conclusion I would say that another of the minor improvements that has been carried out with this respect to the bonding of the rails. It has frequently been found that with the resistance between metallic surfaces brought together under pressure is greatly in excess per unit of area of that of the conductor. The improvements in jointing or bonding the rails together is to greatly increase the area of the pressure contacts so that the current density does not now exceed the capacity of the contacts. The writer's experience indicates that, with a permanent system of earth contacts, the current density should not exceed 50 amperes per square inch. In large systems, where the return circuits amount to several thousand amperes, the rails themselves are frequently welded together electrically. Such systems have been satisfactory in action, and mechanical difficulties that were anticipated in a solidly welded system of tracks, have rarely been experienced.

## THE ROYAL COMMISSION ON ELECTRICAL COMMUNICATION WITH LIGHTHOUSES AND LIGHT-VESSELS.

### FOURTH REPORT.

The following is an abstract of the Fourth Report of the Royal Commission appointed to inquire and report as to what lighthouses and light-vessels it is desirable to connect with the telegraphic system of the United Kingdom by electrical communication, for the purpose of giving information of vessels in distress, or casualties at sea, to places from which assistance could be sent, and of transmitting storm warnings.

In the last report, issued in April, 1895, the hope was expressed that, after visiting Denmark and inspecting the system of electrical communication with lighthouses and life-saving stations in that country, the Commission would be in a position to prepare the way for their final report. In consequence, however, of the serious difficulties which continue to be experienced in maintaining electrical communication with certain light-vessels on the system now employed, it has been decided to postpone the final report until attempts have been made by further experiments to overcome these difficulties.

*Connections which have been Effected.*

There are at present five light-vessels, six island, pile, or rock lighthouses, and 40 shore lighthouses around the coasts of the United Kingdom, which have been placed in electrical communication with the general telegraph system of the country at the national charge.

*The Danish System.*

In August last the Royal Commission visited Denmark and inspected the system of electrical communication with lighthouses and life-saving stations in that country. The system of electrical communication with lighthouses in Denmark is described at some length. Briefly, the system is practically an extension of the general telegraph system of the country. The use which is made of the wires for private and business purposes far exceeds the use to which the connections are put for the purpose of affording assistance to vessels in distress. Much of the important work which is done in the United Kingdom by the Coastguard, the Post Office, and various other agencies is carried on in Denmark by the lighthouse authorities. At Hanstholm, Hirshals, Skagen, and Hammeren lighthouses in Denmark, to which signal stations are attached, messages of any nature, made by means of the International Code of Signals, are received from passing ships, and are forwarded by wire to their destinations, and telegrams can also be sent to the lighthouses to be signalled to passing vessels. The masters of passing vessels make considerable use of the facilities which are offered to them for communicating with their owners and others. Any vessel making her number to one of the four lighthouses just named is reported by telegraph to the exchanges at Copenhagen and Aarhus free of charge, and the wires to the connected lighthouses are also used for sending reports of the state of the weather and the ice to various quarters. The multiplicity of duties which the staff at some of the principal Danish lighthouses have to perform does not appear to affect the efficiency or popularity of the lighthouse service, in which appointments are eagerly sought after. One male and one female assistant, the latter often a member of the family of the head keeper, seem, with help when necessary from the rest of the staff, to be equal to the work of attending to the signal station and telegraphing all the various messages which have to be despatched, as well as of receiving those which are forwarded to the lighthouse. The Government give to the head keepers at those lighthouses at which there are signal stations and telegraph offices special allowances, out of which they have to provide for the proper performance of the duties of those branches of their work. The arrangement gives the head keeper a more direct personal interest in the work of signalling and telegraphing than he would have if special assistants were appointed and paid by the Government for the purpose: it prevents the incurrence of the additional pension charges which would be thrown upon the State if the work was done by assistants belonging to the lighthouse service, and it has worked well and satisfactorily for all parties concerned. The Royal Commission was unable to ascertain what has been the cost to the State of establishing electrical communication with lighthouses in Denmark, or what the annual expenses and receipts are, but the latter, they understand, are not sufficient to counterbalance the expenses. This is no doubt due in part to the fact that the Danish

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Government allow the wires to be used free of charge for such purposes as reporting passing vessels to the exchanges, and sending notice to different quarters regarding the presence of shoals of fish. Messages sent by private individuals have, of course, to be paid for, but the Danish Government seem to regard the electrical communication on the coasts of the kingdom as having been established in the interests of the maritime community, and make no charge for the use of the wires when the messages sent are for the general advantage of that community or any section of it.

*Working of the Electric Cables to the Light-Vessels and Outlying Lighthouses which have been connected.*

As the record of failures of the cables during the twelve months ended December 31, 1895, is one of considerable technical interest we print it in full.

"Kentish Knock" light-vessel.—(1) On May 18, 1895, the veering (electric) cable, which had been laid on November 21, 1894, was found to be broken on the ground. As the light-vessel then on the station was about to be replaced by another vessel, the repairs were not effected until June 11th, when the new vessel was moored in position. (2) On July 12, 1895, communication was interrupted, the veering (electric) cable having been broken by the lightship riding to it. Communication was restored on July 16th. (3) On December 7, 1895, the veering (electric) cable parted, the sheathing having become damaged some time previously. The necessary repairs were effected on December 9th, and no further interruption in communication occurred during the year.

"Goodwin" (North Sand Head) light-vessel.—(1) On January 30, 1895, the veering (electric) cable, which had been laid on September 15, 1894, was reported to be broken, the cause of the rupture being the general decay of the sheathing below the patent swivel. Owing to the cable ship being engaged elsewhere repairs could not be effected until April 10th. (2) The cable laid on April 10th lasted until October 24, 1895, when it broke, owing probably to the parting of one of the arms of the chain cable by which the light-vessel was moored. Bad weather delayed the repair of the vessel's moorings, and electrical communication could not be restored until November 22nd. No further interruption occurred during the year.

"Hasborough" light-vessel.—(1) On May 18, 1895, the first cable to the lightship, which had been laid on October 2, 1894, parted below the patent swivel, owing probably to its having been nipped by one of the lower shackles of the swivel. Communication was restored on June 5th. (2) On November 19, 1895, the veering (electric) cable broke. Owing to bad weather, communication was not re-established until December 1st. (3) Communication was again interrupted on December 8th, and was restored four days later. No further interruption occurred during the year.

"Shipwash" light-vessel.—The first cable to the lightship, which was laid on November 17, 1894, lasted without repair until August 20, 1895, a period of 276 days, when it parted. As the cable ship was engaged on other work, the necessary repairs were not effected until a month later. No further interruption in communication occurred during the year, but as the result of a heavy gale, the outer sheathing of the veering (electric) cable was damaged, and some repairs were effected on December 2nd.

"Formby" light-vessel.—Electrical communication with this lightship in Liverpool Bay was established on October 20, 1895. The cable, which is about four miles in length, places the light-vessel in telephonic communication with Crosby lighthouse, which is in electrical communication with Liverpool and the neighbouring lifeboat stations. This vessel has been supplied with a new form of veering (electric) cable of a more flexible nature, and protected with rings of lignum vitæ, in order to save it from being chafed by the mooring chains, and by the light-vessel herself. No interruption in communication had occurred up to December 31, 1895.

"Gunfleet" pile lighthouse.—No interruption in electrical communication had occurred since the cable was laid in October, 1893.

"Tuskar" lighthouse.—Telephonic communication with this lighthouse had not been interrupted since it was established on September 10, 1894, although the cable was slightly injured in October last.

"Fastnet" lighthouse.—In our first report we recommended the establishment of electrical communication with this lighthouse, which is situated about seven miles off the south-west corner of Ireland. The precipitous rock on which the lighthouse is built is exposed to the full force of the Atlantic seas, and is unapproachable except in calm weather. In 1885 electrical communication by a continuous cable was established with the lighthouse at the instance of the Committee of Lloyds, who had received permission to use it as a signal station, but the difficulty and expense of maintaining the connection were so great that it was abandoned at the end of 18 months, after several lengthy interruptions in communication had occurred. Having regard to the difficulty of maintaining electrical communication with the Fastnet by means of a continuous cable, it was recommended that a non-continuous system should be tried, and effect was given to the recommendation on July 18, 1895.

The system employed in this case deserves some explanation, as it has been found to provide a satisfactory means of electrical communication under very unfavourable circumstances. A submarine cable of the ordinary type, 7·0283 knots in length, is laid from a small bay, called Galley Cove, towards the lighthouse; the sea end is spliced to 17 fathoms of heavy copper wire, insulated with india-rubber and protected by lignum vitæ rings, and this wire terminates in a copper mushroom anchor weighing 4½cwt., which is submerged in 11 fathoms (low water) at a distance of about 60ft. from the Fastnet. The shore end is connected by a subterranean cable with the Post Office at Crookhaven from which is laid another cable 200yds. long, terminating in a copper centipede anchor, sunk in about two fathoms of water in the haven on the further or north-east side of the promontory on which the post office stands. At the Fastnet two short copper conductors, connected with the instrument in the lighthouse, are bolted on to the sides of the rock, one on the north, or land side, and one on the south side, each terminating under water in a copper centipede anchor. This is the present arrangement, but one of the conductors having been broken by the action of the sea, it is proposed to protect the exposed parts of both conductors by passing them through holes which will be drilled in the rock for the purpose. The mushroom anchor near the rock, and the centipede anchor in the haven, form the earth-plates of the line—the post office at Crookhaven, with its batteries and instrument, being intermediate. The circuit is completed by the sea, but part of the current passing through the circuit is picked up by the nearest copper conductor on the rock, and actuates the telegraph instrument placed in the lighthouse. It then passes through the other copper conductor into the sea. In the reverse direction part of the current sent from the lighthouse is picked up by the mushroom anchor, and passing along the main cable, actuates the telegraph instrument in the post office at Crookhaven. The instruments used, both at the lighthouse and at the post office, are a double-current speaking key and a dead beat d'Arsonval reflecting galvanometer, and the signals are those of the Morse Code. Except for a short period, when one of the conductors on the rock was broken, telegraphic communication has been maintained throughout the winter; but it has not been possible to apply the ordinary arrangement for calling attention by means of a bell, and it has, therefore, been necessary for the operators to go to the instruments at stated intervals to ascertain whether there was anything to communicate. Now that the winter has passed, and it has again become possible to work on the rock, no time will be lost in fitting a call-bell, which will be worked by a specially-devised relay.

"Caldy Island" lighthouse.—This lighthouse, in Carmarthen Bay, was electrically connected on July 29, 1895, and no interruption in communication occurred during the year.

"Maplin" pile lighthouse.—Electrical communication was effected with this lighthouse, off the north entrance to the Thames, on September 5, 1895, and no interruption had occurred up to the close of the year.

*Concluding Remarks.*

It will be seen that, as far as the lighthouses are concerned, the cables which have been laid have worked satisfactorily. The first outlying lighthouse which was connected with the mainland was the Gunfleet pile lighthouse, which was placed in electrical communication with Walton-on-the-Naze on October 2, 1893. Since that date four more outlying lighthouses (excluding that on Lundy Island) have been connected, and, although some of these stations are in very exposed positions, communication has not been interrupted with any one of them except the Fastnet.

As regards the cables to the light-vessels the returns are not so satisfactory as was anticipated, but there is reason to believe that many, if not all, of the interruptions have been due to remediable causes, and endeavours are being directed to removing those causes and also to experimenting upon a system of communication by induction as suggested in the last report. Under this system the cable running from the shore is laid in a circle on the bottom of the sea immediately under the light-vessel, the circle having such an area that the vessel will always be within the circumference of it. Round the deck of the light-vessel a number of turns of insulated wire are coiled, which are in connection with a telephonic receiver on board the ship. An intermittent vibratory current is sent through the cable, and is made and interrupted by a Morse key. The vibrations act by induction on the coils of wire on the light-vessel and produce buzzing sounds in the telephone, which, being intermitted by the Morse key, are read as in the ordinary Morse code. By means of a special arrangement a call-bell can be rung. In the same way messages can be sent from the light-vessel to the shore. This system has not yet been subjected to a practical test at a lightship; but the Commission regard it as offering greater chances of success than any of the other inventions of the same nature which they have had before them, and meanwhile defer recommending the establishment of electrical communication with any further light stations, awaiting the result of the experiments which are about to be made.

The Report is signed:—

Mount Edgcumbe (Chairman), Dunleath, Edward Birkbeck, F. L. McClintock, G. S. Nares, J. C. Lamb, W. H. Preece, John A. Kempe, R. Munro-Ferguson.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, June 5th.**

Royal Institution.

*9 p.m.* Evening Discourse: "Electric and Magnetic Research at Low Temperatures," by Prof. J. A. Fleming.

**WEDNESDAY, June 10th.**

Municipal Electrical Association.

*10.15 a.m.* First Annual Convention at the Royal United Service Institution. Presidential Address by Mr. Arthur Wright: "The Municipal Electrical Association and its Objects." Four Papers to be read and discussed.

*4 p.m.* Visit of Inspection to the London Electric Supply Corporation's Works at Deptford.

Institution of Electrical Engineers.

*7.30 p.m.* Students' Visit to the Bankside Central Station of the City of London Electric Lighting Company.

Royal Society.

*9 p.m.* Annual Conversazione at Burlington House.

**THURSDAY, June 11th.**

Municipal Electrical Association.

*10.15 a.m.* First Annual Convention at the Royal United Service Institution. Four Papers to be read and discussed.

*5 p.m.* Visit of Inspection to the Islington Electricity Works, Elen Grove.



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## STEEL-PLATE PORTRAITS

*Of Willoughby Smith (out of print); W. H. Preece, C.B., F.R.S. (President of the Institution of Electrical Engineers); Michael Faraday (1s. extra); Sir John Pender, G.C.M.G., M.P.; Sir William Thomson, F.R.S. (Lord Kelvin); C. H. B. Patey, C.B.; Dr. Oliver J. Lodge, F.R.S.; Prof. William Crookes, F.R.S.; Prof. von Helmholtz: Prof. W. E. Ayrton; Lord Rayleigh, F.R.S.; Cyrus W. Field: Werner von Siemens; Sir James Anderson; Joseph Wilson Swan; Mr. Alexander Siemens; Dr. Heinrich Hertz; Mr. R. E. B. Crompton; William Sturgeon; and Dr. John Hopkinson, F.R.S., have been issued as Supplements to* "THE ELECTRICIAN."

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## LOW-FALL WATER POWER.

It is high time that engineers and persons interested in engineering enterprise should cease to talk of water power as a specially free gift of Nature, and to enlarge on the theme of the many millions of horse-power running to waste that might be utilised at no expense. That the subject lends itself to poetical treatment is undeniable, and undeniable also is the ease with which such poetic utterances may be used to decoy capital into unprofitable paths. There is a sense, of course, in which it is true that water power is freely bestowed upon this earth by Nature, but it is the sense only in which it is also true that every good thing is the gift of a providential arrangement of the universe. The water power which we use, or which, if we chose, we might use, for driving machinery is not more freely bestowed than the coal which we dig, or which, if we chose, we might dig, from the bowels of the earth; or than the oil which we pump, if we wish, from oil wells; or than the natural gas, which we can pipe line from vent holes to our furnaces and gas engines. Every good gift and every perfect gift of Nature is providentially so bestowed that it cannot be used without the expenditure of both capital and labour.

Our attention has been directed to the utilisation of water power, and especially of low-fall water power, in this country, by a Paper which has recently been read by Mr. ALPH. STEIGER before the Institution of Electrical Engineers. Quite rightly the author of that Paper states that low falls are more frequently met with in this country than high falls; indeed, speaking of England alone, and not of the whole of Great Britain, we have no really high falls, and scarcely any of even moderate height. England is the land of gentle, unbroken streams rather than of waterfalls and cataracts. It is important to notice this in any estimate of the value of the water

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power of the country from an electrical engineering point of view. For the cost of developing and working a water mill varies enormously with the available fall, being much greater with low than with high falls. In the very first sentence in his Paper Mr. STEIGER strikes the true keynote—the cheap production of electrical energy. But, having struck the right keynote, he proceeds to play the whole tune in a wrong key. In no single instance, among the many examples he has cited, does he even touch upon the question of cost, either as to the initial cost of the works necessary to develop the mill site or as to the annual expenditure involved in up-keep and attendance. To make matters still worse, he chooses examples which mostly are as free from the conditions of low-fall water power utilisation as it would be possible to find. We are treated to purely descriptive accounts, and interesting but far from convincing pictures, of such works as those at the Falls of Foyers, where the fall is 350ft., and of several installations on the Continent, with falls of 170ft. and under. At most of these places the machinery has been erected by Messrs. ESCHER, WYSS and Co., for whom the author of the Paper is, we believe, the British agent. The only characteristically English water-power plant described is that at Brantham Mills, where the falls varied from 4ft. 10in. down to zero. Here again, however, we find nothing but the most meagre information as to the results which have been obtained. We can admire the ingenuity with which the turbines have been designed to give a nearly constant speed on a widely-varying fall, and we concur in the author's opinion that such a result can only be obtained when there has been careful adaptation in the design and construction of the turbine and outworks to the local conditions, all of which, be it noted, costs money. But we look in vain for any data upon which we might base an estimate of what it would be likely to have cost, if, instead of erecting a flour mill at Brantham Mills, an electric supply station had been erected. The question as to whether or no any given low-fall mill site should be utilised for the production of electrical energy is not: Can the resources of engineering design and skill be made to combat the vagaries of a given mill site to such an extent that reasonably large and fairly constant power can be obtained? Nowadays the ingenuity of engineers can accomplish anything. But the question which ought to be asked, before deciding to commence operations, is: When everything that can be done here has been done to make this a successful mill, what will it all have cost, what will it cost to keep going, and would it have cost more or less if instead of developing this mill site we had gone to the most convenient spot and erected a steam station? It is this latter question which Mr. STEIGER's Paper in no way assists engineers to face. Yet, until we have faced it, how can we ever hope "to show how water power under low falls can be, and is, very advantageously and economically utilised for the generation of electrical energy"?

Occasionally one finds the argument advanced—and Mr. STEIGER's Paper is not free from it—that because electric supply stations worked on moderate and low falls have proved to be successful in Switzerland and in other countries, therefore success may be expected with them in this country. The argument neglects several important differences between the conditions of the countries compared. In the majority of English localities coal is very cheap, and nowhere in this country is it so dear as in Switzerland or in India. Here, too, other sources of power, such as coal-gas, producer-gas and petroleum are much more readily and cheaply utilised than they could be in many foreign countries where water-power plants are to be found. Here, also, land and labour are dearer, and as a result it costs more to construct the works necessary for the continuous usage of a mill-site where the flow is intermittent. Nor should we forget that in a level country like England one of the greatest inconveniences arises from an excess of flow, which "tails-up" the tail race—*i.e.*, floods it to such an extent that there is practically, sometimes absolutely, no fall; while, however large or small the flow may be in the comparatively few low-fall mill sites in Switzerland, the water will always be able to get away clear of the tail race without ponding back. And the marked liability of a water-power station to become crippled, together with the Englishman's dislike to fall back on tallow candles when the electric light fails, render it necessary in this country that all such stations should be provided with auxiliary plant, driven by steam or some other reliable source of power. This increases the prime cost by a considerable amount; and, moreover, even if the stand-by plant is never used—an ideal case, alas, purely supposititious—it is necessary to spend something every year to keep it in order.

These considerations are no doubt trite and obvious, and some will wonder why we have been at so much pains to show that there is small prospect of success in the utilisation of low-fall mill sites in this country. No one, we may be told, expects to see a crop of water-power stations spring up in England. But it must not be forgotten that capital has already been spent on this sort of enterprise, a notable instance of which is furnished by the Worcester-Powick water-power station. The experience of the owners of that station might not indeed have been more fortunate had the water-power side of the system never been adopted, and any attempt to blame the water power exposes the critic to the retort that things would have been better had it not been for the day load at the pumping station. Be that as it may, we venture to think that the Worcester authorities are not now quite so proud of their steam-and-water-power station as they were at the start; and it would not surprise us to see the whole of the water-power department abandoned and the station run entirely by steam. In fact, entailing as it does the transmission of power and the freight of coal by road each over a distance of three miles, the present situation of the generating station is inconvenient both for obtaining fuel and as a centre of supply; and in the event of such a transformation, it would probably suit Worcester better to have its generating station nearer the town. In any case the experience of Worcester furnishes an object lesson, which it would be well for anyone in this country who contemplates a similar utilisation of low-fall water power to learn by heart.

## REVIEWS.

**An Elementary Treatise on the Calculus, for Engineering Students.** By JOHN GRAHAM, B.A., B.E. (London: E. and F. N. Spon. 1896.)

An elementary knowledge of the differential and integral calculi cannot but be regarded as a most valuable adjunct to the mental training of the engineering student. It is not a necessary part of his education in the same sense that a working acquaintance with the slide-rule is, and in the exercise of his profession he may seldom have occasion—even if he have the ability—to apply it to any new problem, of which the solution cannot be found in some standard work. It remains, therefore, somewhat of a luxury reserved for those who aspire to the higher branches: and to all but a few of these, its chief use lies in the fact that it throws open so many of the best books on physical and engineering science. Yet if once acquired, the student will seldom regret the hours that he has spent upon it, and no time is so suitable for its acquisition as that which is passed at the technical college. If he does not then master the

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main principles on which the calculus is based and attain some facility in applying it to simple cases, there is but little likelihood of his doing so when once he has become immersed in the routine of the office, the workshop, or the central station.

The avowed object of the present book is to impart just such an elementary knowledge of the calculus, and it is admirably adapted for its purpose. It forms one of the Finsbury Technical Manuals, and we may trace in it the influence of Prof. Perry's lectures to the Finsbury students. The general order and arrangement of the purely mathematical portion must needs be much the same as in the standard mathematical text books; but the difficult question of how much must be inserted and how much may be omitted without making the treatment cumbrous or incomplete, has been satisfactorily decided by Mr. Graham. Many of the illustrations and examples in the first 200 pages are borrowed from engineering subjects, and serve to enliven the usually dreary pages of mathematical formulæ. The fifty pages of the remaining two chapters are devoted entirely to problems of mechanical and electrical engineering, and of these we can only complain that they are too short. Even at the expense of making the book larger, we think that the engineering examples might with advantage be multiplied, and if in especial we wish for more electrical problems, our demand must be ascribed to our natural bias in favour of electricity.

The ordinary student unconsciously absorbs a certain knowledge of the calculus through the graphic methods, which are now so commonly employed, and nothing renders the subject so clear as appropriate curves. But the great difficulty of the inquiring mind is to fully acquiesce in the differential calculus as a truly logical process. We hardly think that this difficulty is sufficiently faced and overcome. Why should one small quantity, A, be neglected when some other small quantity, B, is not neglected? Granted that quantity A is considerably smaller than quantity B, is the neglect logical? Some books tacitly convey the impression that A may be neglected "for practical purposes." But surely this is a most erroneous statement of the case, which cannot be too strongly combated. The differential calculus has no affinity to the practical art of knowing "what to leave out." The answer given in our author's first chapter is no doubt correct, but is it sufficiently radical? It must rest on the logical concept of the limit of a function, by reason of which the process is absolutely true. Hence we should have liked to have seen more about "limits," so as to compel the assent of the reader.

After this initial mental difficulty, purely mathematical processes carry the learner forwards. Maximum and minimum values of functions find suitable illustrations in Lord Kelvin's rule for the economical sections of electrical conductors and arrangements of cells in a battery, and the application of the calculus to plane curves ends the differential portion.

The processes of integration are then discussed, and followed by their chief applications to the areas of plane curves, of surfaces of revolution, and to volumes of solids of revolution, &c. Fourier's theorem is next treated, and the periodic functions of various curves are developed, the chapter ending with an example for the student which might well represent the flat-topped curve of E.M.F. of an alternator. Possibly room might have been found for a more physical discussion from the point of view of harmonic motions, which are not mentioned. Finally, the most important forms of differential equations are explained and illustrated.

The whole book thus forms a suitable introduction to such a work as Prof. Unwin's "Elements of Machine Design"; or, again, to Prof. Fleming's "Alternate Current Transformer," in which the calculus often appears, and always in so lucid a manner that the student may follow the reasoning. Inspired by success, may he then find time and energy to cope with the more recondite examples to be found in Mr. Oliver Heaviside's writings!

We trust that the second edition of Mr. Graham's book will lead to the disappearance of the table of errata which now confronts the reader as he opens on page 1; and that this second edition may quickly be reached will be the wish of everyone interested in the training of electrical engineers.

**Contrôle des Installations Électriques au Point de Vue de la Sécurité.** By A. Mommerqué. (Paris: Baudry et Cie.)

This book, which has the support of the Minister for Commerce (Posts and Telegraphs) and the Minister for Public Works and Railways, will doubtless find a large field of usefulness, although necessarily limited by obvious considerations to France. It is one of the first, if not the first, attempt to summarise the various public regulations controlling the distribution of electric power in different countries, and also to give in a compendious form the results of experience as regards the best methods of carrying out electric undertakings with due regard to economy of production and to the security of the public.

The first four chapters discuss the practical side of the subject, and give a summary of fundamental facts and methods most in vogue for producing and distributing electric power by continuous and alternate currents. The next deals effectively with the risks and difficulties besetting electric distribution, and the best manner of controlling them. Both danger to life and damage to water and gas pipes are considered very fully. The four chapters following treat of the methods of controlling power station, network, house-wiring and tramways, and contain much practical knowledge in a crisp form. In the concluding chapters the various regulations in force in France are examined in detail. These are interesting, but of course have no special application for engineers here, who find sufficient trouble of their own in our various municipal and Board of Trade regulations.

Among the codes of rules we note those of the British Board of Trade, dated up to June, 1894. This date does not bring them up to date, as it omits the important concessions made February 6, 1896, in which low pressure is defined as not exceeding 500 volts.

The book is well written, and the mathematics, which are of a practical character, are admirably clear. It should prove of much use to French engineers engaged in the supply and distribution of electric power.

**Les Applications Mécaniques de L'Energie Électrique.** By J. Laffargue. (Paris: J. Fritsch.)

This is a handy reference book, giving in a popular way a rough summary of the applications of electric power for factories, mines, aboard ship, agricultural purposes, &c., in Europe and America. There is no serious attempt to describe in detail any of the numerous plants instanced, and hence the usefulness of the book is limited. It is intended to be used in conjunction with a previous work by the same author, in which the practical and theoretical sides of the subject are discussed in detail, and in this connection it possesses undoubted value. Standing alone, the book seems to partake rather of the catalogue order, and might be fitly published by any of the large continental firms for the use of its customers. The last chapter contains a number of tables referring to the advantages of electric power in comparison with steam, compressed air, ropes, belts and hydraulic power, with costs of installations, efficiencies and annual charges. This part will be found both interesting to the consumer of power and to the constructing engineer. The author does not claim that the figures are all absolutely correct, but he considers them to be fair averages, as they are compiled from recent data.

The illustrations of all the sections are mainly from photos, and, although of no artistic merit, are valuable as being true copies of the originals.

Written primarily for use in France, the book is likely to prove interesting to anyone using or about to use electric power who has the necessary elementary knowledge of the French language.

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**The British Association.**—The Mayor of Bristol, following a suggestion of a deputation representing local scientific institutions, has decided to invite the British Association to visit Bristol in 1898. Should this arrangement become a fixture, as well as that for Dover in 1899, the British Association will be "booked" up to the end of the present century.

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# THE UTILISATION OF WATER-POWER, ESPECIALLY WITH A SMALL FALL, WITH SOME EXAMPLES OF PLANTS FOR THE GENERATION OF ELECTRICAL ENERGY.*

BY ALPH. STEIGER.

*(Concluded from page 158.)*

The description of a Jonval turbine installation which I supplied for the Brantham Mills, near Manningtree, in Essex, here illustrated, will show that a very small and varying fall can be utilised with great advantage to obtain nearly a constant power. The local conditions and requirements are most remarkable and interesting. The power is used to drive a modern flour mill, in which the maintenance of a regular speed is of equally great importance as for driving an electrical plant.

The river Stour is a tidal river, with a maximum fall at ebb tide of 4ft. 10in., while at high tide the fall is *nil*. The water is supplied partly by the river itself coming down from the hills of Cambridgeshire, and partly by the rising tide filling the river bed above the mill for a considerable length. The power required is 40 actual horse-power, and it was stipulated that this power should be maintained down to a fall of 40in. On starting the turbine, it was shown, however, that it drove the mill at full capacity and at

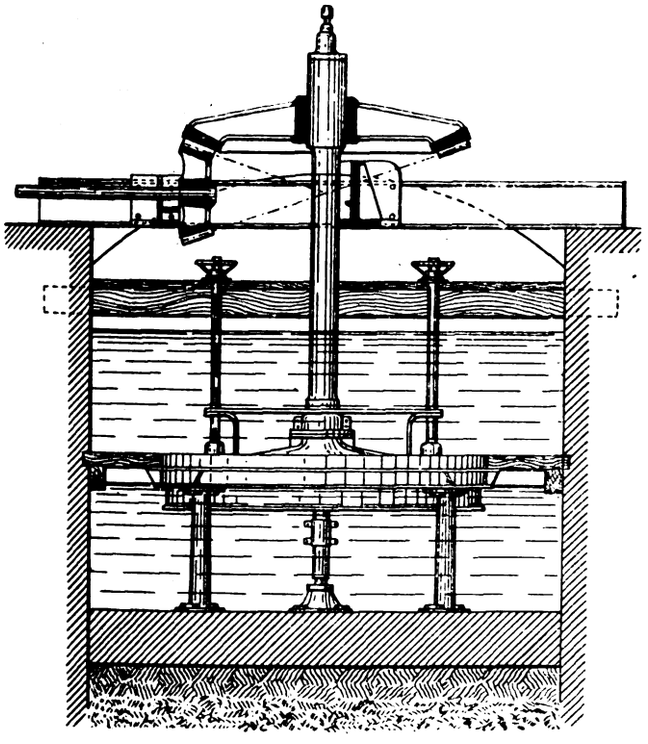

FIG. 5A.—Turbine at Brantham Mills, Essex. Cross Section.

full speed under a fall reduced to 32in. The full power is available during 16 hours of each day, while during six further hours the power corresponding to a fall reduced down to about 1ft. is still utilised for driving a part of the machinery. Comparing the useful power obtained from this varying fall by the new turbine during 24 hours with that obtained by the undershot water-wheel previously working, it is nearly six times larger.

The turbine consists of only two concentric rows of buckets; the inner one is provided with gates, which are opened or closed by hand-wheels, an automatic governor not being generally used in flour mills. The outer row of buckets is just large enough to give the full power required under the maximum fall. As the fall is decreasing by the rising tide, the gates of the inner row of buckets are gradually opened to make up the power by an increased quantity of water, and the more water is passing through the buckets of the inner row the more it acts on a reduced mean diameter, thus maintaining also the proper speed without perceptible loss of efficiency.† The power is transmitted from the turbine on to a horizontal main shaft by means of a pair of bevel wheels. This horizontal shaft is made to run at 75 revolutions, and is provided with a clutch by means of which the turbine is connected with the steam engine if the mill is required to work continuously. When the fall is reduced to more than 32in., the mill is, however, driven separately by the steam engine, and the power of the turbine is used to drive the wheat-cleaning machinery, and eventually some pairs of millstones which can work independent of the automatic roller mill plant. When the fall is reduced to 15in., the power that is still obtained from this turbine is 7 H.P., the turbine naturally running slower; but still this power is quite sufficient to be profitably utilised.

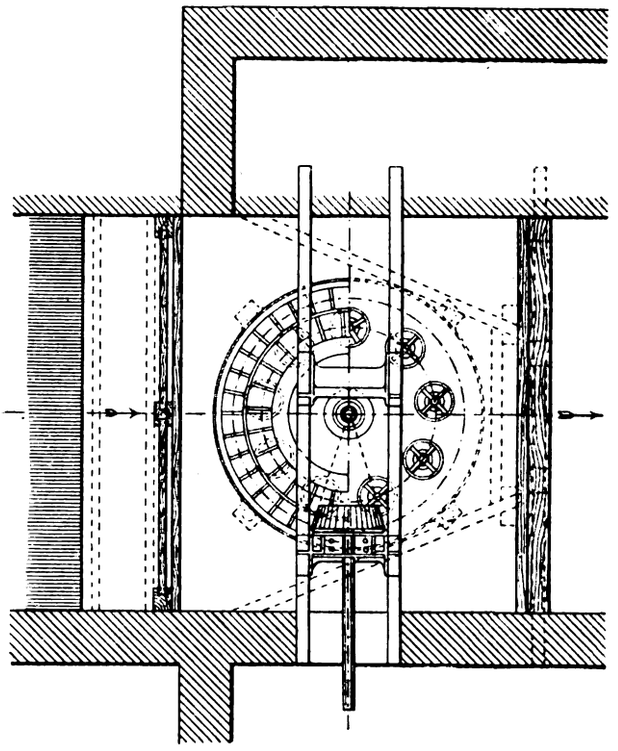

FIG. 5B.—Turbine at Brantham Mills, Essex. Ground Plan.

Assuming that the water power available at Brantham Mills were applied for the generation of electric energy, it would, in the first instance, be necessary to obtain a conveniently high speed to drive an electrical generator without much intermediate gearing. A turbine similar to the one actually working could be made for

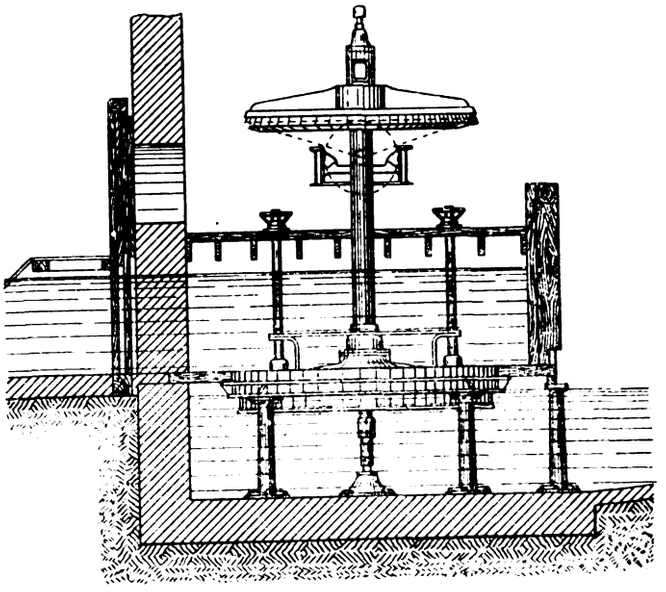

FIG. 5C.—Turbine at Brantham Mills, Essex. Longitudinal Section.

exactly these conditions, running at 30 revolutions per minute, and a pair of bevel wheels put in of such proportions as to give the first motion shaft a speed of 150 revolutions per minute This speed would be very suitable to drive a dynamo of 40 H.P. by means of a belt or ropes. A higher speed of the turbine than 30

* Paper read before the Institution of Electrical Engineers.

† The outside diameter of this turbine is about 10ft., and it runs with 24 revolutions per minute

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revolutions would, for such a low fall, only be obtainable at the expense of efficiency. As in this special case the fall, and consequently the power, varies with the rise and fall of the tide, the full power of the turbine can, of course, only be relied on during 15 or 16 hours every day. The power produced during the time when the fall is diminished beyond the limit at which it is 40 H.P., and at less than the normal speed, could probably be applied to charge electrical accumulators.

The construction of the turbine shaft deserves some notice. The space underneath the turbine being always filled with water, and, therefore, inaccessible, the pan for the footstep is placed on top of a column round which the hollow cast-iron shaft revolves. The upper part of the turbine shaft is widened, and contains an adjustable steel pin which revolves in the pan or cup, filled with oil. Although a well-constructed footstep will last for years without requiring repairs, an easy access to it is of great advantage.

Similar turbines were erected by me in other mills near Norwich, Reading, and Lewes. In all cases the fall varies between (23 inches) 2ft. 6in. and 6ft., the reduction of the fall being caused by floods, while the water supply varies in the proportion of about 1 to 4. In each case the local conditions were carefully investigated and the turbine constructed accordingly. The good results obtained in each case are due to the careful *adaptation* of the turbine to the conditions. The importance of a careful consideration of local conditions is evidenced by several failures which were recently brought under my notice. In one of these instances, the turbine—which in itself is a very good motor—gives very poor results, owing to the disregard of the actual conditions of the locality. Even the construction of some details of a turbine depends sometimes on these conditions; and in several cases now under consideration I have had to depart from the general practice of designs of turbines, in order to secure the highest results when most required.

How varied the construction of a Jonval tube may be, will be shown by the following examples. The turbines of the Geneva Waterworks, built by Messrs. Escher, Wyss and Co., of Zurich, work under a maximum fall of 12ft. during the winter season, when the water supply is shortest, while during the summer season the water supply stored up in the mountains, in the shape of snow and ice, is abundant. The large summer supply reduces the fall, however, to 5ft. 7in. The power of each turbine, of which there are now 17 at work, is 210 actual H.P., and they run at a uniform speed of 36 revolutions per minute, whether the fall is 5ft. 7in. or 12ft. The cost in this case was a secondary question; the turbines have, therefore, been provided with the best possible arrangements to suit the large variations of the fall and quantity of water. The drawing shows three concentric rows of buckets. The outer row alone will develop 210 H.P. under the maximum fall of 12ft.—its outside diameter is 14ft. Each of the two inner rows of buckets is provided with a revolving gate, working separately. Each turbine drives a pair of double-acting plunger pumps direct, the crank common to both pumps being fixed on the vertical turbine shaft.

An interesting turbine installation, under a fall varying from 10ft. 9in. to 8ft. 10in., in connection with electrical generators, is that at Baden, in Switzerland. It was described in *Engineering* of November 1, 1895. This plant was erected to supply the town of Baden with electric light, and the necessary driving power to the new works of Messrs. Brown, Boveri and Co., the well-known electrical engineering firm. The fall had to be created by a weir, and a canal about 2,500ft. long, which added considerably to the cost of the plant. Each of the three turbines is of the Jonval type, giving off 200 B.H.P. It is impossible to build a turbine of that power for the fall available in this case, which would run with a speed high enough to drive a generator direct. The turbines run at 40 revolutions per minute, which speed is maintained under the varying fall by means of gates for the inner row of buckets. The generators—two-phase dynamos of the horizontal type, made by Messrs. Brown, Boveri and Co.—run at 200 revolutions per minute, and are driven direct off the turbine shaft by means of a pair of bevel wheels. The exciter dynamos, of which there are three of 10 H.P. each, are driven each by a separate turbine. These small-power turbines naturally run at a higher speed—namely, 180 revolutions per minute—and drive, therefore, the exciter dynamos without any intermediate gearing.

In most cases in this country where a good water supply is available, the fall will be rather lower than 10ft. or 12ft.; it will therefore require intermediate gearing to drive a high-power generator, and it will even not often be possible to connect it direct with the first main shaft driven off the turbine by bevel wheels. Belt drives are very convenient to get up the necessary speed of dynamos, but for large power they are very expensive, and absorb a considerable amount of the power in friction. The ordinary round hemp and cotton rope is objectionable, on account of requiring frequent repairs and re-splicing. During an inspecting tour in Switzerland last summer, I came across a new kind of hemp rope, which seems to supply just what is wanted to drive large-power dynamos. A piece of this patent rope is here for inspection. It is a plaited rope of extreme pliability, which does not stretch. I found this rope working at the generating station of Schaffhausen. The power at the generating station is transmitted from the countershafts, driven off two turbines of 300 H.P. each by means of bevel wheels, on to the generators by means of 10 such ropes, $1\frac{3}{4}$in. thick. The rope pulleys on the dynamos have a diameter of 5ft., running 300 revolutions per minute. The rope pulleys on the countershaft have a diameter of 13ft. 6in., and the distance between the centres of shafts is 51ft. The power is electrically transmitted to a spinning mill about half a mile distant from the generating station. The secondary station consists of an electromotor of 200 H.P., coupled directly to a main line shaft,

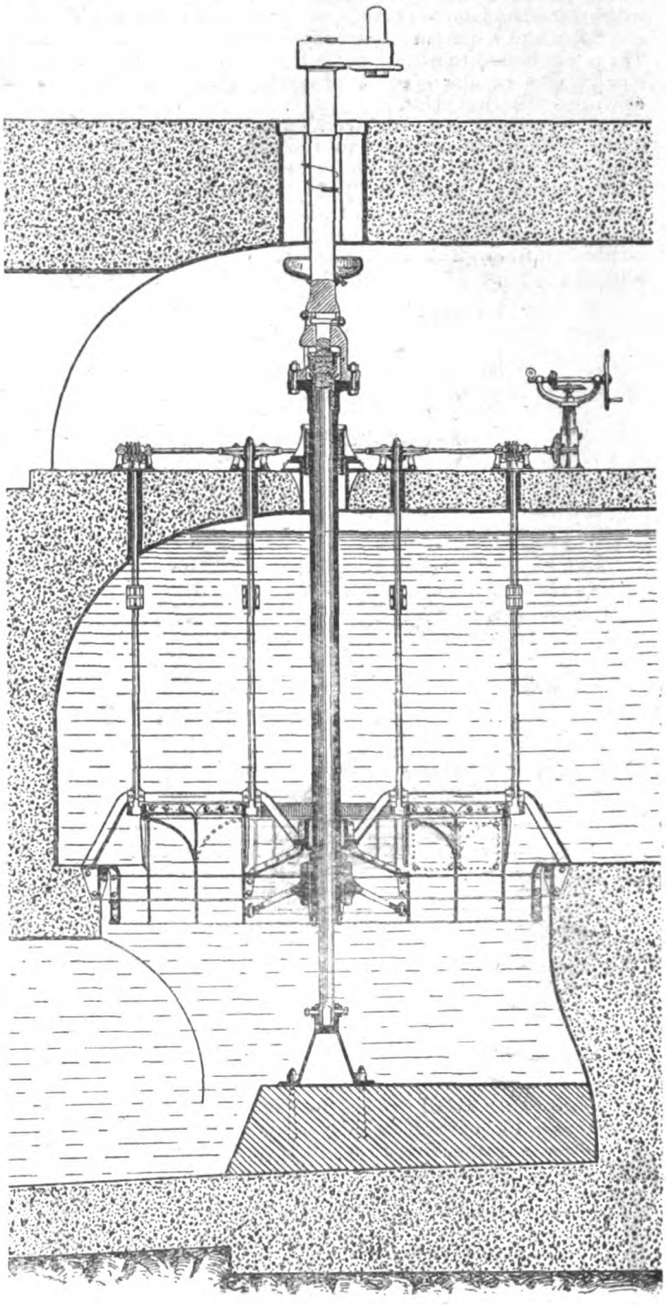

FIG. 6.—Turbines of the Waterworks, Geneva.

and two electromotors of 190 H.P. each, coupled together. The latter, running at 300 revolutions per minute, carry a rope pulley of 5ft. diameter with 14 grooves. 100 H.P. are transmitted by four such ropes to a shaft 21ft. above the electro-motor, at an angle of 51deg., while the remaining 250 H.P. are transmitted to another shaft on about the same level and 17ft. 8in. distant, running with 130 revolutions per minute. In spite of the unfavourable relative position of the shafts these ropes work with extreme regularity and easiness, and their adaptation has, according to the manager of the spinning mill, put an end to the trouble and frequent stoppages caused by the breaking of the round ropes which were previously used.

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Returning to the description of water-power plants proper, two more examples in connection with the generation of electricity deserve to be mentioned, showing how certain objects can be attained by a special construction. One of these is the installation of five new turbines for the aluminium works at Neuhausen, on the Rhine fall, in Switzerland. One of these turbines is here illustrated. Each of these turbines gives off 610 B.H.P. under a fall of 66ft., with a quantity of water of 6,500 cubic ft. per minute. With the high fall a high speed suitable for driving the dynamo direct is naturally obtained—an arrangement which has also been adopted in this case to economise space. On the other hand, the load on the footstep of a turbine of the power mentioned by the pressure of the water, in addition to the weight of the armature of a generator of corresponding dimensions, is so great that a special arrangement had to be adopted to release the footstep of at least a part of that load. In order to overcome this difficulty, the turbine has been reversed, the water passing through the turbine upwards, acting, therefore, in the opposite direction to the weight of the machinery. The boss of the turbine wheel is, moreover, formed into a piston, working in a cylinder, to which water under the pressure corresponding to the fall is admitted, thus counteracting again the weight of the moving parts of the turbine and dynamo. The water, after passing through the turbine, is conducted to the tail-race through a suction tube, the turbine being placed 15ft. 9in. above the tail water. It runs at 150 revolutions per minute, and is a single Jonval turbine. To regulate its speed, if required, a ring gate is inserted in the suction tube, while it can be stopped by a throttle valve in the wrought-iron tube taking the water to the turbine. The total power now utilised by these aluminium works is 4,550 H.P. The turbines were constructed by Messrs. Escher, Wyss and Co., of Zurich, and the dynamos by the well-known electrical works at Oerlikon. Each dynamo is of 7,500 amperes and 55 volts.

The last turbine installation here illustrated is that at Zufikon-Bremgarten, also in Switzerland. The drawing shows another arrangement to counteract the weight carried by the footstep, and at the same time an arrangement by means of which the necessary speed to drive a dynamo of large power direct under a medium fall is obtained. The plant consists of four sets of double Jonval turbines of 325 B.H.P. each, running at 115 revolutions per minute, and a smaller Jonval turbine of 34 B.H.P., driving two exciter dynamos, running with 210 revolutions per minute, and was erected to supply electric light to the neighbouring town of Wohlen, and driving power to the new works of Messrs. Escher, Wyss and Co. in Zurich, and a large flour mill close by these works. The distance over which this power is transmitted is about 11 miles. The fall is 17ft. 6in., and was obtained by building a dam across the river Reuss, and a tunnel about 1,100ft. long across a hill round which the river flows at a rather high speed. The water is divided between two Jonval turbines fixed on one common shaft, so that it passes upwards through the lower wheel and downwards through the upper wheel. By distributing the water in this manner, the diameter of each turbine is reduced, and the speed consequently increased. At the same time the pressure of the water, which would otherwise act on the footstep, is entirely counterbalanced. The central part of the lower wheel is, moreover, formed into a disc, on which the water presses from below, releasing the footstep also partly by the weight of the revolving parts of the turbine and the dynamo. The space between the two turbines on each shaft is connected with the tail-race by a flume formed of concrete, which acts as a suction tube. This turbine

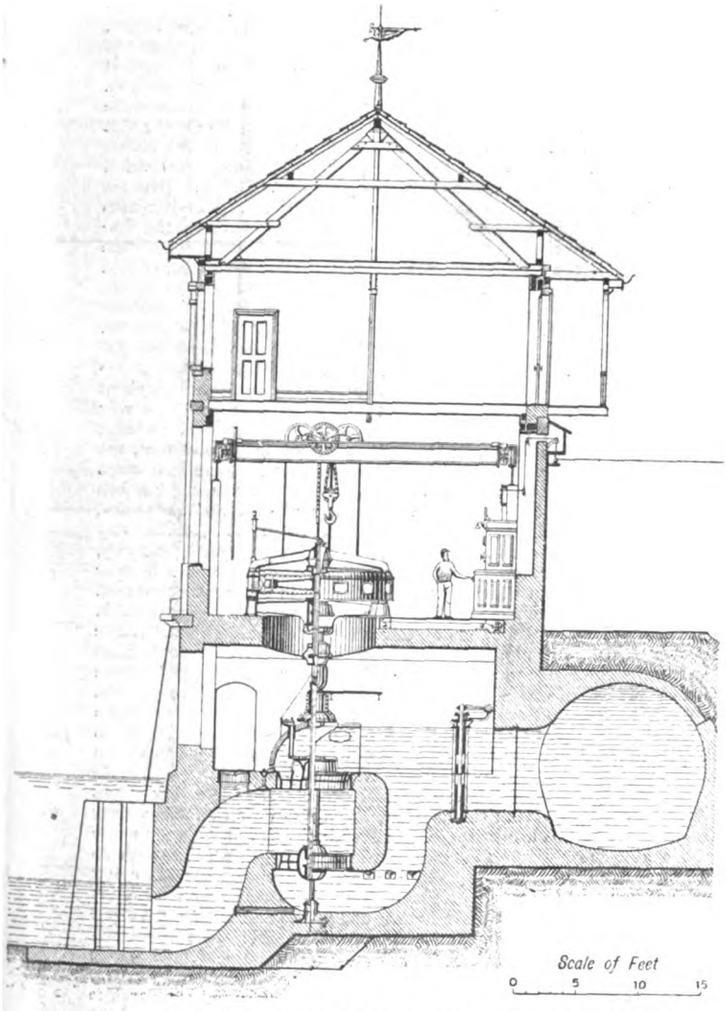


FIG. 8.—Turbines at Zufikon-Fremgarten, Switzerland.

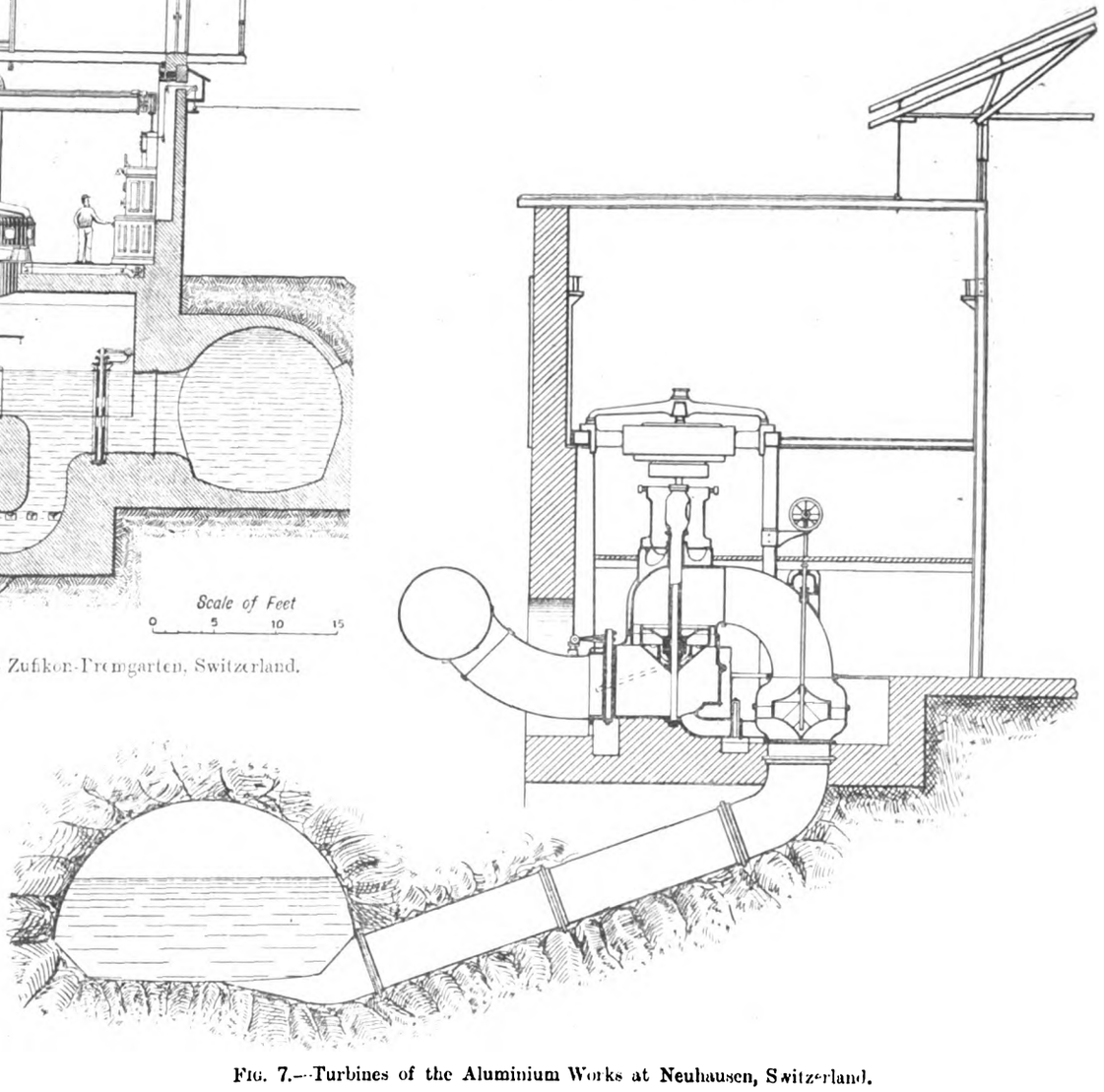

FIG. 7.—Turbines of the Aluminium Works at Neuhausen, Switzerland.



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plant was also erected by Messrs. Escher, Wyss and Co., and the dynamos were built by the Oerlikon works.

The examples given above of the utilisation of water power may be considered as representative types of successful installations under different conditions. They are sufficient in number and variety to prove the necessity of a selection from motors which are different in principle, and of the careful adaptation of the turbine selected to the local conditions and requirements.

A turbine installation under a low fall will be more costly than one under a higher fall; it is, consequently, of special importance to obtain the highest possible efficiency, even at an extra expense, under a low fall. The cost of the turbine itself is only a fraction of the total outlay for the plant, including foundations, connection with the machinery to be driven, and sometimes a weir and a canal. The cost of these permanent structures exceeds that of the motor; it is, therefore, a penny wise and pound foolish policy, after putting in the permanent structure, to try and cut expenses by putting in a turbine of insufficient capacity or inferior efficiency. The commercial value of a water power depends rather more on the annual outlay on the same than on the first cost, and the annual outlay for the work obtained from the power is the smaller the higher the efficiency of the plant.

The efficiency of a turbine which can be obtained and honestly guaranteed, even if the fall is low, is about 75 per cent. Eighty per cent. and a little over is sometimes obtained under favourable conditions, and has been proved by careful tests made by responsible experts; but an efficiency of 85 and 90 per cent., sometimes claimed, is never reached, if the quantity of water be *accurately* measured during the test. If the efficiency of the turbine is guaranteed at all, it should be stated not only for the most favourable conditions, but also for a reasonable *minimum* of the fall or the quantity of water.

In many instances within my own knowledge, water power, in itself sufficient to drive the machinery of a factory, but improperly utilised, is supplemented by artificial power, produced by steam, gas, or oil engines. The loss of money caused by the waste of the cheap power from a running stream in this manner amounts certainly to a big sum in this country alone. The annual cost of such auxiliary power, calculated for 3,000 working hours, may be put at three to four times the cost of water power, and calculated for 6,000 working hours, four to eight times the cost of water power. A judicious utilisation of the water power in such cases would not only result in an enormous saving of money, but in a gain of a large amount of power now unutilised. Most factories are closed at night time, when the water is allowed to run away without being made use of. Assuming that the water power is insufficient to drive all the machinery in the daytime, while it is wasted during the night, electrical storage batteries in connection with a generator might very advantageously, and perhaps with greater economy, be used instead of auxiliary steam, gas, or oil engines.

It seems probable that in the near future the electrical transmission of power will take the place of shafting and belt drives in factories, when certainly the waste of water power would be prevented in the manner suggested. Owners of factories driven by water power might even find that by improving their water power they obtain spare power which could be profitably applied by the generation and distribution of electrical energy in the immediate neighbourhood. I may add that the majority of large-power central stations now being erected in Switzerland for the generation and distribution of electrical energy are mostly utilising small or medium falls varying between 10 to 30 feet. The storage of water in the shape of snow and ice on our mountains provides us with a good water supply during the summer, but the low temperature in winter reduces that water supply very considerably. The water power there is just as variable as in other countries, and those falls which can be advantageously utilised on account of being situated in the inhabited and industrial districts are often not any higher, or not much higher, than in this country; the only difference being that such small falls occur more frequently, rendering a concentration of large power in one place easier, and perhaps less costly. Still, it is my conviction that concentration of water power for the distribution of electrical energy, or for the generation of a large amount of electric current, as required for electro-chemical and electro-metallurgical processes, is possible in many places in this country without going into prohibitive expenditure for canals, &c.

In conclusion, I hope to have succeeded in my endeavour to show how water power under low falls can be, and is, very advantageously and economically utilised for the generation of electrical energy; and that a very large amount of water power is now running to waste which could, in conjunction with electrical machinery and apparatus, be turned to profitable account by such a hearty co-operation of the electrical and the water-power engineer as has resulted in such success of commercial enterprise in my native country.

**Speakers who have returned their proofs revised are denoted by an asterisk.**

## DISCUSSION.

*Mr. TREMLETT CARTER said that he wished that a more competent person than himself might open the debate; but there were a few remarks he wished to make relative to the utilisation of low falls for electrical purposes, especially such falls in this country. Mr. Steiger had promised, in the opening part of his Paper, to prove the utility of low falls, and at the end of it he said he hoped he had succeeded in his endeavour to show that low falls can be economically used for electrical generation. Mr. Carter trusted he might be pardoned if he failed to appreciate Mr. Steiger's logic. The author had given a number of examples of water-power utilisation. He had first given the Falls of Foyers, where the fall was 350ft.; next he mentioned Chaux-de-fonds, where the fall had been stated to be "only 170ft." Brantham Mills were described with a fall of 4ft. 10in.—quite a low fall—but that case was a flour mill. The turbines made only 24 revolutions per minute—quite an impossible speed for a dynamo, without considerable loss of power in the gearing that would have to be used. Then Mr. Steiger mentioned the Geneva Waterworks, with a minimum fall of 5ft. 7in., which was also a non-electrical example; after which he gave the case of Baden, a 10ft. 9in. fall. That was an electrical example, but the author furnished no particulars as to the results obtained or the cost of the scheme initially. The author next cited the Neuhausen aluminium works, electrical enough, but the fall is 66ft. Then came the description of the Zutikon-Bremgarten installation, with a fall of 17ft. 6in. Mr. Carter thought that the figures given in these examples did not go to prove that low falls were useful for electrical purposes in this country.

Mr. Steiger had stated that England is a land of low falls, and Mr. Carter agreed with him there; but low falls were subject to several distressing complaints. In the first place, there is the complaint of too little water, owing to drought. But that was nothing to the complaint of too much water. He had seen what might be described as a very desirable mill-site laid under a vast sheet of water—mill-race, tail-race, almost the whole mill, under one level extent of flood, and that, not because of any unusual catastrophe, but merely because there had been a little extra heavy rain. This was a very common thing in the low falls of this country, the tail-race being frequently "tailed up" or ponded back to such an extent that the turbines will not work. Another very distressing complaint occurs in winter, when the mill-pond, mill-race, turbines, in fact everything, get frozen up. There was still another common complaint from which low-fall mill-sites in this country suffered. He referred to the principle of "first come, first served," that obtained in a great many of the English rivers and streams. He would give an example to illustrate this. A small electric supply station with which he was familiar was driven by undershot water-wheels, with secondary batteries and a steam engine as stand-by plant. It was quite a complicated affair. The principal trouble at this station arose on account of the action of a miller, whose mill is situated a short distance up the stream. A miller is nothing unless thrifty, and before that miller leaves his mill in the evening he shuts down the main sluice, and saves up the whole river for the morning. Now, the electric light station wants the river mostly during the night, but cannot get it. It can only get it in the daytime. You cannot work a water-power station when someone has switched off the river, or if you wish to run the station during the night you must dig a mill pond large enough to store up half a day's worth of river, so as to be able to get water when the miller next door higher up has shut down. At the station mentioned Mr. Carter said it was impossible, for special reasons, to have a big mill pond, so they had to put in a large secondary battery plant, and everyone would realise how inefficient it would be to depend to so large an extent on batteries. Those were some of the difficulties and troubles which were encountered on low falls, and all these troubles made it absolutely necessary to put in steam or some other stand-by plant, which enormously added to the initial cost of the undertaking. Stand-by plant will in fact duplicate the horse-power of the generating machinery, though, since steam plant is cheaper than low-fall water-power plant, it does not quite duplicate the cost.

But even if we had a low fall from which these vices were absent, Mr. Carter pointed out that there would always be this objectionable feature—that an enormous mass of water would have to be dealt with, per unit of power, as compared with a high-fall plant. He would give an example which would show this to be the case. Suppose we wanted to get 1 kilowatt at the switchboard; then, with a low fall of only 3ft., and allowing an over-all efficiency of 50 per cent. between the turbines and the switchboard it would require a flow of 3,000 gallons per minute. He thought Mr. Steiger would agree that 50 per cent. was a very liberal allowance for the efficiency, taking into account the fact that double or treble reduction gear, belts, &c., would have to be used. He had seen mills where the power was taken a sort of personally conducted tour over the mill, before being ultimately taken to the dynamo. Now compare the 3,000 gallons per minute with what would be necessary on a fall of 350ft., such as at the Falls of Foyers. The efficiency might easily be 70 per cent., and in that case only 18 gallons per minute would be required for 1 kilowatt at the switchboard. The larger bulk of water in the low-fall plant would entail far more expensive works and engines, to give sufficient water-way. Besides this, so much water in motion was a difficult thing to control, and would increase the trouble in governing. It was difficult to get very close governing with any type of water plant; but on a *low* fall the difficulty was enormous, owing to the huge mass of water to be controlled quickly. Mr. Carter also took exception to Mr. Steiger's advocacy of impulse turbines for dynamos on moderately high falls. To select these, as had been done at Foyers, in order to suit them to the speed of the dynamos, was wrong, and it was altogether a new thing for dynamos to require the engine to be built to run as slowly as possible. The turbines ought to be adapted to the mill-site, and then the dynamos adapted in design so as to run direct-coupled to the turbines.

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Looking at the comparative costs of low-fall water power and coal or other sources of power, Mr. Carter thought that low falls were not cheap. Mr. Steiger had referred to water power as "a free gift of Nature," but he (Mr. Carter) thought there was often a legacy duty of 100 per cent. Nothing was to be made out of it. It was better to use coal, which we paid for, than to have to depend on a free gift like this, which came only in wet weather.

*Mr. ALEXANDER SIEMENS, in thanking Mr. Steiger for bringing his Paper before the Institution, said that it was very interesting to learn what had really been done in Switzerland, even if the falls of the various installations could not exactly be called low falls. He thought the Paper quite proved that low falls were adaptable for driving steadily, as in the case of the Manningtree Mills. But in saying that he said all that the author had really been able to demonstrate in favour of low falls. He had said that the mills were run about 16 hours a day. They had two interruptions of four hours—a tidal interruption—and therefore some addition to the "free gift of Nature" had to be provided. With regard to the objections brought forward by Mr. Carter, he might mention that they were founded on experience. The author had brought forward his Paper with a view to teaching them that water-power was applicable to electric driving; but it should not be forgotten that Lord Armstrong, nearly 20 years ago, put up at his private house a small installation with water power to light his picture gallery, and at the same time had a motor driving a lathe or saw or something of that kind. The original installation he believed was even at work at the present day. Further, in 1881 the town of Godalming was lighted by low-water power. There was a mill, with all the advantages described by Mr. Carter, which was utilised for driving the dynamos; and Godalming certainly had the distinction that it was the first town in the whole world to have all its streets lighted by electricity, and lights distributed to private houses where required. Unfortunately, however, very little was required, and the thing was not a financial success—it was before its time. Fifteen years ago there were mills working under exactly the same conditions mentioned by Mr. Carter; and those were the drawbacks in England of utilising water power. It could not be relied upon; it could not be worked by itself. They must have something to fall back upon; and when they had to put up steam plant, or whatever it was, capable of dealing with the whole of the lighting, why complicate the matter by having water-power plant alongside! He was sure English engineers were quite awake to the beauty of water power, where water power was attainable; but the low falls in England were, as far as he could judge, not adapted to electric lighting.

Mr. SHOOLBRED asked to be permitted to mention a long-standing example of a low fall not mentioned by the author—the celebrated Menier's chocolate works in France. That fall was a peculiarly difficult one, varying from about 5ft. 6in. to as low as 15in. at times. The whole of the River Marne was there dealt with. One interesting feature connected with the falls there was that Girard's impulse turbines were used, which the author had stated were difficult to manage with low falls. Those turbines had been working there for a very long time. There were three of them, and they adapted themselves admirably to the differences of falls. Recently, however, as Dr. S. P. Thompson had told the meeting, the largest of these, that for the smallest fall, had been replaced by an ordinary undershot wheel. He thought that sometimes impulse turbines were of use generally; but he quite admitted that under certain circumstances reaction turbines, especially with low falls, might be found to be more useful on the whole. Impulse turbines, however, should not be altogether set on one side. Most of the author's examples were confined to the Jonval turbine. There was a reaction inward flow turbine which had been used for many years in this country, and which from its authorship ought to be highly acceptable to electrical engineers. It was known as the "Thomson reaction inward flow turbine," the inventor being the late Prof. J. Thomson, brother of Lord Kelvin. In illustrating the low falls in Switzerland and the value of water power in that country, the author had forgotten the fact that the circumstances under which the water supply was obtainable there were directly opposed to what they were in this country. He referred more particularly to the time of year. Mr. Steiger had stated that it was in summer especially that they obtained their largest supply of water. The greatest difficulty experienced in this country when dealing with low falls was the absence of water, and in some instances, as Mr. Carter had mentioned, floods occurring at a certain time of the year. It was the absence of water, in summer especially, that rendered it difficult to utilise hydraulic power with advantage, as engineers in this country otherwise certainly would. They were bound ultimately to fall back upon steam power, and then came the question, Why complicate the matter and add to the capital outlay by having two sets of plant, one of which was lying idle for half the year?

*Mr. M. MOWAT said he quite agreed with the author that there was a great deal of motive power running to waste which might be utilised with very great advantage in the interests of the country. He believed the time would gradually come when water power would be far more utilised than it was at present. He had had no experience as an expert in the preparation of the necessary plant; but his firm, Messrs. Ritchie, Steuart and Co., of Bombay, as representing the Gokak Water Power and Manufacturing Co., were perhaps at the present time employing a larger amount of water power than any in Her Majesty's dominions. About 13 years ago his firm secured a lease from the Government of India of the power at the Falls of Gokak in the Southern Mahratta country. They had now eight turbines of 250 H.P. each. They were using 1,500 of that horse-power, soon they would be using 2,000 H.P., and they intended ultimately to work up to something like 4,000 H.P. Mr. Steiger had mentioned what had been done as to turbines and plant employed, but he had given no commercial results which are essential. Some of those results he could himself supply. He was glad to be able to say that Messrs. Escher, Wyss and Co., for whom Mr. Steiger acted as agent, had supplied his firm with the plant. The water fall was 200ft. high. The capital employed there in two mills was £200,000, and the plant to utilise that water power cost about £22,000. By the utilisation of water power instead of coal they were able to give a larger dividend than they could if they used fuel. The work done at the mill was of the best character. He might mention that his firm was not one of those who allowed water to run to waste during the night. They took care of and husbanded every available cubic foot, so as to have it for work during the day. The driving was not done by means of dynamos. The two mills were at a distance of about an eighth of a mile from the turbines, and by means of large wire ropes, supplied by a firm in Newcastle, the mill was driven. The plant had worked splendidly, no hitch having ever occurred. He mentioned that as showing what water power could do. The utilisation of power, as mentioned by Mr. Steiger, could not fail to do a great deal of good. The more the question of water power was looked into and the power availed of, the greater would be the benefit to a great industrial country like ours.

*Mr. STEIGER, in reply, said that Mr. Carter had stated that impulse turbines were only suitable for extremely high falls, and that even in the case like that at the factory at Foyers they were unsuitable. He most emphatically contradicted that statement. The actual plant at this factory differs slightly from the diagrams. An impulse turbine, or "action" turbine, was suitable anywhere for a fall of 3ft. up to any number of thousands of feet, where it was constant and could be regulated according to the quantity of water without loss of efficiency. If a miller shut off the water at night and prevented his neighbour a little lower down working his electric plant, that was not the fault of the power but the fault of the laws which permitted such a state of things. In every country where water power was appreciated the law made very strong restrictions preventing anybody from having the right to take away water from his neighbour during the time he did not use it. [Mr. Carter said that he had carefully gone into the legal point of the question, and found that they were not blessed with such a law as that in this country.] Mr. Steiger said that water power would be much more appreciated in this country when it was really known what could be done in that direction. With regard to the automatic governors, alluded to by Mr. Carter, he might mention that they worked on low-fall turbines as well as on high-fall turbines; and on the latter the connection of an automatic governor to obtain exactly the proper speed was just as difficult as in the former, because under a high fall the areas through which the water giving a large amount of power passed was so small that by a trifling movement a very great variation of power could be produced. The application of an automatic governor for a high-fall turbine was sometimes an extremely difficult question, but it could be done by properly studying the conditions and proper means. With regard to the adaptation of turbines to dynamos, or dynamos to turbines, it had been found convenient in the case of the dynamos used in the aluminium works at Neuhausen, and in other cases where large dynamos were used, to connect them direct with the turbine shaft. If a dynamo required a diameter of, say, 10ft. such as the dynamos at Lyons, then the speed of the dynamo was given and the turbine maker would supply a turbine which would suit that speed.

Mr. Siemens had alluded to the failure of the turbine plant at Godalming for the electric lighting of the town. He did not know what sort of turbine was used, but certainly it had been proved, in more instances than those which he had given, that a water-fall varying from 1ft. to 5ft. or 6ft. could be used, and the power obtained was satisfactory. If the fall and quantity of water corresponded to a power of say 100 H.P. for nine months of the year, it was useless to put up a dynamo and plant requiring 150 H.P. Those conditions must be gone into before putting down a plant. A turbine even of the highest efficiency for any fall or quantity of water cannot give power beyond that which is in the water, just as a dynamo would probably not give more than 95 per cent. or so of the power for which it was constructed. Mr. Shoolbred had alluded to action turbines on low falls, but he had overlooked the fact that it had been mentioned in the Paper that low falls were very seldom found without variations of the water levels. That was a great difference. If he had water power, where the tail water never rose, or where the difference was only a few inches, then he certainly applied an action turbine; but in the case of driving dynamos, where he wanted to use as high a speed as possible, he would give preference to a reaction turbine, not on account of the inferiority of the action turbine under such conditions, but on account of the higher speed desired, which he could only obtain from the reaction turbine. He could make a reaction turbine smaller in diameter for a good fall than an action turbine, because a reaction turbine was less sensitive to the variations of the angles at the inner and outer circumference of the buckets. Mr. Mowat had alluded to a plant in India. That plant was under rather a high fall. The turbines are similar to those at Chauxdefonds. They were impulse turbines, and had, he thought, given satisfaction to the owners. Mr. Shoolbred had alluded also to the water wheel of Prof. Thomson. He had seen that wheel once, but not the actual plant. He believed it was a turbine which gave a good efficiency at full gate. He could not say how the efficiency was at part gate. It was a pity that so few tests had been made in this country with turbines so as to give reliable information as to their value. Anyone requiring a turbine should insist on having a written guarantee that it must give a certain power on such and such a fall, with such and such a quantity of water, and also under worse conditions on which the turbine might work for a considerable length of time.

*Gen. WEBBER, in moving a vote of thanks to Mr. Steiger for his Paper, reminded the members that whatever the criticism might be as to the use of water power in the past, and whatever the opinions, such as those expressed by Mr. Carter, might be, this was a very large and important question, and they ought to be very thankful to a gentleman of the experience of Mr. Steiger for coming forward and giving them a Paper which he regarded, and which he thought the meeting would regard, as an



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inducement to many to go more deeply into the question. He was in the habit of inspecting water powers of that character, water powers with low fall and great irregularity, and he was sure that none of them could fail to call to mind instances in which it would be well worth their while to go and investigate the circumstances, and see whether they could not utilise the power with which Nature had provided them at a very small cost.

*Prof. SILVANUS THOMPSON, in seconding the vote of thanks, said there was one little correction he should like to make to a remark made by one of the speakers. He had recently visited the mill of Menier and Co., where the fall of the river Marne was used, and he had found that on account of the diminution in the height of the fall at the time when floods were coming down the river they had been compelled to put in, in addition to the turbines, an undershot water wheel.

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The following remarks have been communicated by Mr. GEIPEL: He had been anticipated in some of his remarks by Mr. Tremlett Carter, with whose views he generally agreed; but there were one or two points in this Paper not touched upon to which he desired to refer. Mr. Steiger recognised the difficulties in utilising low falls due to variations in head and quantity—in the one extreme you have all head and little water, while after heavy rain you may have abundance of water and little head, and between these two limits you have all degrees depending upon the proverbially variable British weather. Mr. Steiger proposed to meet these difficulties by subdividing the turbine into several compartments; it may be that in some cases this is a good arrangement, but Mr. Geipel had had some experience in the use of water power for electric lighting purposes, and found that the varying load on the dynamo adds again to the difficulties of the varying water power. It is also to be remembered that a turbine has a *critical speed* at which the best efficiency is obtained, and that this critical speed varies with the head of water, whereas, on the other hand, the dynamo requires one constant speed. He was of opinion that it is frequently preferable, therefore, to subdivide your water power and use several turbines, each driving its own dynamo. These turbines should be arranged for working at different heads, one should be for the maximum head, and of suitable size to use only the minimum quantity of water available under that condition. The second turbine should be suitable for a less head and larger quantity of water, the third more so, &c. The number of these units would, of course, be governed by the conditions. An additional advantage of this method is that repairs may be effected to one unit, whilst others maintain the supply. Mr. Geipel was quite aware that this system may not be economical in all cases, especially where the maximum available power is small; but in many cases it will prove, in his opinion, to give a very much better all round efficiency than the compound turbines referred to by Mr. Steiger.

There is a more important point only briefly referred to by the author, and that is the question of first cost, as to which the author writes "The commercial value of a water power depends more on the annual outlay than on the first cost." On this point, Mr. Geipel was directly at variance with the author. He had always thought that the annual outlay on turbines was almost negligible, and that the only other consideration was first cost; if that item be also negligible, why then the millennium of those gentlemen who regularly promote, as they do, in the public press, the utilisation of the tides, is verily at hand. It is, unfortunately, this very question of excessive first cost, which makes the power produced by low-water falls in tides so much more expensive than in the case of steam or other engines. The importance of first cost is being daily driven more closely home to the minds of all electric engineers, and for that reason it is to be regretted that this Paper contains no information whatever upon this important point.

The use of storage batteries for storing the power during periods when the power is not required is well known. Mr. Geipel has, in several cases, found it cheaper to construct a water reservoir, which, of course, effects the same purpose. With regard to the difficulty experienced by the author with round ropes, Mr. Geipel thought he must have got hold of a very bad quality of round rope. The arrangements of the pulleys are good, and the strain is only 80lb. to 83lb. per square inch, so that with good English-made round ropes we should have no hesitation in transmitting more than double the power with satisfactory results.

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## ARC LIGHTING PRACTICE.*

BY ALEX. DOW.

Mr. John Hesketh's comments † on arc lighting practice in his country and this are both interesting and valuable. The paragraphs as to lamp supports, globes and carbons deserve the careful study of American electric light men, for it is in these particulars that our practice has been, and still is, susceptible of much improvement.

In the matter of carbons it is not so very long since American 10-ampere lamps, whether for indoor or outdoor use, were uniformly fitted with $\frac{7}{32}$in. or $\frac{1}{4}$in. carbons, moulded solid and copper-coated. Sometimes the lower carbon was not coppered; when the lamp was used for interior lighting this was considered preferable, but neither the use of cored uppers nor of an upper of greater diameter than the lower was admissible. The practice to-day is much better. The introduction of arcs on constant potential systems brought in the imported carbons, with cores of differing diameters; and the alternating arc was a rank failure until a proper carbon and a 30 or 33 volt adjustment were adopted.

The $\frac{1}{4}$in. coppered carbon still holds the field in street lighting, and is likely to hold it for some time to come. The practice of using partly burned uppers in the lower holders, and double carbon lamps for all-night street lighting, are the factors of greatest importance in deciding this, because they require the purchase of but one size of carbon (usually 12in. long, but $\frac{1}{4}$in. diameter) and yet allow of every piece of carbon being fairly burned out, the short lengths produced at one season being mated and reissued to the trimmers at another. The worst fault of the $\frac{1}{4}$in. uniform carbon plan is the tendency to and "lapping" of points during the run—that is to say, the dropping of the upper carbon past the point of the lower, causing a short arc or total extinction. If the current is a trifle high, so that the conical points are longer than normal, or if the carbons are a little crooked, this trouble may become serious. Lamps on towers or other supports much affected by wind or vibration are specially liable to it.

In the plant I operate, analysis of the "outs" for two months showed that lapping was responsible for too much of the total trouble. We were running with $\frac{7}{32}$in. (11mm.) carbons in both holders, and a large number of lamps were on towers, while still another large number were on poles to which electric street railway span wires were attached. We changed to $\frac{5}{16}$in. (16mm.) uppers, retaining the $\frac{7}{32}$in. lowers. Result for four winter months' operation of 1,480 street arcs is just one "out" by lapping. We cannot see any practical difference in the total light. Experiments show a little difference, but it is negligible in comparison with the improved reliability.

When one turns from street lighting to interior work it is seen at once that the day of the uniform carbon is gone. I have only a dozen interior lamps—the incidents of a plant installed primarily for street work; but these dozen use three different carbons, to wit, 13mm. American-made cored uppers with 13mm, American solid lowers, forced, and not coppered, these being pairs for 45 volts by 9·6 amperes direct-current arcs, and 13mm. "Electra" cored, for alternating 30 volts by 15 amperes arcs. It is not unusual nowadays to find a station carrying in stock ten different carbons for interior work, and the use of uppers of larger diameter than the lowers is frequent, though not yet general. I fear that the refinements found in the best European carbon practice will (like the best of the European arc lamps) never acquire a permanent footing here. The effort to systematise which has reduced constant-current series arcs throughout the United States to two standard currents, 9·6 and 6·8 amperes, will reduce carbons to a very few sizes and styles. To our central-station men life is too short to fuss with lamps of the delicacy of chronometers and with carbons of different sizes for each month in the year.

I notice, however, the differentiation of the street-lighting lamp from that rented to private patrons. It is not long, say three years, since the total difference was in the style of the jacket—the street lamp jacket was japanned iron, while the private customer's lamp was done up in brass. Now the difference is radical. I have already noted it in carbons. In mechanism the private lamp (if I may so call it) is frequently a shunt wound lamp if run on a series circuit, and often it has a rack feed. The public lamp is usually differentially wound and almost always has a clutch feed. The difference in mechanism extends even to the adjustment of individual lamps, the station lampman cultivating a feed by imperceptible movements for the private lamp, which the said lampman calls a "sneak" feed, while on the public lamp he adjusts for a "drop" feed—that is to say, he tries to have the clutch kick itself entirely clear of the rod at the instant of feeding, causing a *drop* rather than a *slide* of the upper carbon, and the regulating magnet is relied on to immediately adjust the arc to the proper length when the clutch gets its new hold.

There is reason in all the differentiation. The shunt lamp (for the benefit of English readers I explain that a shunt lamp is that in which the separation of the carbons is produced by a spring or weight, while the magnetism due to a shunt winding draws them together; as distinguished from a differential lamp, in which the separation is due to a series coil)—the shunt lamp tends to regulate for constant volts at the arc without regard to the current. This is because the separating force of the spring or weight is constant. It follows that such a lamp will maintain a silent arc, if proper carbons are selected, with a very wide range of current. And so long as the average customer will insist on judging of his light by looking at the arc instead of at the illumination, this quality of the shunt lamp will much reduce the total of the "kicks" received per year. The sneak feed is, of course, the perfect feed and stops all hissing or flaming.

But consider the street lamp. It is differentially wound because with that winding a decrease of current shortens the arc and so reduces volts as well as amperes. For the normal condition of a dynamo on street-lighting work is full load, and its fre-

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* From *Electrical Engineering*, April.

† "An English Engineer's Views on Arc Lighting Progress." By John Hesketh, A.M.I.C.E., M.I.E.E., Borough Electrical Engineer, Blackpool, England. *Electrical Engineering*, pp. 128-133, No. 38, Vol. VII. February, 1896.

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quent condition is overload ; and it will be remembered that these series dynamos are designed with a drooping characteristic, an increase of current causing a fall of voltage, and the maximum voltage for any given speed corresponding to a current less than normal and to instability of point of commutation, so that a small further reduction of current will cause flashing. But with differential lamps in circuit, a reduction of current is at once compensated for by the shortening of the arcs, which reduces the necessary terminal voltage and assists in steadying the machine. It follows that such a dynamo can be operated with differential lamps nearer to its maximum voltage than with shunt lamps.

This gives the central station the equivalent of a reserve of dynamos for use in emergency. Of course, the light will be run with full current under normal conditions, and sufficient reserve for the common accidents of operation must be provided in the shape of spare dynamos. But it is possible, as we did experimentally not long ago, to operate 158 hissing arcs on a 100-light machine without putting any street in darkness, and much more to the satisfaction of the police and the general public than if 100 silent arcs had been maintained and the other 58 extinguished for the rest of the night. Had the lamps been shunt wound the limit would have been about 110, because each lamp would have insisted on getting full voltage for a silent arc, and that number would have put the dynamo on the top of its characteristic curve, and therefore to its flashing point.

As regards the drop feed, the reason is with the lamp. The lampman expects that lamp to stay in service and operate without cleaning or adjustment for at least a year, and if it stays out for two years he is not surprised. It has to stand summer heat when the running temperature of the mechanism is 150deg. to 160deg , and winter cold when the clutch and trips have to start work at 20deg. below zero of Fahrenheit scale. Also the rods have to be wiped many times by trimmers' cloths, which are not chemically clean ; and be handled by trimmers' fingers or mittens, as the season may decide, which said fingers and mittens are sure to be dirty. And that clutch is supposed to grip that rod every time and release it only on the call of the control magnet. Now the drop adjustment will, with a proper clutch, do its work whether the rod is clean or dirty, wet or dry, worn or new. It will feed a round file correctly, if the file is of the same diameter as the proper rod. You could not get a sliding feed with that file. The only fault of the drop feed is the momentary hiss, say two seconds, at the time of feed. On the street this is never noticed, though in interior work it would cause a claim for a rebate. And the compensation for this little fault is that the rod gets and needs no care but the daily wipe, and the adjustment needs attention only once a year.

But it is in outward appearance that the differentiation of the private and public lamp is most complete. The latter is still the same substantial, clumsy article, with no pretence to beauty of design or finish. The former is sometimes an artist's dream, and sometimes, alas, a nightmare.

Before quitting the subject of lamps, I venture to predict that the "inclosed arc," having the arc maintained in an inert atmosphere, will be the feature of private lighting for the present year. This is not a novelty, but it seems at last to have got past the experimental stage and to be a practical commercial article of decided value, particularly for interior work.

Mr. Hesketh's statement of his experience with a 60-light (3,000-volt) Ferranti rectifier is of much interest. As noted in my previous Paper, the rectifier has a province of usefulness, and the production of a successful 60-light machine enlarges that province, and also causes the hope that the device will soon be perfected in even larger sizes. It will, doubtless, be introduced in America before long, and our conditions will bring about the 100 and 125 light sizes. I do not see why, if a commutator on a dynamo shaft delivers 6,250 direct volts smoothly and successfully, a motor-driven commutator should not rectify a corresponding alternating voltage. The constant current transformer can be designed to give the same characteristic as the dynamo, and there is no vital difference between a rectifier and an "open coil ' commutator.

As to relative efficiency of the rectifier in Mr. Hesketh's station, compared with the 50-kilowatt direct dynamos here. He gets 73 per cent. I get identically the same. The efficiencies here are distributed as follows :—

Say of 1,000 watts indicated power in engine there are expended :

| | | | |
|---|---|---|---|
| 12½ | per cent. = 125 | watts | in engine friction, |
| 3 | „ = 26 | „ | rope transmission, |
| 14 | „ = 119 | „ | dynamo losses. |
| Total losses, 270 | | „ | leaving 73 per cent. net output. |

Data for these efficiencies were obtained from tests of the various parts. The engine friction is not unreasonably large in a triple vertical engine with 11½in., 18in., and 29in. cylinders ; 18in. stroke, and two 7,500lb. flywheels, at 200 revolutions per minute. Efficiency of rope transmission was obtained by comparison of pairs of dynamos direct-coupled, shaft to shaft, against the same pairs roped together, the one dynamo running as a motor and driving the other. The loss was almost the same at all loads and with different pairs, averaging 1,472 watts—a little less than 3 per cent. of 50 kilowatts. The dynamo efficiencies were got by several methods : By the Hopkinson method with three dynamos in series ; the same, but with a lamp load on the third dynamo ; by driving a dynamo by a previously calibrated constant-potential motor, *i.e.*, the motor efficiency was obtained by a brake test, and the efficiency so obtained applied to the power absorbed by it when driving the arc dynamo.

I do not question that the rectifier is more efficient than a 55-light Brush set. The dynamo in such a set has to contend with excessive engine losses, and is itself far from being an efficient machine. Its standing in the electrical community is based neither on its efficiency nor its good looks, but on its capacity for hard work and bad usage.

For the conditions of American practice in street lighting, the 100 or 120 light series circuit is a necessity. From where I sit tonight, in hearing of the "sing" of the brushes, the air line distance to lights in each of three directions is five miles, the distance by streets about seven miles. Many single circuits of No. 6 (0·162in. diameter) wire are 25 miles long. If those circuits were operated at 3,000 instead of 5,000 volts, the circuits would be greater not only in number, but in total mileage. The $C^2R$ losses on an output of 1,492 arcs and 25 "series" incandescents are nearly 65 kilowatts, say 8⅔ per cent. They will be about 7 per cent. on the increased output in prospect, as some of the longer circuits in the outer wards will be filled up with lamps. A return to 60-light circuits would mean an enormous increase in the copper, not only for new mains to divide the existing circuits, but for heavier copper to keep down the $C^2R$ loss to an economical figure. When an engineer has to plan a distribution for street lighting over 30 sq. miles of city, he is glad to use 5,000 or 6,000 volts for transmission, even at some sacrifice of station efficiency, and even when coal is but $2.25 (say, 9s.) per ton of 2,000lb.

As to engine efficiency—a larger engine would be a very little better. In my own case I sacrificed some net engine efficiency by insisting on the simplest possible valve gear, on outboard bearings, and on exceptionally heavy flywheels ; all of these points being to my mind essential to reliable operation. We use on test just 15lb. water per indicated horse-power per hour. In practice we don't do so well ; because, of course, there are more or less petty leaks of steam *out*, and of air *in* ; and because the auxiliaries (the independent condenser and feed pumps, and the little non-condensing set we run as an exciter for our "side-show" of incandescence lighting) are *not* economical. Practice shows 16·8 to 17·2lb. per horse-power per hour of the main engines. We put the heat of the steam from the auxiliaries back into the feed water, and it ends at the coal pile in the consumption of about 2·25lb. of coal per indicated horse-power. The most practical statement of all is that after we have run our trifling day load—some 35 to 50 H P.—and kept the steam pipes warm and the fire pump moving, and banked fires and done all the odd jobs of the 24 hours, we have used about 4·7lb. of coal per kilowatt hour of output. If we had a day load like the night load, we would get that figure down below 4lb.

I doubt whether a 500 H P. engine would be appreciably better in everyday practice, even with the refinements of Corliss gear or balanced valves. I see more possible improvement in properly proportioning the cylinder sizes to the average load than in the refinements of valve gear ; for there is nothing more common in American lighting practice than an underloaded Corliss engine, and nothing that can get away with more dollars without the suspicion of the operator. From the rather meagre data that reach me by the English technical papers, I suspect that the same trouble afflicts the English stations which use a few large units ; and that the superior economy of those equipped with a multitude of Willans engines of small size is due very largely to their never running an underloaded engine. The inherent economy of the Willans engine is a matter of proper cylinder sizes and of minimised temperature range ; and the practical economy is in a full load ; but you cannot get those ideas into a man who believes in valve gear. He will not believe you so long as the "clickety-click" of the trips sings a song of sixpenny saving in clearance and cut off, though there be a loop like a truelove knot in the card of the cylinder which operates as an annex to the Corliss gear.

But I don't object to trips in their proper place, nor to 500 H.P. engines, nor any other size of proper proportion. I selected my own size because I believed four dynamos as many as should be roped to one engine ; for the ratio of dynamo troubles requiring a stop of the machine is to engine troubles of similar importance nearly as one to four with such engines and such dynamos. Then I decided that the economical voltage of the system was 5,000 to 5,500, and assuming the standard current of 9·6 amperes for street lighting arcs, the set of four dynamos figured up to a little over 200 kilowatts. Cylinder sizes were selected to give equal steam economy at full load and at three-quarter load, because in a street lighting

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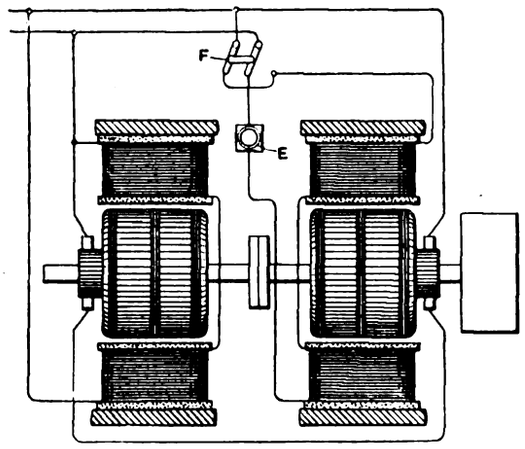
plant of four running sets it is always possible to divide the work so as to give each unit at least three-quarter load, and at any load between three-quarter and full the economy will be a trifle better. Shafts and bearings were made amply heavy enough for an overload, if an emergency should ever necessitate it, but one does not expect steam economy on an overload; it does not happen often enough to affect the annual economy, and if it be anticipated it is cheaper to meet it by increased steam pressure than by having the cylinders too large for normal conditions.

This disquisition has run away from arc lighting altogether, yet I trust it will be profitable to some arc lighting man who wonders where his coal goes to, seeing that both engine and boilers are plenty big enough to do their work and as much again. If that man will understand that his extra boiler capacity had better be standing idle, but ready to fire on a moment's notice, and that his big cylinders had better be traded for others of half the piston area to fit the same engine bed and shaft, he will have learned the first and greatest rule of central station economy.

## A METHOD OF REGULATING MOTORS.*

In the operation of electric motors from supply circuits, conditions are sometimes encountered in which a wide variation of speed is desired or essential. An example of this is a condition in which, for instance, it is required to deliver 10 H.P. at any speed between the limits of 100 and 500 revs, and to maintain this delivery at any desired speed between the limits above referred to. To accomplish this result, there have been two methods in use, one of which is to vary the speed by interposing resistance in the armature circuit, thereby reducing the voltage on the armature and consequently the speed. This method has the disadvantage that there is a comparatively large loss in the resistance, and consequently a low efficiency. The other method is to reduce the voltage upon the armature of the motor by introducing a rotary transformer between the supply circuit and the motor to be operated, which transformer




A System of Motor Regulation.

is so arranged that the voltage supplied to the motor may be varied between the limits of zero and a predetermined maximum. This method has the disadvantage of a large investment in dynamo machines, because the rotary transformer used consists of a primary motor and a secondary generator, each of which has an output equal to that of the main motor to be operated.

In the method about to be described, instead of using one motor, two machines are used, each of which will give one half the desired delivery. For instance, in the condition previously referred to, two motors of 5 H.P. each at 100 revs. are operated in unison, and cooperate with each other so as to fulfil the requirements of 10 H.P. delivery at any speed between the desired limits.

The accompanying illustration shows a diagrammatic embodiment of the method. The machines are coupled directly, E representing a rheostat, and F a reversing switch. The action in general is as follows: In starting and when operating at minimum speed, the two machines are acting in unison as motors. The speed is gradually increased until it reaches its predetermined maximum, first by reducing the field of one of the machines, thereby transferring the voltage of the line to the other, and then by reversing the field on the former machine and gradually increasing it, thereby adding to the line voltage the voltage of the former machine, the latter machine receiving the combined voltage. This method is due to Mr. James Burke, of New York.

* From the *Electrical Engineer* of New York.

# CORRESPONDENCE.

## ALTERNATING ARCS AND WAVE-FORMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read with much interest in your issue of May 22, 1896, the letter from Mr. Steinmetz criticising your leader of May 1st. But I think that his historical sketch is more misleading than the absence of a sketch of which he complains, since he makes no reference to the first and more important works on the subject of the alternate-current arc curves.

The first indication of the distortion of a sinusoidal into a rectangular wave was given not by Messrs. Tobey and Walbridge in 1890, but by Prof. Joubert in 1881, and was taken as a basis for calculation by Dr. John Hopkinson in his celebrated Paper on "Alternate Currents" some years later. On the other hand, Mr. Steinmetz's Paper on the "Power Factor of the Arc," in *Elektrotechnische Zeitschrift*, in 1892, to which he refers in his letter, was anticipated by a Paper of my own presented half a year sooner, in April, 1892, to the French Physical Society, and abstracted about the same time in *La Lumière Electrique*. Lastly, the question of the distortion of waves by the alternate-current arc was for the first time fully analysed in another Paper published in *La Lumière Electrique* of September 16, 1893, that was abstracted for the Chicago Congress, and completed in *L'Industrie Electrique*, of August 10, 1895. This Paper covered far more than the actual subject under discussion, and contains one hundred curves of alternate-current arcs. Should Mr. Steinmetz and Mr. Frith favour me with a perusal of these curves, they would become better acquainted with the various conditions that can occur in the use of alternating arcs, and would fully recognise that their own conclusions are equally incomplete because they have not taken account of the nature of the carbons employed.

With the same alternator feeding an arc lamp one can produce P. D. curves of the most varied character, according to the material of the core, the length of the arc and the amount of the self-induction in the circuits (it matters little whether this self-induction be inside or outside of the alternator). With the low-voltage carbons actually employed in Europe in ninety per cent. of the lighting plants, the arc alters very little the form of the wave. To get the celebrated flat-topped form of wave it is necessary to employ high-voltage or coreless carbons, and in consequence *to put only two lamps in series instead of three* on 110-volt circuits. High-voltage carbons alter the form of the P.D. curve by making it flat-topped *even with low self-inductance machines*, contrarily to Mr. Steinmetz's opinions. The difference got by introducing high inductance is to make the ascent of the curve steeper, as I explained in my Paper, and all alternators may give the same curve with an alternate-current arc when the lamps are provided with sufficient inductance. Highly inductive alternators are very badly chosen if adopted for making studies of the arc, for it is impossible to obtain with them the various forms of wave attainable in the ordinary distribution at constant voltage where the inductance of the generating machinery is negligible in relation to that of the circuit. For this purpose, after experimenting with Gramme and De Meritens alternators, I myself soon came to prefer a machine of low inductance and sinusoidal E.M.F., in order to completely explain with it the effects of variable resistances and inductances, as well as the curious phenomena of the hissing arc that cannot be obtained with inductive circuits. Had but some attention been paid to these results, as I have paid attention to the works of English and American experimenters, probably many of the unnecessary questions on the subject could have been spared to those who have discussed it at the present time as one possessed of novelty.—Yours, &c., A. BLONDEL.

Paris, May 25, 1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Through your courtesy in forwarding me an advanced proof, I have read M. Blondel's letter on the subject of alternating arcs and wave forms. When M. Blondel wrote, my

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Paper had not yet been published, and therefore he may be excused in assuming that I referred to the behaviour of the arc in altering the wave form as *possessed of novelty*. Further, M. Blondel would have seen that a reference was given to a former Paper from which the curves were taken, and which was translated in full in *L'Eclairage Electrique*, November 24, 1894, in which Paper the work of M. Blondel was specially called attention to. Indeed, I have always studied M. Blondel's work with much interest.—Yours, &c., JULIUS FRITH.

London, June 2, 1896.

## WAVE FORMS.—A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May we be allowed to point out an evident printer's error in your report of the Discussion at the Institution on May 14th? In the remarks of Dr. Fleming the following words occur:—

"*The authors seem to imply in their Paper that they had the idea at one time that the sine curve gave the greatest iron loss.*" We think that the word "they" should be replaced by the word "he" (Dr. Fleming), as the latter held the above (implied) opinion in his letter of June 28, 1895, in *The Electrician*.

The opinion we have expressed on all occasions is that the sine wave is a form not to be considered as *critical* with regard to the iron losses in transformers. The italics are ours.—Yours, &c.,

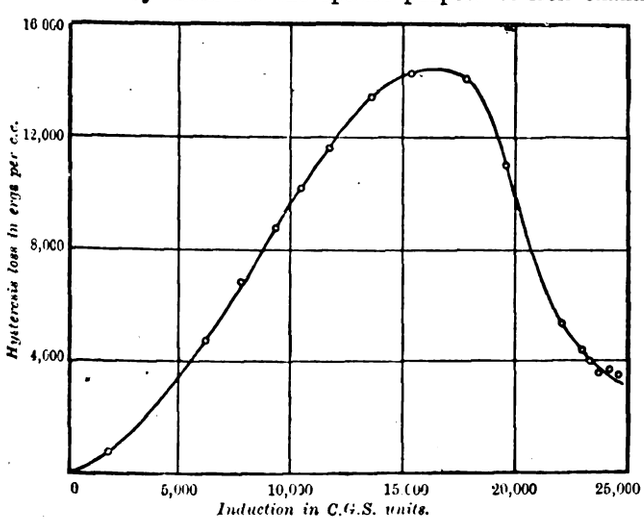
STANLEY BEETON,
C. PERCY TAYLOR,
JAMES MARK BARR.

## HYSTERESIS OF IRON IN A REVOLVING FIELD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In connection with the above subject, it may be of interest to your readers to mention that during the last six months experiments have been conducted in the electrical laboratory of University College by Messrs. R. Beattie and R. C. Clinker, by the aid of a revolving electromagnet constructed by them for the special purpose of iron examination. By the device of employing a very thin circular disc of iron or steel, suspended with its plane in a horizontal position, and hung on a torsion wire in the revolving magnetic field, they have been able to measure the relative values of the hysteresis in the iron for various inductions. The curve here given shows the results of some experiments, and it confirms Mr. Baily's discovery that beyond a certain value of the induction the hysteresis loss in iron in a revolving field is diminished. By the use of very thin discs of iron or steel the induction can be carried up to high values. The influence of any eddy current loss in affecting the deflection of the disc can be eliminated by experiments at various speeds of the magnet. The curve shows clearly that beyond a certain value of the induction the hysteresis loss falls off very rapidly. A fuller description of these experiments will be published at a later date by Messrs. Beattie and Clinker.—Yours, &c.,

J. A. FLEMING.




## ELECTRICAL TREVELYAN ROCKER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The "Electrical Trevelyan Rocker," described in your last issue by Mr. T. A. Vaughton as presenting "what appears to be a new electrical phenomenon," is a very convenient form of apparatus, but scarcely involves a novel principle. In the *Electrical Review*, Vol. XXVI., p. 656, 1890, there will be found a sketch of an electrical Trevelyan rocker, which depends upon this same curious effect. The phenomenon was observed in connection with some experiments upon electrically-driven tuning-forks, in which I required to leave the prongs free; *l. c.*, p. 57.

It may be interesting to Mr. Vaughton to know that if an ordinary Trevelyan rocker is balanced between its leaden block and a metallic knife-edge, and a current of, say, ten amperes is sent through it, the rocker will work without previous heating.

The "buzzing" in telephones is frequently due to a Trevelyan effect in the loose carbons of the transmitter; and it is not unlikely that the "hissing" of arcs may be associated with the same action.—Yours, &c.,

2nd June, 1896. ROLLO APPLEYARD.

## TRANSPARENCY OF FILAMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to the letter which appeared in your columns re the "transparency" of incandescent lamp filaments, I may point out that in my letter of April 16th I avoided the word "transparent" and used the phrase "transmitter of light."

I do not hold that my suggestion is the true explanation of the result obtained, as I gave the subject very little consideration: but I may point out that the fact of the filament casting a shadow of itself does not invalidate the suggestion I put forward; for does not a piece of opaque glass transmit light, and at the same time cast a shadow? while no one will say it is transparent in the everyday meaning of the word, *i.e.*, something you can see through.

Again, since the result we are discussing is a photograph, it is possible that the carbon at incandescence is a transmitter of actinic or chemical rays only. This would not in any way interfere with the shadow cast by the filament, but would still constitute the filament a transmitter of light.

It is quite possible that incandescent carbon may not be a transmitter of light at all, and the effect shown in the photograph be due to other causes; but at the same time the mere fact of the filament casting a shadow of itself does not negative the suggestion put forward originally, as I have shown above.—Yours, &c., ROBERT D. CASSELLS.

Pollokshields, N.B., May 18, 1896.

**Rope Gearing.**—A useful *brochure*, entitled "Manila Rope," has recently been issued by the C. W. Hunt Company of Rope-makers of New York, and forms a handy treatise on the use of ropes for the transmission of power. The early portions of the book describe the properties of manila fibre and the process of working it into finished cordage. These portions are usefully and interestingly illustrated, and among the pictures we notice an ancient Egyptian rope-walk. The illustrations showing splicing and fastening links are useful, though links have not much been used in this country. A number of tables and formulæ for rope transmission of power occur throughout the book, and a set of power curves enables the horse-power of any given rope to be determined for any given speed by simple inspection. From the sections of rope pulley grooves which are shown, it is evident that American practice differs from English in this respect. Doubtless this is partly or wholly caused by the tendency to run at higher velocities in America. Apparently the American grooves are easier and cheaper to cut, but we doubt if they wear out the rope so slowly as in English practice. However, this is merely our impression on examining the sections shown. Certainly, in some plants in America cotton and manila ropes have run satisfactorily for a great many years without renewal.

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# LEGAL INTELLIGENCE.

## Franklin and Gould v. The Exeter Electric Lighting Company (Limited).

This case came before Mr. Justice North in the Chancery Division yesterday.

The plaintiffs are trustees for the debenture-holders, and state that the Company had entered into an agreement with the Exeter Corporation for the sale of their undertaking for £7,500, which agreement would take effect on the 30th inst. The only asset of the Company outside this sale consisted of certain book debts, and a few chattels worth about £1,000, making in all £8,500. The debentures amount to £12,000. The Company was in difficulties, and there were debts which it could not pay—one of the unsecured creditors was suing the Company—and under these circumstances the debenture-holders' trustees sought to enforce the security under the debenture deed, and to ask for the appointment of a Mr. Knill as receiver with power to manage until the sale to the Corporation was effected. No opposition was offered by the Company, and judgment was given for the amount of plaintiff's security. Mr. Knill was appointed receiver and manager.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations.**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either *singly* at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated; price 12s. 6d. Will be ready next week.

**"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.**

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

TENDERS INVITED.—The Corporation of Leeds require tenders for an electrical installation sufficient for working by the overhead system a double track of tramway seven miles in length. The work is divided into seven contracts, details of which will be found in our advertisement columns. Tenders have to be sent in to the Town Clerk, Town Hall, Leeds, not later than June 20th, and particulars, plans, &c., can be obtained from the City Engineer, Municipal Buildings, Leeds, or from Dr. John Hopkinson, F.R.S., 5, Victoria-street, Westminster, London, S.W.

——— The Shoreditch Vestry invite tenders for the supply of insulated conduits, cables, switch and fuse boards and all sundry fittings and materials for installing the electric light in their new dust destructor and electricity supply station. Specifications, &c., may be obtained from the consulting engineers, Messrs. Kincaid, Waller and Manville, 29, Great George-street, Westminster, S.W., and tenders must be sent in to Dr. H. Mansfield Robinson, Vestry Clerk, Town Hall, Old-street, E.C., by 4 p.m. on Tuesday, the 16th inst. Further particulars are given in our advertisement columns.

——— The Corporation of Burnley invite tenders for the supply and delivery of armoured concentric underground cables. Specifications, &c., may be obtained from the Borough Electrical Engineer (Mr. W. R. Wright), and tenders must be sent to the Chairman of the Electric Lighting Sub-Committee, Town Hall, Burnley, by Wednesday, the 24th inst. Some additional information appears in our advertisement columns.

——— The Directors of the Caledonian Railway Company require tenders for twelve months' supplies of a quantity of stores, particulars of which are given in our advertisement columns. The requirements include copper rivets, &c., india-rubber, galvanised wire, telegraph and electric appliances, tools, bolts and nuts, &c. Specifications and forms of tender and other information can be obtained from Mr. Jas. Lorimer, Superintendent of Stores, Charles-street, St. Rollox, Glasgow. Tenders have to be sent in to the Secretary (Mr. J. Blackburn), at the Company's offices, 302, Buchanan-street, Glasgow, by Monday, the 15th inst.

——— Owing to the impending expiration of the concession of the Jamaica Street Car Company, who own about 12 miles of horse tramways in Kingston, tenders are invited for a licence to establish and work a system of rapid transit in the island of Jamaica. Plans, &c., can be seen at the office of the Crown Agents for the Colonies, Downing-street, S.W. Tenders to the Clerk of the Privy Council, Kingston, Jamaica, by July 31st.

——— Tenders are required for the supply and erection of a 92-unit *continuous-current dynamo*, and a 3½-unit combined steam engine and dynamo. Tenders to Learoyd Bros. and Co., Milnsbridge, Huddersfield, by noon of 19th inst.

——— The Municipal Authorities of Benevento invite tenders for the concession for *supplying* electric current for public and private lighting. Tenders to the Consiglio Comunale di Benevento (Italy) by the 20th inst.

——— The Municipal Authorities of Ocaña are inviting tenders for the concession for the electric lighting of the town for ten years. Tenders to El Secretario del Ayuntamiento de Ocaña (Toledo), Spain, by the 30th inst.

——— The Paris Municipal Authorities require tenders for the supply of a dynamo for the Buttes-Chaumont central station. Tenders to be sent to l'Hotel de Ville, Paris, by the 17th inst.

——— The Belgian State Railway Authorities require tenders for the supply and erection of the necessary plant and fittings required for the electric lighting of the fifth section of the locomotive works at Malines. Tenders to be sent to the Bourse, Brussels.

——— The Municipal Authorities of Alberique require tenders for the electric lighting of the town for ten years. Tenders to El Secretario del Ayuntamiento de Alberique (Valencia), Spain, by the 12th inst.

TENDERS ACCEPTED.—The Electric Light Committee of the Aberdeen Town Council have decided to accept the tender of Messrs. M'Kinnon and Co. for the supply and erection of boilers, pumps and feed-water heaters at the electricity supply station, at £2,995. The Committee have also let out separate contracts for the mason, joiner, plasterer, plumber and painter, and slater work, in connection with the extension of the station. The total of these amounts to £3,148. 16s.

——— Messrs. Richard Crittall and Co. have secured the contract for the electric installation at the West Sussex County Asylums, Chichester. The contract includes plant, battery of accumulators, wiring and fittings. The consulting engineers for the work are Messrs. Massey and Allpress.

——— At the last meeting of the Hampstead Vestry it was reported that the Brush Company were not prepared to carry out the portion of their tender for the supply of additional plant at the electricity station unless their tenders for the steam alternator and switchboard were also accepted, and under these circumstances it

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was decided to accept the tenders of Messrs. J. E. and S. Spencer (for tank and appurtenances at £395) and Wright's Patent Heater Condenser Company (for feed-water heater and steam pipes at £967) in lieu of the Brush Company's original tender.

TENDER ACCEPTED.—Some time ago the Colchester Town Council invited tenders for erecting and equipping electricity supply works, and tenders were received from Messrs. Christy Bros., the Brush Company, Siemens Bros. and Co., and the Electric Construction Company. The figures for carrying out the necessary works and for loaning temporary plant for lighting the military hospital were respectively £13,092 and £147, £12,076. 15s. and £186, £11,477 and £375, and £10,675 and £257. 10s. The Electric Light Committee now recommended that the tender of the Electric Construction Company be accepted, and that application be made to the Local Government Board for sanction to borrow £15,000 for carrying out the scheme, and this has been agreed to.

SALE BY AUCTION.—Messrs. Percy Huddleston and Co. notify in our advertisement columns that they will sell by public auction, on Tuesday, the 16th inst., the contents of the Acme and Immisch Electric Works, Ferdinand-street, Chalk Farm, N.W., comprising dynamos, motors, electrical instruments and apparatus, engines, boilers, &c, and lathes, punching and shaping machines, tools, &c.

APPOINTMENT.—At Wednesday's meeting of the Burnley Town Council the appointment of Mr. W. R. Wright as borough electrical engineer was confirmed. The salary is £200 per annum, to be increased to £250 at the end of twelve months.

APPOINTMENTS VACANT.—The Leyton Urban District Council invite applications for the post of resident engineer to the electric lighting installations now in course of construction. Some further particulars are given in our advertisement columns.

——— The Corporation of Lincoln, invite applications for the position of electrical engineer. Salary £300 per annum. Applications to Mr. H. K. Hebb, by Saturday, 6th inst.

LIQUIDATIONS.—A petition has been presented by Messrs. B. Verity and Sons for the compulsory winding-up of the Coventry Electrical Engineering Company (Limited), and will be heard at the County Hall, Coventry, on the 9th inst.

——— It has been decided to wind up the London Refuse Steam Generator and Electrical Power Corporation (Limited), and Mr. C. W. Grimwade, 38, Coleman-street, E.C., has been appointed liquidator.

THE "ENGINEERING MAGAZINE."—The contents of the June number of this magazine include: "The Fruits of Fraudulent Railroad Management," by J. Selwin Tait; "The Absence of Facts about the Nicaragua Canal," by Charles B. Going; "Relation of Electrical to Mechanical Engineering," by Elias E. Ries; "The Domestic Architecture of Washington City," by Glenn Brown; "Recent Improvements in Gold Milling," by H. M. Chance; "Modern Machine Shop Economics" (III.) by Horace L. Arnold; "The Electric *versus* the Hydraulic Elevator," by W. Baxter, jun.; "Bank Revetment of the Mississippi River," by H. St. L. Coppée; "Minor Mineral Products of the United States" (II.), by David T. Day; and "Quackery in Engineering Education," by E. H. Williams, jun., D. C. Jackson, H. K. Landis and George L. Hoxie. The usual exhaustive review of the World's Press is also given. This number, as well as all the back numbers, may be obtained at the offices of the European Edition, 1, 2 and 3, Salisbury-court, Fleet-street, London.

"CASSIER'S MAGAZINE."—The contents of the June number of this Magazine include "Electric Current Supply from Central Stations," by John W. Lieb, junr.; "Steam Superheating," by W. H. Patchell; "Steam Raising," by Bryan Donkin; "The Value of Engineering Publications in Law Suits," "Compressed Air for Street Railroads," "Making Steel Forgings in America," "Economic Workshop Output," "Modern English Traction Engines," and "Peat Fuel in Germany."

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BALLYMENA.—A special Electric Lighting Committee has been formed by the Town Commissioners.

BANGOR.—The City Council apparently intend to proceed with their electric lighting scheme, and a formal resolution has been passed in favour of making application to the Board of Trade for a Provisional Order.

BREST-ST. PIERRE CABLE.—This cable being now repaired, telegrams can be forwarded by the "P. Q." route.

BRIGHTON.—Col. J. O. Hasted, R.E., held a Local Government Board inquiry on Tuesday into the application of the Town Council to borrow £35,900 for electric light extensions. The Corporation was represented by Mr. W. P. Boxall and the Borough Electrical Engineer (Mr. Arthur Wright). Mr. Boxall gave particulars of the progress of the electricity works and of the various extensions that had been carried out. Having regard to the rapid increase in the demand for current, it was obvious that further extensions were necessary, more particularly as the Corporation had decided to supply electric current throughout the streets of the town, and the greater part of the present loan would be utilised for this purpose. Mr. Arthur Wright, who gave particulars of the proposed extensions, stated that the idea was to have public electric lighting in every street where mains were laid. The works included extensions and new machinery, new mains, &c. There was no opposition.

CHAPEL LIGHTING.—Brunswick Chapel, Sheffield, is to be wired for the electric light.

DUBLIN SOUTHERN TRAMWAYS.—The tramways of the Dublin Southern Company have been certified by the Board of Trade as fit for public traffic.

DUNDEE.—The accounts of the Electricity Department for the past year show a profit of £1,126. 15s. 1d. At the meeting of the Council, on Friday last, Mr. Treasurer Ritchie moved the abolition of meter rents and the adoption of a uniform system of discounts for the gas and electricity departments. After a long debate the motion was agreed to.——As the result of a conference between sub-committees of the Town Council and Harbour Board, it has been decided to introduce a scheme for electrically controlling the clocks of the town. An experimental installation is to be at once erected.——An interesting epitome on the progress of electric lighting in Scotland was recently given by one of the members of the firm of Lowdon Brothers, of Dundee, to a local journal. Mr. Lowdon admits that the electric light made but slow progress in Scotland until the introduction of the incandescent lamp, since which time it has gradually forged ahead, and is now being taken up in real earnest, especially amongst mill-owners, and in spinning and weaving factories. This is noticeable all over the North. Mr. Lowdon has to record very little motive power work by electricity in Scotland, and looks forward to a speedy improvement in this direction.

ECCLES.—Unless satisfactory indications were given that the Town Council intended to proceed with their electric lighting scheme the Provisional would expire, and consequently the Electric Lighting Committee have notified the Board of Trade that borrowing powers are being sought in order that the provisions of the Order may be carried out.

A Local Government Board inquiry was held on Wednesday last by Mr. G. W. Willcocks into the application of the Town Council to borrow £20,000 for electric lighting purposes. The Town Clerk, Mr. G. W. Bailey, appeared in support of the application, while Mr. Overend Evans represented a body styled "the Eccles Property Owners' Association." The Town Clerk detailed the steps that had been taken by the Council in preparing an electric lighting scheme. Tenders had been invited in order to ascertain its probable cost, and the offer of the Manchester Edison-Swan Company for £13,792 was considered most suitable; buildings, &c., would come to £4,969, making a total of £18,761. The scheme involved the lighting of all the streets in the borough, and it was proposed to adapt the present street lamps for incandescent electric lighting. Mr. S. T. Clirehugh, the consulting engineer, gave technical details of the scheme. He estimated that the annual working expenses, interest, repayment of the sinking fund, &c., would amount to £2,066. The capacity of the proposed works would be 750 20 c.p. lamps for public lighting, and 3,750 16 c.p. lamps for private lighting, and if all these lamps were on order there would be a satisfactory profit. The witness was cross-examined at some length by Mr. Evans and other opponents of the scheme as to certain details of the scheme now proposed to be carried out, with a view to comparison between this and a scheme proposed by Dr. J. Hopkinson some time ago for lighting the Eccles district. Evidence was also given by Mr. W. P. J. Fawcus, and the inquiry was adjourned.

As if to encourage the local authority to proceed with the scheme, Messrs. Ermen and Roby, who have decided to introduce the electric light at their extensive works, have written asking if the Council would be prepared to supply current to about 1,500 16 c.p. lamps. If the Council do not proceed with their electric lighting scheme the firm intend to put down an independent plant.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from May 28th to June 2nd, with the ports of destination:—

*Australasia*—Albany, £38; Brisbane, £1,411 (submarine cable); Melbourne, £407 (including £294 telegraph material); Otago, £46; Perth, £147; Sydney, £706; Wellington, £19. *Ceylon*—Colombo, £107. *Egypt* Suez, £25. *Holland*—Amsterdam, £60; Rotterdam, £10: *India*—Bombay, £63. *Japan*—Yokohama, £138. *Russia*—St. Petersburg, £33. *South Africa*—Cape Town, £180; East London, £233; *Straits Settlements*—Singapore, £34. *Sweden*—Gothenburg, £135 (telegraph wire).

*Foreign made Electrical Apparatus and Material.*—Foreign made goods have been exported from this country as follows:—

*Australasia*—Melbourne, £36. *Italy*—Leghorn, £43 (electric meters). *Siam*—Bangkok, £1,550.

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ELECTRICITY IN MINING.—As an indication of the advances which are being made in the application of electricity to mining, it is now becoming the general practice to insert in the prospectuses of gold mines for which capital is invited, full particulars regarding actual or projected electrical installations at the mines, as a further inducement, we presume, to the public to subscribe.

ELECTRIC PUMPING MACHINERY.—In the annual report of Young's Paraffin Light and Mineral Oil Company (Limited) the Directors' estimated capital outlay during the current year includes a sum of £2,500 for electric pumping machinery at Polbeth.

EXETER.—The formal transfer of the Exeter Electric Light Company's undertaking takes place on the 30th inst., and the Council anticipate an increased demand as soon as they are in a position to give a continuous supply of current. The condition of the plant at the station is at present engaging the attention of the Electric Lighting Committee.

INTERNATIONAL TELEGRAPHIC CONFERENCE.—A slight amendment is necessary to the list of names given on pages 158 and 159 of our last issue. The delegates to the conference representing the Post Office, Cape Colony and Natal are as given in our list, except that they act jointly, and that Mr. R. J. Mackay acts as secretary. The delegate for India is Mr. S. P. W. V. Luke, C.I.E. Mr. R. T. Brown's name should be omitted as representing the West India and Panama Telegraph Company.

LAHORE (INDIA).—The municipal authorities of this town are at present considering the question of the erection of an electricity supply station. Plans and estimates have already been prepared and submitted to the local Legislative Council.

LEEDS.—The Yorkshire House-to-House Company recently offered to supply the Corporation with electrical energy for working the tramways, and to put down special plant at their station in Whitehall-road for the purpose. Under a contract for a short period they would supply 300,000 units per annum at 2·3d. per unit, this price to be materially reduced if the term of the contract were extended, or an increased quantity of current be required. As an alternative the Company suggest that the Corporation should provide the special plant and apparatus, which could be of a portable nature and suitable for use at any permanent station the Corporation might erect.

LINCOLN.—The Town Council have purchased a piece of land as a site for an electricity generating station, in connection with which application is now being made for a Provisional Order.

LLANELLY.—Mr. J. C. Howell has submitted an estimate to the District Council for the electric lighting of the principal streets of the town. The matter is being considered by the Property Committee.

MANCHESTER.—The Special Tramways Committee have presented an elaborate report on the purchase of the local tramways by the City Council. The Glasgow, Blackpool, Plymouth, Leeds, and Huddersfield municipal tramways have been inspected, and the condition of working noted; but the Committee recommend that the further consideration of the matter be postponed till 1898, when the lease of the first portion of the lines expires, and in the meantime that the Corporation obtain parliamentary powers to work the tramways. The report was discussed at considerable length at the Council meeting on Wednesday, several members contending that the Council ought to take over the lines as soon as possible, and to introduce electric traction throughout the system. The last paragraph was amended so as to read that parliamentary powers be obtained in the next session of Parliament, and in this form was agreed to.

MATLOCK.—A telephone exchange has been established in this town.

OLDHAM.—The accounts of the Electric Lighting Committee for the year ended March 25th have been published, and are of a highly satisfactory character. The total capital expenditure of the year amounted to £6,289. 9s., gross revenue to £3,847. 13s. 4d., and expenditure to £1,577. 17s. 9d., a balance of £2,269. 15s. 7d. Interest on loans came to £813. 8s. 4d., and sinking fund instalment to £608. 12s. 7d., leaving a net profit of £847. 14s. 8d., which with £902. 3s. 7d. brought forward, makes a total of £1,749. 18s. 3d. to be carried forward. During the period under review, 179,966 units have been generated and 147,432 have been sold, increases of 95,599 and 78,434 units respectively on the previous year. There were 113 customers (representing an equivalent of 11,830 8 c.p. lamps) connected, an increase of 58 customers and 4,890 8 c.p. lamps respectively for the year. The maximum demand was on January 6th, the load at the station being indicated at 251 kilowatts, an increase of 116 compared with the previous year. January 6th was also the record day as to the number of units sold, the figures being 1,232 units, against 641 last year. The Committee recommend that after March 25th last the price for current used by private customers in excess of two hours' daily average maximum demand shall be reduced to 4½d. per unit, and for all current supplied to street lamps 4d. per unit. Application has been made for additional borrowing powers to the extent of £15,000. The Committee also report that two additional engines and dynamos of 200 H.P. each have been erected, and 1,187 yards of mains have been laid during the year.

PACIFIC CABLE.—Reuter's agency, under date May 29th, reports that "the Committee of Commerce of the United States House of Representatives has authorised a report to be presented in favour of the Substitute Cable Bill, which provides that the Postmaster-General may contract with the Pacific Cable Company of New York for the construction of a cable from the United States to Hawaii, Japan, and China, via the Midway Islands. It is provided that the President may control the line in time of war. The grants and subsidy for the new cable amount to $100,000 yearly, with the right of way over United States territory."

PERSONAL.—Mr. J. Harrhy, Superintendent of the Eastern and South African Telegraph Company at Benguella, West Africa, is leaving the Coast for England.

POLICE.—The journalist named Norman M'Leod who was charged at Marlborough-street Police Court with obtaining credit to the extent of £35. 10s. from Mr. R. Aylmer without informing him that he was an undischarged bankrupt, has decided to pay the money to the prosecutor, a course to which the magistrate has assented.

POPLAR (LONDON).—The Board of Works have decided to apply to the Board of Trade for an extension of time for complying with the terms of their Provisional Order.

ROTHERHITHE (LONDON).—The London Electric Supply Corporation have applied to the Vestry for leave to lay mains in the Rotherhithe New-road and Bush-road.

SUNDERLAND.—The Electric Light Committee recommend the Town Council to reduce the price of electrical energy for motive power purposes from 3½d. to 2½d. per unit. The Committee have also formulated a scheme for the further extension of the mains.

ST. HELENS.—The Local Government Board have sanctioned the borrowing of £10,000 by the Town Council for electric lighting purposes. The Council consider the period over which the repayment of the loan is spread inadequate, and have instructed the Town Clerk to apply for an extension.

SWANSEA.—On the recommendation of the Markets Committee, it has been decided to light the new Corporation Market electrically.

TUNBRIDGE WELLS.—The statement of accounts of the Corporation's electricity works for the period ended March 31st last is issued. Since the commencement of supply on August 7, 1895, 72,072 units of current have been generated, 60,571 of which have been sold, and 2,011 used on the Corporation's works. The total number of lamps connected at the date of the report is 7,066 incandescents and 21 arcs. The total capital raised is £25,000, and as no payment is due upon these borrowings until September 25th next no charge is made in the accounts for interest or sinking fund. The total capital expenditure to March 31st is £15,408. 18s. 9d., leaving an unexpended balance of £9,591. 1s. 3d. The revenue account shows a net profit of £737. 13s. 7d., subject, of course, to a proportion of interest and sinking fund charges.

WELLS.—The Town Council have decided to instruct Dr. John Hopkinson to prepare plans and specifications for the establishment of electricity supply works. This decision has been come to owing to friction with the Gas Company as to the cost of obtaining Parliamentary powers for the purchase of the gas works by the Council.

WORTHING.—The Town Council are endeavouring to obtain an extension of time for carrying out the provisions of their Provisional Electric Lighting Order.

## PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

### APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

May 11, 1896.

9,959. W. H. LANDER. Dublin. Improvements in electrical arc lamps.

9,960. F. HELMAN and J. CARROLL. Liverpool. Improvements in electric bell communication.

9,964. G. H. NISBETT. Liverpool. Improved electric cables.

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9,974. M. Binswanger and F. G. Bell. London. Improvements in and connected with electric switches.

9,975. F. Bathurst. London. Improvements in and relating to conduits for electrical conductors.

9,976. M. Binswanger and F. G. Bell. London. Improvements in hand telephones and in compound switches therefor.

9,994. H. J. Allen. London. Improvements relating to electric traction.

10,015. R. J. Crowley and A. B. Hutchings. London. Improvements in writing telegraphs

10,017. W. J. Davy. London. Improvements in electric arc lamps.

May 12, 1896.

10,047. P. K. Stern. London. System of and means for electrical transportation.*

10,066. J. Y. Johnson. London. Improvements in devices or apparatus for duplicating graphophone records. (The American Graphophone Company, United States).*

10,069. M. Pfatischer. London. A new or improved method of and apparatus for electrically controlling or adjusting the position of rudders, guns, signals, or other devices.

10,095 P. Schmidt. London. Improvements in electric batteries.*

10,096. A. O. Mackin. London. Improvements in arc electric lamps.*

10,106. W. S. Steijes. London. Improvements in step-by-step printing telegraphs

10,124. J. Devonshire. London. Improvements in systems of distribution of alternating electric currents. (C. P. Steinmetz, United States.)*

10,127. H. H. Leigh. London. Improvements in electric tram trolleys. (H. R. Keithley, United States.)*

10,134. W. J. Brewer. London. An improved system of and apparatus for the collection of electricity from overhead conductors and in conduits connected therewith.

May 13, 1896.

10,171. F. Dresser. Liverpool. Improvements in thermostatic circuit closers for electric fire and heat alarms.

10,189. F. H. Royce and E. A. Claremont. Manchester. Improvements in carbon brush holders for electromotors and dynamos.*

10,205. F. W. Heaton, H. Smith and A. Lindley. Manchester. An improved tumbler or lever action switch for electric power or light.

10,267. C. Hoepfner. London. Improvements in electrodes for galvanic batteries.

10,272. H. T. Harrison. London. Improvements in dynamo-electric machines.

May 14, 1896.

10,284. G. W. Pridmore, T. I. Sturgeon and E. Yorke. London. A new and improved reflector in connection with glass bulbs or glow lamps for electrical lighting.

10,349. A. M. Clark. London. A process of preparing metals for galvanic, electrolytic, and for other purposes.

10,358. H. Carbonelle. Liverpool. An improved system for registering or storing electric currents, and for reconstituting and delivering the currents so stored.

May 15, 1896.

10,414. W. H. Scott. Norwich. Improvements in electric hoists.

10,415. W. Sillery. Wrexham. Dynamo electrical collecting apparatus.

10,429. T. R. D. Kenny. Bradford. Improvements in holders for electric glow lamps.

10,442. W. R. Ridings. Birmingham. Improvements in arc lamps.

10,455. R. Norman. Eastbourne. Improvements in electric motors.

10,456. R. Norman. Eastbourne. Improvements in electric motors and their arrangement.

10,472. G. A. Grindle. London. An improvement in active material for secondary voltaic batteries.

10,497. J. Perry and T. Tomlinson. London. Improvements in or relating to electric traction.

May 16 1896.

10,608. The Edison and Swan United Electric Light Company (Limited) and C. F. Proctor. London. An improvement in tumler electric switches.*

May 18, 1896

10,669. A. G. New. Woking. An electrical variable speed gear.

10,670. A. G. New. Woking. An electrical variable speed gear.

10,698. H. C. Bird. London. Improvements in or applicable to electric alarm apparatus.

10,718. H. O. Tudor. London. Improvements in the manufacture of positive lead electrodes for electrical accumulators.

10,720. J. A. Timmis. London. Improvements in electrically-braking railway vehicles.

May 19, 1896.

10,772. Otis Elevator Company (Limited). London. Improvements in starting and stopping devices for electrically-operated elevators. (Otis Bros. and Co., United States.)*

10,781. H. J. Dowsing. London. Improvement in apparatus for the application of electricity to vehicles driven by mechanical means.

10,788. E. J. Bagnall. London. Improvements in electric arc lamps.*

10,803. E. Davies. Manchester. Improvements in or applicable to apparatus for heating by electricity.

10,804. H. H. Lake. London. Improvements in electric railways. (E. H. Johnson and R. Lundell, United States.)*

10,811. A. J. Marquand and E. Hancock. London. Improvements in the production of electrodes suitable for secondary batteries.

10,816. J. Devonshire. London. Improvements in electric measuring instruments. (E. Thomson, United States.)*

10,817. J. Devonshire. London. Improvements in and connected with electric brakes for electrically propelling vehicles. (W. B. Potter, United States.)*

10,818. J. Devonshire. London. Improvements in contact making and breaking devices at drawbridges in the overhead circuit of electric tramways. (W. B. Potter, United States.)*

10,846. W. P. Thompson. Liverpool. Improvements in or relating to magnetically affecting the counter electromotive force of the voltaic arc of an electric arc lamp. (C. L. Coffin, United States.)*

May 21, 1896.

10,906. W. Kingsland. London. Improvements in and connected with electrical traction.

10,948. F. Brown and C. H. Offord. Walsall. Automatic gear for making and breaking electrical contacts at given times, which times may also be varied at will.

10,949. R. O. Allsop. London. Improvements in the application of electrical motive power to cycles and road vehicles.

10,988. D. Cook. Richmond. Electromagnetic gearing.

10,993. E. Bailey and J. M. Symington. Glasgow. Improvements in electric incandescent lamps.

11,035. F. G. Treharne. Cardiff. Improvements in the manufacture of electric insulation tubing and electric insulators.

May 22, 1896.

11,133. G. Bell and G. W. Bell. Liverpool. Improvements in or connected with apparatus for the electrolytic decomposition of liquids.

11,162. F. W. Golby. London. An electric alarm apparatus. (H. Winter.)*

11,212. T. Clark. London. Improvements in dry cells for galvanic batteries.

11,216. C. Dawson. London. Improvements in electro-chemical apparatus. (F. Manza, Austria.)

11,230. H. Pieper, Fils. London. Improvements in electrical regulating apparatus for arc lamps.

11,232. C. F. P. Stendebach and O. H. Linker. London. Improved electric current conducting apparatus for electric railways.*

May 23, 1896.

11,249. W. Griffin. Halifax. Improvements in the method of and apparatus for driving electric cars.

11,320. W. M. Klees. London. Improvements in electric railway signals.

11,338. E. A. G. Street. London. Improvements in electrodes for electrolytic purposes

## SPECIFICATIONS PUBLISHED.

**Note.—All Specifications can now be obtained at the uniform price of 8d. each.**

1895.

1,587. Hope-Jones and Bowell. Electrical clocks, &c.

8,696. Wright and Quin. Electric distribution.

8,904. Menges. Battery plates.

10,895. Stegmann. Electric light standard.

11,233. Peschek. Arc lamps.

11,801. Darrah. Electric incandescent lamp reflectors.

12,035. Phipps. Cutting off gas or electric current.

18,318. Adams. Suspending arc lamps, &c.

24,375. Hegner. Electricarc lighting.

1896.

977. Parshall. Synchronising alternating current motors.

2,003. Lake (Merritt). Telegraph repeaters.

2,382. Lake (Lewin). Dynamometers.

4,234. Zimmerman. Electric lamps for vehicles.

4,788. Jacques. Electric battery, &c.

5,412. McKenna (Webb). Telephones.

6,305. Hull. Electric railways.

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## BOOKS RECEIVED.

"Les Nouveautés Electriques." By Julien Lefevre. (Paris: J. B. Baillière et Fils.)

"Instructions for Working Plant manufactured by the Brush Electrical Engineering Company (Limited)." Second Edition. Price 2s. 6d.

"The Water Supply of Barracks and Cantonments." By Major G. K. Scott Moncrieff, R.E. (Chatham: Messrs. W. and J. Mackay and Co.) Price 10s. 6d.

"Electric Lighting." By Francis B. Crocker. Vol. I. (London: E. and F. N. Spon.)

"The Facts of Life." By Victor Bétis and Howard Swan. (London: George Philip and Son.) Price 3s.

"Magnetismus und Elektrizität." By Dr. Gustav Benischke. (Berlin: Julius Springer.)

"Electricity in its Application to Telegraphy." By T. E. Herbert. (London: F. H. Goldspink and Co.).

"Inventions and their Commercial Development." By John Samson. (London: Simpkin, Marshall and Co.) Price 1s.

# COMPANIES' MEETINGS AND REPORTS.

## West Coast of America Telegraph Company (Limited).

The nineteenth ordinary general meeting of this Company was held last Friday, under the presidency of Mr. J. Denison Pender.

The SECRETARY (Mr. Frederick L. Robinson) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: In moving the adoption of the report and accounts I will deal with the report and with various items in the accounts. The gross income for the past year amounted to £32,930, as against £21,754, an increase of £11,176. This includes, however, as I will presently explain, a rebate of £3,140 made to this Company out of the international traffic receipts by two of the associated companies. The real income earned was therefore £29,790, or an increase of £8,036 for the year. During the early part of last year the traffic receipts were sufficiently favourable to justify the hope that the year's working would result in our making both ends meet, but later on the local traffic fell off, mainly in consequence of the stagnation in the nitrate trade, and this state of things continued during the remainder of the year, so that it is only owing to the rebate that we are able to meet our working expenses and also the interest on the debentures. The expenses for the year were £776 in excess of those for 1894, the increased expenditure being principally due to the higher sterling value of the Chilian dollar. This is especially the case in salaries of native employés, rent and taxes, &c., which are paid in dollars, their value being taken at the rate of exchange of the day. The London office expenses, the working expenses of your repairing steamer "Retriever," and the cost of maintaining the cables and land lines are much about the same as in the previous year. The chief item of expense this year has been a new boiler for the repairing ship. We have been obliged to send out a new steel boiler to the steamer "Retriever" to replace the old boiler, which, notwithstanding the care and attention of the engineers of the steamer—to whom every credit is due—was becoming inefficient after being in use for 17 years—an exceedingly long time, I believe—and as it is poor economy to try and save money by allowing our property to deteriorate, it was considered necessary by your Directors that a new boiler should be put in the ship. This was made in England and shipped to Callao; the total cost, including freight, taking out the old boiler and fitting the new one in its place, was £1,978. The steamer was also fitted with new coal bunkers, funnel and ventilators, and is now considered to be in first-class condition, and, barring accidents, fit for service for many years to come. With regard to repairs and renewals, during the past year the shore ends of the cable at Arica had to be renewed, and a bad fault cut out near Iquique, caused by the foundering of a vessel, which went down on the cable and damaged it very much. The Valparaiso-Talcahuano cable was interrupted by a submarine landslip, and repaired in July. I have given you, I think, full particulars in regard to the Report and Accounts, and before moving their adoption, I will, as briefly as possible, speak of our present position. The completion of the arrangements among nitrate producers to restrict the output for a term of years, and the disappearance of the friction hitherto existing between Chili and Argentina, will no doubt tend towards a revival of trade on the West Coast and have a beneficial effect on our local, as well as on our international traffic. The latter class of traffic has, I am happy to say, grown steadily since the opening of the lines between Valparaiso and Buenos Aires, in March, 1894; and in regard to the working of this line, which belongs to the Pacific and European Telegraph Company, and of the connecting cables of the associated companies, I may mention that the result of the University Boat Race last March was transmitted from London to Valparaiso, a distance of nearly 8,000 miles, in 45 seconds, and on to Iquique and Lima a few seconds later. Such a magnificent result was not achieved without preparation, but it serves to show the perfect working of our telegraphic system between this country and Chili and Peru. Of course, I do not mean to say that a message in the ordinary course could be sent at that pace, because special arrangements were made for it, but we often send messages such as the result of the Boat Race and the winner of the Derby—or something of a similar sort—really to see what can be done when arrangements are made to carry a message right through without hindrance; and when you come to think of the different transmissions that the message has over the course of the 8,000 miles, I, who know a great deal about it, having been associated with telegraphy for a great many years, consider it almost a marvel. Before concluding, I wish to make it very clear to the shareholders that the special rebate which relieved them of what would have been a loss of £3,140 on last year's working must not be taken to mean that in the event of a deficit this year it will be wiped off in a similar way. Our normal proportion of the international traffic receipts was fixed at the commencement by the associated companies—that is to say, we all agreed temporarily to certain rates when the Pacific and European line was opened, because four companies have to participate in the through rate, of which this Company is one. It was fully anticipated at the time that arrangement was come to that our share of the pool, added to our local traffic receipts, would be sufficient at least to pay our working expenses and the debenture coupons, if not to leave a balance over: but last year's working, no doubt due to temporary causes, did not realise these anticipations, and under the circumstances, and having regard to the general policy which resulted in the formation of the Pacific and European Telegraph Company, and the alliances thereunder, the special rebate in question was allowed to this Company. It must, however, be clearly understood that it was only allowed for the year 1895, and that it is quite possible it may be declined for the year 1896. However, we can only hope that the traffic may increase and that we shall be able of ourselves to make both ends meet. So far, however, the traffic this year remains pretty much as it was last year, but when you compare last year's figures with those of 1894 it is very satisfactory to find that we have an increase of over £8,000, and that we are really getting within measurable distance of making both ends meet. I think that is all I have to say, but if any one wishes to ask any questions, I shall be happy to answer them if it is in the interest of the Company that I should do so. I now move—

"*That the report and accounts for the year ended December 31st, 1895, now presented, be received and adopted.*"

Mr. FREDERICK WALTERS briefly seconded the motion, which was at once carried unanimously without discussion.

The CHAIRMAN proposed the re-election of Mr. Walters to his seat at the board.

Mr. PACE seconded the resolution, and remarked that everything in connection with the Company was now in such excellent order that with a better exchange and improved trade, the Company would enjoy a certain share of prosperity, although, perhaps, not its former prosperity.

The resolution was carried unanimously.

Mr. WALTERS, after acknowledging his re-election, proposed the re-appointment of Mr. Pender.

Mr. CLAY seconded the motion, which was carried unanimously.

The CHAIRMAN, in acknowledging his re-election, stated that there were only two Directors of the Company, and he believed that by their articles of association two members of the Board had to retire every year. His colleague and himself, therefore, had to go out of office every year, but it was hardly worth while at the present time to appoint another Director, the fees of the third Director going into the coffers of the Company.

The auditor, Mr. John Francis Clarke, having been re-elected,

Mr. LAMONT proposed a vote of thanks to the Directors for their management of the Company's affairs in the past year, and to the Chairman for presiding. He wished that the statement submitted to them had been more satisfactory for both Directors and shareholders, and that the Chairman could have held out a hope to them of a dividend in the current year.

Mr. PACE, in seconding the motion, observed that they had to thank the Directors for their care of the Company's interests, and in having succeeded so far in getting the Company "round the corner."

The motion was carried unanimously.

The CHAIRMAN, in reply, said he believed that everything that was possible to be done was being done by them. He would be glad if they would allow him to include in the vote of thanks the staff both in London and abroad.

Mr. LAMONT: Certainly.

The CHAIRMAN: Those gentlemen, he was sure, worked as hard as they possibly could to promote the welfare of the Company.

The proceedings then terminated.

## West African Telegraph Company (Limited).

The report of the Directors of this Company for the year ended December 31st last will be presented to the meeting of shareholders to be held at Winchester House, London, E.C., on Thursday next, at 12:15 o'clock.

The Company's revenue amounted to £74,333. 4s. 9d., against which £17,474. 10s. 2d. is charged for ordinary expenses, and £6,298. 1s. 10d. for expenditure relating to repairs of cables, &c. After providing for income tax, &c., there remains a balance of £49,660. 2s. 2d. From this balance £11,322. 17s. 10d. is deducted for interest on debentures, and £12,333. 6s. 8d. for sinking fund, and £15,000 has been put to the general reserve fund. An interim dividend for the six months ended June 30th last of 2s. per share has been paid, and the Directors now recommend a final dividend of 6s. per share, making 4 per cent., free of income tax, for the year ended December 31st. £1,760. 5s. 8d. is carried forward.

Sir Henry C. Mance, C.I.E., offers himself for re-election as Director, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co.

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## Electric Traction Company (Limited).

The report of the Directors of this Company for the year ended December 31st will be presented to the shareholders this day (Friday).

The allotment of the Company's share capital, the whole of which has been subscribed, took place on June 18, 1895. The Deferred shares are fully paid, and £2 per share has been paid on the Ordinary shares. On June 18, 1895, the Company entered into a contract with the Central London Railway Company for the acquisition of the necessary land and the construction and equipment of the railway with all its appurtenances to the satisfaction of the railway company's engineers. Immediately after the execution of this contract the Directors proceeded with the compulsory acquisition of the properties required for the station sites and the generating depot at Shepherd's Bush, with the result that thus far upwards of three-fourths of the total number of claims have been settled or adjudicated upon. This work is being pushed forward as quickly as possible, so that possession of station sites may be obtained to enable the work of construction to be commenced not later than July 1st next.

The line from Shepherd's Bush to the Bank has been divided into six sections, and on February 19th last, a selected number of firms, all of whom were approved by the engineers to the railway company, were invited to tender for the construction of the tunnels and shafts and incidental work in respect of these six sections. A considerable number of tenders having been received, the Directors have entered into the following sub-contracts:—Shepherd's Bush to Marble Arch, Mr. J. Price; Marble Arch to Post Office, Messrs. Walter Scott and Co.; Post Office to Bank, Mr. G. Talbot. The arrangements with regard to the station at Liverpool-street are progressing satisfactorily. The prices at which these sub-contracts—which cover the principal part of the work of construction—have been let, and the cost of acquiring the station sites are fairly in accord with the estimate formed as to the cost of the undertaking, and confirm the Directors' anticipation that the construction and equipment of the Central London Railway will be carried out within the contract price, with a fair margin of profit to this Company.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**ELECTRICAL COPPER COMPANY (LIMITED).**—This Company was registered on May 23rd, with a capital of £500,000 in 150,000 Preference and 350,000 Ordinary shares of £1 each, to acquire certain patents and inventions relating to the industrial electrolysis of metals, to acquire any other patents, licences, concessions, &c., relating to the manufacture or treatment of copper or other metals, or substances, and to use, develop, work and deal with the said patents and patent rights. The first subscribers, with one share each, are:—H. M. Matheson, C. A. Fould, E. Dumoulin, A. McKechnie, R. M. Moir, R. Lorimer and L. S. Johnson. The first Directors are:—H. M. Matheson, A. Fould, W. Jacks, A. McKechnie, R. M. Moir and E. Dumoulin.

**MALAGA ELECTRICITY COMPANY (LIMITED).**—This Company was registered on May 23rd, with a nominal capital of £57,000 divided into 10,000 Ordinary shares of £5 each, and 7,000 Deferred shares of £1 each, to enter into an agreement with Messrs. Zulueta and Co. to carry on the business of an electric lighting company in all its branches at Malaga (Spain), or elsewhere; to construct, lay down and fix all necessary cables, wires, lines, accumulators, lamps and works; to generate, accumulate, distribute and supply electricity, and to carry on the business of electricians, mechanical engineers, suppliers of electricity for light, heat or motive power purposes, manufacturers of and dealers in electric accumulators, lamps, lamp-posts, electric elevators, carbons, steam and other engines, turbines, water-wheels &c. The first subscribers are:—J. M de Zulueta, merchant (1,900 shares), A. Fowler, engineer (1,250 shares), Louis Floersheim, merchant (1,000 shares), F. S. Isaac (1,000 shares), A. Hill, (1,000 shares), T. W. Bernard (400 shares), and R. C. Wyatt (100 shares). The first Directors are Messrs. R. C. Wyatt, G. von Chauvin and A. Fowler.

**SIMPLEX ELECTRIC TRAMWAY CONDUIT SYNDICATE (LIMITED).**—This Company was registered on May 29th, with a capital of £30,000 divided into 5,000 "A" and 25,000 "B" shares of £1 each, to acquire from Mr. James B. Atherton, Rainhill, Lancs., the benefit of a certain invention in relation to improvements in the means of and apparatus for distributing and collecting electricity for the propulsion of vehicles, and to carry on the business of tramway and railway proprietors, manufacturers of accumulators, dynamos, trams, locomotives, &c., electricians, electrical engineers, electrical contractors and suppliers of electricity. The first subscribers, with one share each, are:—James B. Atherton, manufacturer, T. Snape, J.P., A. Adam, J. Atherton, R. Watson, J. Monkhouse, A. Wilkinson and R. Sumner. The first Directors are:—E. K. Muspratt, A. Adam, T. Snape and James B. Atherton.

**SOUTHERN CROSS EXPLORERS (LIMITED).**—This Company was registered on May 28th, with a nominal capital of £60,000 in £1 shares, to carry on, amongst other businesses, that of an electric light and power supply, telephone or telegraph company in all or any of its branches.

**QUEEN ANNE'S RESIDENTIAL MANSIONS AND HOTEL COMPANY (LIMITED).**—This Company was registered on May 27th, with a capital of £250,000 in 35,000 Preference and 15,000 Ordinary shares of £5 each, to acquire amongst other things the business, undertaking and assets of the Queen Anne Mansions Electric Light and Heating Company (Limited), and to carry on the business of an electrical engineering, electric lighting and power supply company in all or any of its branches. The first Directors are:—H. Bennett, J. Cator, J. Newmarch, Lord Berkeley Paget, E. Rawlings and Col. R. Vivian.

## CITY NOTES.

**MEMORANDA**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31½d. per oz. (June 4th). Consols (2¾ per cent.) 113¼—113⅜ for money, 113⅜—113½ for account; 2½ per cent. 106¼—106½ (June 4th). Stock Exchange Settling Days: Consols, July 1st; Stocks and Shares Continuation Day, June 10th; Ticket Day, June 11th; Pay Day, June 12th; Mining Share Carry-over Days, June 9th and 23rd.

**AKTIENGESELLSCHAFT ELEKTRICITATSWERKE VORMALS O. L. KUMMER AND CO.**—A dividend of 8 per cent. for the past year has been declared by this Company. The capital has been increased from £75,000 to £125,000.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended May 31st were £842, against £929 in the corresponding week of 1895, a decrease of £87. The total receipts for the half-year amount to £20,535, against £20,533 for the corresponding period of 1895, an increase of £2.

**CROMPTON AND CO. (LIMITED).**—Mr. John Trotter has joined the Board of Directors of this Company, and has been elected Chairman, in place of Viscount Emlyn, who resigned that position on being elected Chairman of the Great Western Railway Company.

**DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the month of May are £2,396.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the month of May, 1896, amounted to £73,853, against £68,382 in the corresponding period last year.

**EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the month of May, 1896, amounted to £50,256, and to £44,620 in the corresponding period of 1895.

**ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).**—The Directors of this Company have decided, subject to audit, to recommend the payment of a further dividend upon the Ordinary shares at the rate of 30 per cent. per annum for the six months ended May 31st, making, with the interim dividend at the rate of 10 per cent. per annum already paid, a total dividend of 20 per cent. for the year, and also to recommend a dividend of £20 on each Founders' share for the year. The trustees for the Founders' shares reserve fund propose to distribute to the holders of such shares a sum of £20 per share for the year out of the proceeds of investments sold and dividends received in respect of the Founders' reserve fund, making, with the before-mentioned dividend, a total distribution of £40 on each Founders' share. The dividends, &c., are payable on the 19th inst. The transfer books and register of members will be closed from the 5th to the 18th inst. inclusive.

**ELECTRIC AND POWER SCHEMES IN VICTORIA.**—The Hon. Agar Wynne, ex-Postmaster-General of Victoria, and Mr. J. A. Dawson (late Lecturer on Electrical Engineering at the Ballarat School of Mines in the same Colony) are now in London in connection with a scheme of electric lighting and power transmission. It is proposed to consolidate several Victorian supply companies into one large concern. Electric lighting is well established in the Australian Colonies, and only requires developing. The Victorian Government has recently passed an Act to facilitate and regulate the supply of electricity, which has considerably strengthened the position of companies by granting them concessions extending over a term of 25 or 30 years. This Act was framed by the Hon. Agar Wynne during his term of office, and is the first attempt at legislation on the subject in the Colonies. The gentlemen named have, we are informed, full powers to act for the companies interested, and may be communicated with at the Langham Hotel, Portland-place, W.

**HELIOS ACTIEN-GESELLSCHAFT FUR ELECTRISCHE LICHT UND TELEGRAPHEN-BAU.**—At the recent general meeting of this Company it was decided to issue £50,000 Four per Cent. Debenture stock, for the purpose of acquiring a fresh site for the erection of new workshops.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended May 31st amounted to £1,809. The amount for the corresponding week last year was £1,146; increase, £663.

**QUEEN ANNE'S MANSIONS LIGHTING AND HEATING COMPANY (LIMITED).**—The trustees to the debenture holders announce that they are prepared to pay in cash all interest accrued on the debentures to the 1st inst., and also one moiety of the principal, and, further, to deliver to the debenture-holders Second Debentures of the Queen Anne Residential Mansions and Hotel Company (Limited) for the other moiety.

**RUSTON, PROCTOR AND CO. (LIMITED).**—The report of the Directors of this Company for the year ended March 31st last states that there is a gross profit of £45,431 on the year's trading (including £3,065 brought forward), from which £4,411 has been deducted for depreciation of plant and machinery, Directors' fees, &c., leaving a net balance of £41,019. After paying interest on the £250,000 debentures, and the interim dividend of 5s. per share, there remains a balance of £24,144, and the Directors now propose to pay a dividend of 11s. per share, making, with the interim dividend, 8 per cent. for the year; £8,000 goes to the reduction of goodwill account. At the annual meeting of the shareholders on Wednesday, the report and accounts were agreed to.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended May 29th, after deducting 17 per cent of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,590.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half month ended May 31st are £2,818, against £2,620 in the corresponding period of 1895. The January receipts (estimated at £5,523) realised £5,624.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, May 27. | Price Wednesday, June 3. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending May 30. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 48 50 | 48 50 | 5 2 0 | Jan., Apr., July, Oct. | .. .. | .. .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 91½ 92½ | 92 93 | 5 7 6 | " " | 92½ | 91½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 8⅞ 9⅛ | .. .. | .. .. | 9⅛ | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 18 3 | January and July .. | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10 11 | 10 11 | .. .. | .. .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15 15½ | 15 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15⅝ | 15½ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 117 | 113 117 | 4 6 11 | June and December | 114½ | 114 |
| 10,000,000 | $100 | $8⅓ | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 2 10 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 3/0 | Cuba Submarine | 12 13 | 12 13 | 6 3 1 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 17½ 20½ | 19½ 20½ | 4 17 7 | .. .. | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 4 5 | 4 5 | 4 0 0 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 15 3 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 103⅞ 109⅞ | 106⅞ 109⅞ | 4 4 1 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10 | 9½ 10 | 4 0 0 | Jan., Apr., July, Oct. | 9⅝ | .. |
| 400,000 | 10 | 2/6 | Eastern | 17 17½ | 17 17½ | 3 14 4 | " " | 17½ | 17⅜ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 18⅝ | 18½ 18⅝ | 3 4 0 | " " | 18⅝ | 18 |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 130 133 | 130 133 | 3 0 3 | May and November | 133⅛ | 132 |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 109 | 106 109 | 4 13 0 | February & August | .. | .. |
| 250,000 | 10 | 6/6 | Eastern Extension | 17⅜ 18⅛ | 17½ 18 | 3 17 9 | Jan., Apr., July, Oct. | 17⅝ | 17⅜ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 131 134 | 131 134 | 3 0 3 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900 | 101 105 | 101 105 | 4 17 1 | January and July .. | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 17 1 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 103 | 105 108 | 3 14 11 | February & August | 105 | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 110⅞ 113⅞ | 110⅞ 113⅞ | 3 10 11 | May and November | .. | .. |
| 180,227 | 10 | 2 6 | Globe Telegraph and Trust | 10½ 11 | 10½ 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅝ | 10⅜ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17 17½ | 17 17½ | 3 8 7 | " " | 17⅛ | .. |
| 150,000 | 10 | 10/0 | Great Northern | 23 24 | 23 24 | 4 3 4 | Jan., April, and July | .. | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1833 issue | 104 107 | 104 107 | 4 14 7 | March & September | .. | .. |
| 17,000 | 25 | 37.6 | Indo-European | 52 55 | 52 55 | 4 10 11 | May and November | 54 | 53 |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 1 9 112 | 5 8 7 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 11 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's xd | 6½ 7½ | 6½ 7½ | 5 8 1 | April and October . | .. | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 135 140 | 135 140 | 4 5 9 | " " | .. | .. |
| 15,609 | 10 | 2/0 | West African Telegraph | 7⅛ 8⅛ | 7⅛ 8⅛ | .. .. | January and July .. | .. | .. |
| £233,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 103 106 | 103 106 | 4 15 6 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. .. | January and July . | 1⅛ | 1⅛ |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 99 104 | 100 105 | 7 17 8 | June and December | 103 | .. |
| 88,321 | 10 | 0/6 | West India and Panama xd | 1⅛ 1⅜ | 1 1⅛ | .. .. | .. .. | .. | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference xd | 11⅛ 11⅜ | 11 11⅛ | 5 4 4 | May and November | 11⅜ | 11⅛ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference xd | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 11 9 | June and December | .. | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian xd | 9½ 9⅝ | 9 9½ | 4 14 10 | May and November | 9⅝ | 9½ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred xd | 6⅜ 7½ | 6⅜ 7½ | 5 3 8 | " " | 7 1/16 | 6⅞ |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary xd | 2½ 3 | 2½ 3 | .. .. | .. .. | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 104 108 | 104 108 | 5 13 2 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 104 108 | 104 108 | 5 13 2 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 2 3 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 105 | 102 105 | 5 15 11 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3 3½ | 3 3½ | 3 11 5 | .. | 3 1/16 | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/16 1/16 | 1/16 1/16 | .. .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | 1/16 1/16 | 1/16 1/16 | 7 5 6 | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7½ 7⅝ | 7⅝ 7¾ | 3 9 10 | June and December | 7⅛ | 7½ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 18 | 16 18 | 3 6 8 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16⅛ 17⅛ | 16⅛ 17⅛ | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅝ 6⅞ | 6⅝ 6⅞ | 3 12 9 | " " | 6¾ | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 4 6 | January and July .. | 108⅛ | 107½ |
| 58,000 | 5 | 3/0 | United River Plate | 3½ 4 | 3½ 4 | .. .. | " " | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 99 104 | 100 105 | 4 17 1 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ 15½ | 14½ 15½ | 3 4 6 | .. | 15½ | 15 1/16 |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ 17 | 16½ 17 | 3 10 7 | .. | .. | .. |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 138 | 134 138 | .. .. | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. .. | .. .. | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 8½ 8¾ | 8½ 8¾ | .. .. | .. .. | 8½ | .. |
| £67,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | .. .. | .. .. | .. | .. |
| 22,175 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8½ 9½ | 8½ 9½ | .. .. | .. .. | .. | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ 13½ | 12½ 13½ | 4 8 11 | .. .. | 13¼ | 13 |
| 8,322 | £5 | .. | House-to-House Electric | .. .. | .. .. | .. .. | .. .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. .. | .. .. | .. .. | .. .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. .. | January and July .. | .. | .. |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 8 8¼ | 8 8¼ | 3 10 7 | .. .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | .. .. | .. .. | .. .. | .. .. | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 14 15 | 13½ 14½ | 2 15 2 | .. .. | 14⅜ | 14½ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 123 | 120 123 | 3 14 5 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9 9½ | 9 9½ | .. .. | .. .. | .. | .. |
| .. | .. | .. | Rand Electric | ⅜ ½ prem | ⅜ ½ prem. | .. .. | .. .. | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 10½ 11 | 10½ 11¼ | .. .. | .. .. | 10⅝ | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 3 7 | .. .. | 10½ | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9½ 10 | 9½ 10 | 3 10 0 | .. .. | 9⅝ | 9½ |
| | | | **ELECTRIC MANUFACTURING, &o., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1⅝ 1⅞ | 1⅝ 1⅞ | 5 8 8 | .. | .. | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅞ 1⅞ | 1⅞ 1⅞ | 3 4 0 | .. | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 114 | 111 114 | 3 19 9 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1½ 1⅞ | 1½ 1⅝ | 8 10 11 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 104 107 | 104 107 | 4 5 9 | January and July .. | .. | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. .. | .. .. | .. .. | .. .. | .. | .. |
| 110,000 | 2 | .. | Electric Construction | 1½ 1⅝ | 1 1½ | .. .. | .. .. | 1⅝ | .. |
| 12,845 | 2 | 2 9/8 | Do. 7 per Cent. Cumulative Pref. | 2½ 3 | 2½ 3 | 4 13 4 | September | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ ⅞ | ½ ¾ | .. .. | .. .. | .. | .. |
| 22,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. .. | .. .. | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23 24 | 23 24 | 4 3 4 | February & August | 23⅜ | 23 |
| £200,000 | 100 | 4½% | * Do. 4½ per Cent. Debentures, 1896 | .. .. | 105 107 | .. .. | March & September | .. | .. |
| 15,995 | £10 | .. | International Okonite Ordinary | .. .. | .. .. | .. .. | .. .. | .. | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. .. | .. .. | .. .. | December and June | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ⅛ ¼ | ⅛ ¼ | .. .. | .. .. | .. | .. |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 41 | 38 41 | 4 7 10 | March and July.... | 40 | 39 |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 105 | 104 107 | 4 15 3 | January and July | .. | .. |
| 37,514 | £5 | .. | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. .. | .. .. | .. .. | .. .. | .. | .. |
| 41,093 | £5 | .. | Do. Preference (fully paid) | .. .. | .. .. | .. .. | .. .. | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16 17 | 16 17 | 3 8 7 | March & September | 16⅝ | 16½ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 17 18 | 17 18 | 3 17 9 | .. | 17⅝ | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 114 | 109 114 | 3 19 9 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 42 44 | 42 44 | 2 16 10 | January and July .. | .. | .. |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 15 15½ | 15 15½ | 3 4 6 | .. | 14⅞ | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 135 137 | 135 137 | 2 18 5 | May and November | .. | .. |
| 87,500 | £10 | 3½% | Liverpool Overhead Railway | 14¼ 14½ | 14 14½ | 2 2 6 | .. | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 17⅛ 17⅜ | 17⅛ 17⅜ | 2 16 10 | .. | .. | .. |
| 135,000 | Stock | 4% | Do. 4% Debenture | 114½ 116½ | 114½ 116½ | 3 10 10 | January and July .. | .. | .. |

In calculating the yield on this security allowance has been made for accrued interest but not for redemption.

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# THE UNIVERSAL STEAM ENGINE

(RAWORTH'S PATENT).

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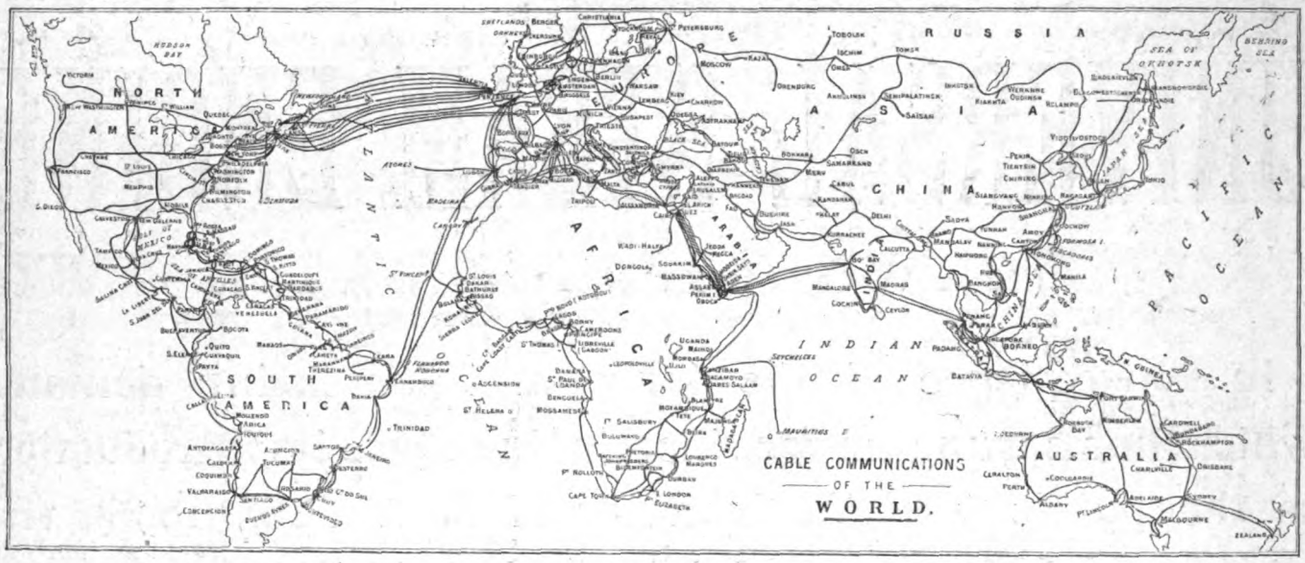
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

# EASTERN TELEGRAPH COMPANY

IN CONNECTION WITH THE (LIMITED),

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6. STEAM ENGINES.
7. DYNAMOS, SWITCHBOARDS and ACCESSORIES.

Tenders endorsed with the number of the contract must be sent in, addressed to the Town Clerk, Town Hall, Leeds, not later than JUNE 22nd next.

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Sealed Tenders, addressed to me, and endorsed "Tenders for Electricity Works," must be left at my office, on or before Thursday, June 25th.

A fee of one guinea will be charged for a copy of either of the specifications, which will be refunded on the return of the specification, accompanied by a bonâ fide tender. The lowest or any tender will not necessarily be accepted.

By Order,
J. L. WHEATLEY, Town Clerk.

Town Hall, Cardiff, May, 1896.

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THE CITY OF LONDON ELECTRIC LIGHTING COMPANY (Limited).

NOTICE is Hereby Given that the TRANSFER BOOKS and REGISTER of Holders of Debenture Stock will be CLOSED from the 21th to the 30th June, 1896, inclusive; and that the Transfer Books and Register of Holders of Preference Shares will be CLOSED from the 30th June to the 14th July, 1896, inclusive, for the preparation of interest and interim dividend warrants.

By order,
J. CECIL BULL, Manager and Secretary.

1 and 2, Great Winchester-street, London, E.C.,
11th June, 1896.

THE EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (Limited).

The SHARE REGISTER of this Company will be CLOSED from the 7th to the 14th JULY next, both days inclusive.

By order,
F. E. HEISE Secretary.

Winchester House, Old Broad-street,
London, E.C., 5th June, 1896.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (Limited).

NOTICE is Hereby Given, that the TRANSFER BOOKS of this Company will be CLOSED from WEDNESDAY, 17th, to TUESDAY, 23rd June, both days inclusive, preparatory to paying an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended March 31st, 1896, and payable on the 24th June.

By order,
RICHARD COLLETT, Secretary.

Winchester House, Old Broad-street,
London, E.C., June 10th, 1896.

**APPOINTMENT VACANT.**

COUNTY BOROUGH OF SOUTH SHIELDS.

ASSISTANT ELECTRICAL ENGINEER.

The Electric Lighting Committee invite APPLICATIONS for the post of ASSISTANT and DRAUGHTSMAN to the Borough Electrical Engineer, at a salary of £100 per annum.

Candidates must have had training in mechanical and electrical engineering and be competent draughtsmen.

Preference will be given to candidates who have had experience in a high-tension alternating station.

The person appointed will be required to devote the whole of his time to the service of the Corporation.

Applications, with copies of not more than three testimonials, to be delivered under cover, endorsed "Assistant Engineer," at the office of the undersigned not later than 10 a.m. on Thursday, 25th June, 1896.

By order,
J. MOORE HAYTON, Town Clerk.

Court Buildings, South Shields, June 9, 1896.

**SITUATIONS VACANT AND WANTED.**

TELEGRAPH INSTRUMENT MAKERS.—FOREMAN WANTED to take charge of repairs department in a large factory. Must be a first-class mechanic, well up in modern methods of economically manufacturing and repairing all kinds of telegraph and telephone apparatus, a good organiser, and have had previous experience in a similar position.—Address in confidence, giving full details of past experience, age, and salary expected, to No. 2,220, *Electrician* Office, Salisbury-court, Fleet-street, London, E.C.

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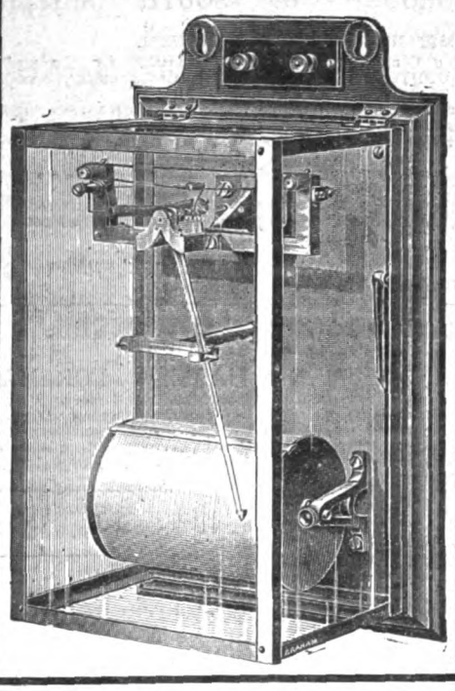

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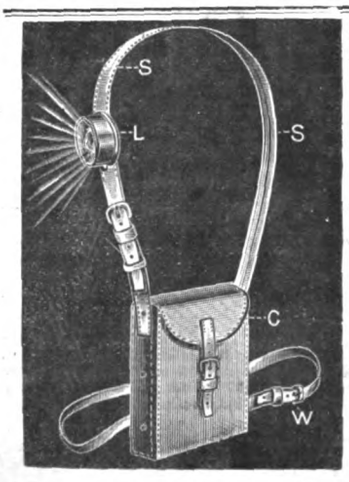


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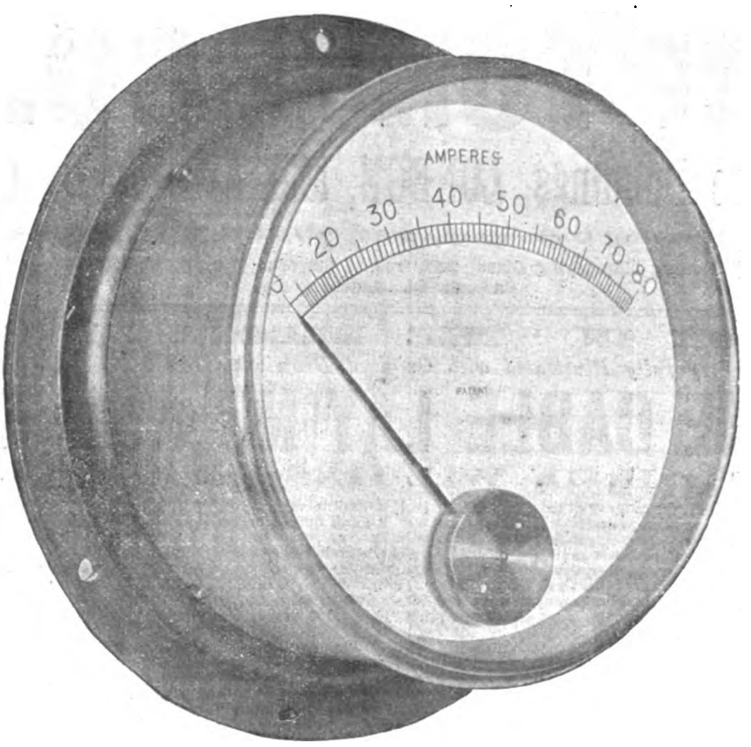


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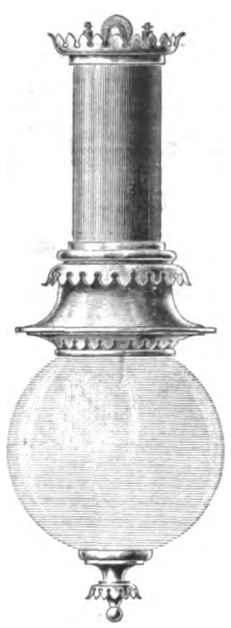

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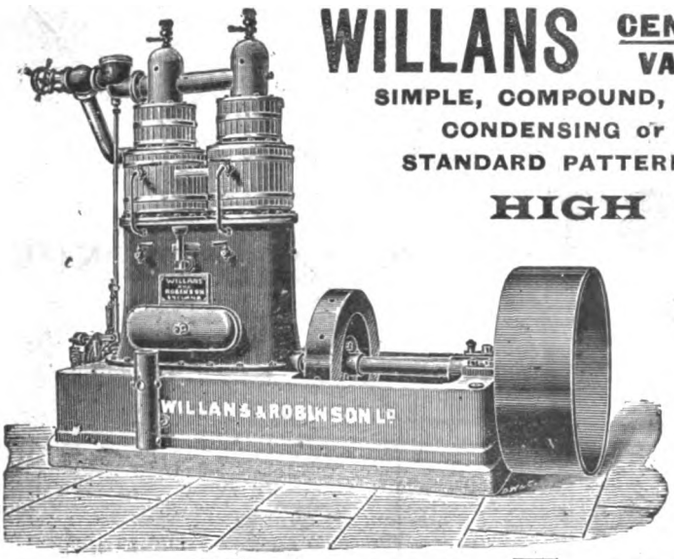


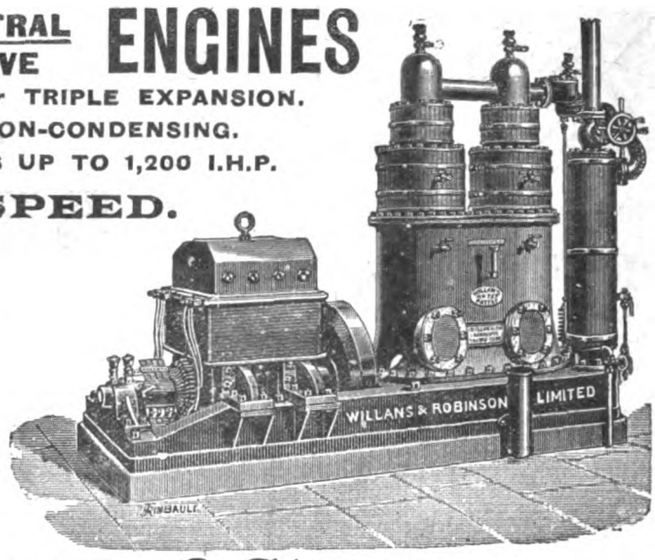


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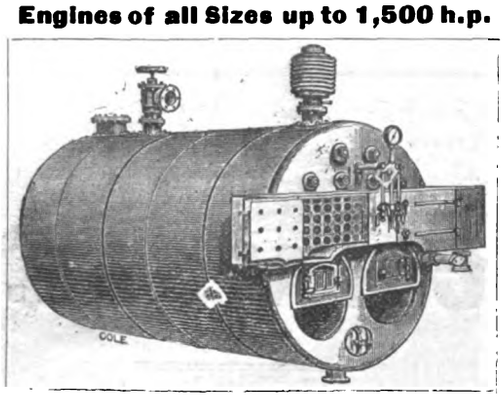

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A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 943. [Vol. No. 7. XXXVII.] FRIDAY, JUNE 12, 1896. PRICE SIXPENCE.


## NOTES.

THE statement that has gone the round of the daily papers, to the effect that electric traction trials took place on the Inner Circle after hours on Monday and Tuesday night is correct, with this exception—there was nothing electric about the traction. Experiments were merely made to ascertain accurately the starting effort, average power, average speed, &c., &c., of a locomotive attached to a fully-loaded Metropolitan train. The data thus obtained will certainly be made use of in connection with electric traction schemes, but that is the only connection the trials had with electricity.

BUT a very small proportion of the comparatively few electrical exhibits at the Royal Society's *conversazione*, last Wednesday, were on show for the first time. RÖNTGEN ray apparatus was again very much to the fore, an interesting series of experiments in this evergreen subject having been exhibited by Prof. SILVANUS THOMPSON, who also showed EBERT'S method of exciting luminescence in a vacuum tube by means of high-frequency discharges. Messrs. SIEMENS, BROS. AND CO. showed a collection of historically interesting vacuum tube apparatus. Many of the specimens, however, including the 1751 vacuum tube of Dr. WATSON, were shown only in *facsimile*. Among the entirely novel exhibits we noticed a set of apparatus for the magnetic testing of bar and sheet iron, shown by Prof. AYRTON and Mr. MATHER. Although this apparatus, we believe, has never before been shown in public, it has for some time past been used in the laboratories of the Central Institution, and mention of it was made by Prof. AYRTON at the meeting of the Institution of Electrical Engineers, when Prof. EWING described his hysteresis meter.

THE method adopted in using this testing set consists in placing the test bar, or test bundle if sheets are being proved, as a yoke in the field magnets of a little two-pole dynamo. Coils are placed on the test piece, the winding being so adjusted that ten times the magnetising current gives the value of H, this current being passed through an ammeter in the exciting circuit. The armature of the little dynamo is run at a steady speed of 1,150 revolutions per minute, as indicated by a speed indicator coupled to the spindle; and the E.M.F. generated is indicated by a high resistance or electrostatic voltmeter placed across the brushes. When the voltmeter reading is multiplied by 10,000, the product is the value of B in the test piece. A rheostat in the exciting circuit enables a succession of conditions to be produced, and the fact that all the magnitudes are read as steady deflections makes the method very handy and convenient.

NEAR by Prof. AYRTON and Mr. MATHER'S exhibit Mr. J. FRITH showed the apparatus which he had used in connection with his measurements of the resistance of the electric arc. The apparatus was in action, and very prettily showed the curious difference between the behaviour of a solid and a cored carbon arc, in respect of the phase relation of current and impressed potential difference. It may be of interest to those of our readers who were not privileged to attend the Royal Society's *conversazione* to know that the Lords of the Committee of Council on Education have arranged that most of the exhibits shall be shown to the public for a fortnight, in the western galleries of the Science Museum at South Kensington.

THE ordinary Friday Evening Discourses at the Royal Institution concluded last week with an address of unusual interest on "Electric and Magnetic Research at Low Temperatures." Not only were Dr. FLEMING'S experiments so arranged as to be visible to all whom they might concern, but the lecturer spared no pains to make their purport plain to his audience. As we hope to publish Dr. FLEMING'S discourse in full at an early date, we will only allude now to a few of the many striking experiments and interesting points.

BY means of a huge slide-wire bridge the great increase which takes place in the conductivity of pure metals when cooled to the temperature of liquid air was very prettily shown. An iron coil was balanced against a copper coil at the temperature of the room (an unpleasantly high one, we may remark in passing, notwithstanding the large quantities of liquid air which were being ladled about); the iron coil was then immersed in liquid air, and not until the slider had been moved to nearly the other end of the bar was the balance restored: at −197deg. the iron was a 30 per cent. better conductor than the copper. Did our electric supply companies but know the secret of maintaining their mains at this refreshing temperature, the public might possibly have to place a limit on their dividends. Of course, as the lecturer tantalisingly pointed out, could we keep our wires at absolute zero the finest

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metallic filament might serve the purposes of the largest undertaking. At the same time, there would appear to be certain drawbacks to this happy state of things, since the electromagnetic screening power of pure metals increases *pari passu* with their conductivity. The augmentation in the screening power of a very thin aluminium sheet, which is brought about by low temperature, was well shown by placing a glow lamp in the secondary of a small transformer. At the temperature of the room the sheet, when interposed between primary and secondary, had but little effect; after immersion in liquid air its interposition immediately dimmed the light.

Low-temperature research does not, however, result merely in the discovery of extraordinary peculiarities, such as the varied magnetic states of nickel-iron alloys and manganese steel, but we have in liquid air a splendid piece of physical apparatus. Let us take, for instance, the quaintly abnormal behaviour of bismuth. Chemically prepared with all possible care, the resistance curve of pure (?) bismuth exhibits a minimum point at −80deg. The electrolytically-prepared substance, on the other hand, behaves in a perfectly normal manner, and its resistance line, like that of any other self-respecting metal, tends towards zero at the absolute zero of temperature. It is evident that we have here a method of detecting impurities rivalling the spectroscope in sensitiveness.

Dr. Fleming, at the conclusion of his discourse, hazarded an hypothesis, but we cordially concur in his dictum "that a much more important duty at the present time is the collection of facts and the completion of accurate quantitative measurements." England has now a long lead in the matter of low-temperature research, and we trust that both the men and the money will be forthcoming to enable this lead to be maintained. Science, it is true, knows no geographical boundaries, but many of those who devote their lives to scientific research still retain a remnant of an ancient superstition known as patriotism, and would like in this matter to see England first—and the rest nowhere.

The first meeting of the Municipal Electrical Association was a distinct success. Representatives of the Board of Trade attended and took part in the debates, and everyone else who had the remotest claim to be listened to was urged to do likewise. So catholic, indeed, was the spirit prevailing that one almost expected to hear the President call upon any stray representative of the gas interest who might, perchance, be present to say what he could in his own defence or—for ever after hold his peace. By way of reaction, possibly, against the long-drawn-out agony of the proceedings of more elderly institutions, the Papers, and, with few exceptions, the remarks of the speakers, were distinguished by extreme brevity, not to say extreme haste. The defect, however, is one that time will cure; the Municipal Electrical Association, we doubt not, will soon acquire the leisurely dignity of age.

The debates on Wednesday morning centred around two burning questions; the high voltage lamp and the control of the consumer's wiring by the electrical undertaker. The same sharp divergence of opinion as to the merits and demerits of the 200-volt lamp displayed itself in the theatre of the Royal United Service Institution, as was recently the case at 25, Great George-street. The evidence of the few central-station engineers who have had actual experience of 200-volt lamps was uniformly favourable, and the prognostications of those who have not as yet taken the plunge were as uniformly unfavourable. There are not at present sufficient data to warrant dogmatic generalisation. The discussion, therefore, was mainly of use in showing that the central-station engineer is not going to be "rushed" into this new movement, that he fully realises, to quote Mr. Stearn's words, "the high-volt lamp movement would be self-condemned unless an 8 c.p. lamp is forthcoming," and that he has not lost sight of the consumer's point of view.

Mr. C. H. Wordingham's Paper on "The Control by Municipal Authorities of Consuming Devices and the Wiring connecting them to the Mains" gave rise to a very instructive debate. There was a marked consensus of opinion that on no account should municipalities undertake house-wiring themselves. On the other hand, there was an equally marked expression of opinion in favour of uniform stringent rules to be relentlessly enforced. Well, for our own part, we must confess to a disbelief in the efficacy of stringent rules, and in the policy of enforcing them with a high hand. There was sound common sense and no little knowledge of human nature in Mr. Raworth's appeal to municipal engineers. Let them, he said, by all means draw up a uniform code of rules, and make them as stringent as they please, within reason; but instead of irritating and alarming the consumer by insisting on a rigid adherence, let them present each intending user of current with a nicely got-up copy of the rules, and gently hint that he would do well to bind the wiring contractor to act up to them. Let the energetic engineers, who, at the late Westminster Conference rightly struggled to be free, do as they would be done by. Time and enlightened self-interest will eliminate jerry-wiring in due course, and as far as may be.

On Thursday Mr. Arthur Wright's Paper on "The Cost of Electricity Supply" was discussed with so much vigour that it appeared at first as if no energy were left to discuss Mr. J. A. Jeckell's Paper on "Cable Specifications and Tests." Mr. Alexander Siemens, however, in the course of a long and interesting speech, touched upon so many sore points that before the debate terminated Mr. Nisbett, Mr. Stuart Russell and Mr. Callender, as representing sellers of cables, and Mr. Crompton and Mr. Raworth, as representing buyers, had taken part in it. The speeches were all of a thoroughly practical character, and will repay perusal. A Paper left over from the previous day was then submitted to the happy despatch, and two more Papers were promised for the afternoon. Certainly a little more deliberation in the proceedings of the Municipal Electrical Association would not be amiss; they resembled in many respects the breathless haste of a meal snatched at a railway station by a traveller in the Scotch express.

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As will be seen in another column, it is announced that Messrs. Willans and Robinson (Limited) intend to petition for the extension of one of the master patents embodied in their well known steam engine. This patent principally relates to the use of the air cushion or elastic buffer, which does duty in place of compression and pre admission of steam during the later part of the return stroke. Upon the use of this cushion the successful working of the single-acting engine invented by Messrs. Willans and Robinson largely depends, and it may be said to constitute one of its vital parts. In itself the idea possesses all that "unusual merit" without which no invention can have its letters patent extended beyond the ordinary natural period. The days of the years of a patent are 14 years, and if by reason of "unusual merit" they are to gain another seven years it must also be shown that "inadequate remuneration" has resulted during the normal life. Moreover, it must be shown that inadequacy of reward for his labours has been no fault of the patentee. Much will turn upon the limit which is placed upon the adjective *adequate*. A priceless invention can never be adequately rewarded, even though by its aid the patentee should rival Cræsus. Again, it may be argued in this particular instance that though through the electric lighting industry the Willans engine has done well, it might have done very much better and have reaped a more adequate reward had the electric traction "boom" commenced some 10 or 14 years ago, instead of to-day. In view of the well-deserved prosperity of Willans and Robinson (Limited) the arguments brought forward to prove the inadequacy of the financial return upon Patent No. 4,901 of 1882 will be of unusual interest to inventors.

Congratulations were the order of the day at the thirty-third annual general meeting of the Incorporated Gas Institute recently held in the rooms of the Society of Arts. Mr. W. R. Chester, in the course of his Presidential Address, spoke jubilantly of the prospects of the gas industry, and informed his audience that the electric light was being left far behind in the race for public favour as an illuminant, and was for many years to come likely to enjoy the equivocal title of "the light of the future," and this title no gas engineer would grudge it. The figures presented by Mr. Chester in support of this view do not quite bear out his statement, but this is a mere detail. Gas engineers had, the speaker said, grown accustomed to startling sensations in connection with the electric light in times past; but the "worst development" was in these days hardly likely to cause the purveyors of gas any serious alarm. The meeting reflected the optimism of its Chairman.

**Royal Society.**—Among the Papers down for reading at the Royal Society yesterday was a Paper by Dr. J. A. Fleming, F.R.S., and Prof. J. Dewar, F.R.S., on the "Magnetic Permeability and Hysteresis of Iron at Low Temperatures."

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique ..... ..... | Dec. 19, 1895. |
| Ceara—Maranham ..... | April 28, 1896. |
| Monte Alegre—Santarem ..... | May 5, 1896. |
| Cadiz—Teneriffe..... | June 6, 1896. |

**Pacific Cable Conference.**—The first meeting of the Committee of the Imperial, Canadian and Australian delegates appointed to consider the scheme for the establishment of a direct cable communication between England and Australia through the dominion of Canada, was held last week at the Colonial Office. The Committee have decided that the meetings shall be absolutely private, and that no communications shall be made to the Press as to the proceedings.

**Institution of Electrical Engineers.**—The Honorary Solicitor of the Institution considers that, inasmuch as the form in which the resolutions amending the Articles of Association passed at the special general meeting, held on the 29th u't., was not precisely in accordance with the notice convening the meeting, it is necessary that the matter should be commenced *de novo*, and a meeting for that purpose is to be held on Monday next, the 15th inst., at four o'clock, at the offices of the Institution. The meeting is, of course, for Members only.

**Electric Traction Schemes for Glasgow.**—The Tramway Committee of the Corporation have received an offer from the Simplex Electric Tramway Conduit Syndicate (Limited) to carry out the work of demonstrating the suitability of their system for the Glasgow tramways. It is suggested that the Springburn route should be selected, and the Syndicate will carry out the work in connection with the demonstration at their own expense. Drawings and estimate for the application of the system to the tramways generally of the city have been submitted.

**The Claret-Wuillemier System of Electric Traction.**—Our Paris correspondent writes that the electric tramway from the Place de la République to Romainville has been working satisfactorily since its inauguration a few days ago. We fully described the Claret-Wuillemier sectional-conductor method of working in our issue of September 28, 1894, p. 630. The system was in operation for six months at Lyons during the Exhibition. In Paris there would appear to be considerable sparking as the collecting shoe successively leaves each sectional conductor.

**Terrestrial Magnetism.**—In his Annual Report to the Board of Visitors the Astronomer Royal states that the usual magnetic observations have been made at Greenwich, the mean declination for 1895 being 16deg. 57·4min. west. Uncertainty attaches to the results of the mean horizontal force owing to the permanent effect of the iron in the new altazimuth pavilion, and the results of the magnetic dip are affected to the extent of about 3min. or 4min. for the same reason. An independent determination at a place sufficiently removed from the building is urgently required, but the question has been deferred pending the settlement of the site for the new magnetic building. During the year 1895 there were no days of great magnetic disturbance.

**The Trunk Telephone Service.**—In Tuesday's *Times* Messrs. Mellors, Basden and Mellors, of Nottingham, write as follows:—

We yesterday had occasion to telephone to Birmingham. After conversing for about one minute the girl at the Post Office telephoned, "Time up." We thereupon asked for a second three minutes, stating that we would pay for it. The answer was, "You must ring off and telephone to the National Telephone Company again for them to ask us to put you in communication." This meant a further half-hour in getting through by the exchange between here and Birmingham. We to-day wanted to converse with Mansfield, and after one minute's conversation, owing to one of the principals having to be called to the telephone, the Post Office again informed us "Time was up," and they could not allow us to continue the conversation, but we must ring up again. On complaining to the National Telephone Company they inform us that from June 1st the Post Office authorities have taken over the trunk lines. We have never had this difficulty before, and it practically renders the telephone to long distances almost useless for business purposes. It therefore appears as if the State control is to be exercised to the detriment of business matters.

**A Willans Patent.**—Notice is given that it is the intention of Willans and Robinson (Limited) to present a petition to Her Majesty in Council praying that Her Majesty may grant new letters patent, or that the term of patent No. 4901 of October 14, 1882, may be extended. Notice is further given that on July 11, 1896, next, or on such subsequent day as the Judicial Committee of Her Majesty's Privy Council shall appoint for that purpose, application will be made to the said Committee that a day may be fixed for hearing the matter of the petition and any person desirous of being heard in opposition to the petition, must give notice of

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such opposition and enter a caveat to that effect in the Privy Council on or before the said July 11th, next.

**London-Paris Trunk Telephone Communication.**—In the House of Commons last week the indefatigable Mr. Henniker Heaton asked, amongst other things, whether it was the fact that two new telephone cables and land lines were about to be constructed between Paris and London; whether he could state what was the estimated cost, and whether any reduction in the present high tariff of 8s. for three minutes' conversation was contemplated. Mr. Hanbury replied that the Governments of the two countries were agreed that at least one new submarine cable for telephonic and telegraphic purposes ought to be laid, and the land lines to serve this cable were in course of construction. The question of a second new cable was still under consideration. As a contract for the construction of the first cable had not been made, it would not be convenient to give an estimate of the cost. The expenditure on the cable and the receipts for the whole service would be shared equally between the two countries. No reduction in the charges for telephonic conversations with Paris was contemplated.

**Niagara.**—General satisfaction, says our Niagara correspondent, is felt at Niagara Falls and, in fact, all Western New York, over the fact that on Thursday, May 28th, just before the close of the 30-day period following the end of the Legislature's session, Governor Morton signed the Bill confirming and ratifying the power rights of the Niagara Falls Hydraulic Power and Canal Company. This Company is the oldest power concern at the Falls, and now for the first time it has a legal and recognised right to divert water from the Niagara river for power purposes, the Bill containing the following important declaration:—

Section 1.—The right of the Niagara Falls Hydraulic Power and Manufacturing Company to take, draw, use and lease and sell to others to use the waters of Niagara River for domestic, municipal, manufacturing, fire, and sanitary purposes, and to develop power therefrom for its own use, and to lease and sell to others to use for manufacturing, heating, lighting and other business purposes, is hereby recognised, declared and confirmed, and the exercise thereof by said Company, its successors and assigns, to take and to draw water from Niagara River for use and disposal to others to use for the purpose above specified and for the development of power for use and for disposal to others to use for purposes above mentioned, is hereby limited and restricted to such quantity of water as may be drawn by means of the hydraulic canal of said Company when enlarged throughout its entire length to a width of 100ft., and to adopt a slope sufficient to carry at all times a maximum uniform depth of 14ft. of water, provided that exercise by said Company of the rights hereby declared and confirmed shall not impair the practical navigation of Niagara River.

**Tommasi Electro-Refining Apparatus.**—At a recent meeting of the Académie des Sciences, M. D. Tommasi described an arrangement devised by him in connection with the refining of ores and alloys. The electrolytic vessel is rectangular, and contains a pair of anodes; in the middle of these anodes is the cathode, which consists of a rotating disc not plunged completely into the electrolyte. The disc as it emerges from the liquid passes between two rubbers, which deprive it of the spongy deposit as fast as it is produced. Suitably arranged troughs are ready to receive the deposit as it falls from the disc. The anodes are either plates or compacted granular powder. The inventor claims for this device that polarisation is completely suppressed, since the rotation of the disc against the scrapers facilitates the liberation of the hydrogen; and the metal which is deposited on the disc, being taken away as rapidly as it is deposited, is not oxidised, which results in a lower resistance and consequent economy in electrical energy. Finally, M. Tommasi claims that the density of the electrolyte is maintained fairly uniform by the agitation caused by the rotation of the disc.

**The Control of Telephone Operators.**—To overcome the disadvantages of the present system of supervising the operations of telephone operators by the personal supervision of another official, the Stockholm Telephone Company recently introduced into their larger exchanges an automatic device which allows of a strict control over the working of the exchange. The *Elektrotechnische Zeitschrift*, in its issue for June 4th last, gives the following description of the arrangement:—The exchanges are fitted for night service, and for that purpose the annunciators are provided with contact devices, which in falling close a circuit and cause a bell to ring. This arrangement is now employed during the daytime, but a call-indicator is put in place of the bell. This call-indicator consists of an electromagnet, the armature of which moves a signal behind a little window. The ring-off indicators are provided with the same device, the only difference being a different colour of the signal. Besides facilitating the control of the operators, the arrangement assists the operator to a large extent, as it saves the continuous and tiring observation of the annunciator-board. The operator has only to watch the call-indicator, and, when it signals, to look at the annunciator-board. The new exchange at Christiania, just opened, has a similar device.

**Damage by Lightning.**—Several fatalities and considerable damage to property occurred last week by reason of the thunderstorms that took place in various parts of England. At Stanley Downton, Gloucestershire, Harry Stanley, a young farm worker, of Coaley, was killed by lightning on Friday evening. A heavy storm of rain, accompanied by thunder and vivid lightning, came on while the deceased was at work, and he left one field to shelter under an elm tree in another. He was subsequently found under the tree sadly disfigured. His watch was scarcely recognisable as a watch, and a wooden handled knife was charred. The bark of the tree was in part stripped off.—During a thunderstorm at Newton Cunningham, Donegal, on Saturday last, two men named Campbell and Rutherford were struck by lightning and killed.—At Middlesborough a quarryman employed at the Ayton Whinstone Quarries was struck by lightning whilst breaking up some whinstone, and killed.—On Wednesday evening, as a family party who had been on pleasure to Great Ayton were returning home in their waggonette, a flash of lightning struck the vehicle and its occupants. The driver was seriously struck on the forehead and neck. The other members of the party were comparatively unhurt.—At Thirsk, a farm labourer named Fleet, who had had to stop ploughing operations on account of the storm, and was returning home with a pair of horses, was struck and killed. One of the animals, a fine mare, was struck dead, and the other horse had its shoes torn off.—At Middleham, a race horse, which was being exercised on the moor, was killed.—During a severe thunderstorm at Alfreton a lad named Walter was struck by lightning and seriously injured; and one Alfreton farmer had ten sheep killed during the storm.

**Contemporary Electrical Science.**—In *Wiedemann's Annalen* we find an interesting Paper by P. Drude on the anomalous electric dispersion of liquids. The most remarkable observation is that certain substances do not damp electric oscillations to the same extent as might be expected from their conductivity. The better a body conducts the more rapidly should electric oscillations die out when propagated through it. But a 5 per cent. solution of copper sulphate, which is 6,000 times more conducting than glycerine, does not surpass the latter in damping power. An electric wave 74cm. long will only proceed for a wave length and a-half in either liquid. Further investigation showed that glycerine, ethyl and amyl alcohol, and acetic acid exhibited anomalous electric dispersion and absorption. The dielectric constants of these liquids for slow oscillations is smaller than the square of the electric index of refraction for rapid oscillations. Water, methyl alcohol, and benzol show no such anomalies.——A. Hagenbach made some thermo couples of amalgams of certain metals and their salts. The accepted theory demands that as the salt solutions are diluted the thermo-electric force increases. This is actually the case with monovalent ions, but does not hold good for divalent metals such as cadmium and lead. A couple, consisting of cadmium amalgam and a solution of a cadmium salt, decreases in E.M.F. as dilution is increased from 0·1 to 0·0001.——Leo Arons describes his apparatus for investigating the arc light produced between terminals of mercury, amalgams, and alloys. The arc is produced in a tube bent into an inverted ∩ at the top. It can be exhausted, and an "arc" some 2ft. in length can be produced. The tube is surrounded by a water jacket to keep it cool. A lengthening of the arc by 1cm. requires an additional pressure of 0·67 volt.——G. C. Schmidt proves that all bodies fluoresce when dissolved in suitable solvents.

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## WOLVERHAMPTON ELECTRIC SUPPLY SYSTEM.

*Early Developments.*

On August 25, 1893, an Act of Parliament was passed confirming the Provisional Order, among others, of the South Staffordshire Electric Lighting Company, for supply of electric light over a portion of Wolverhampton. Two other concerns, at a shortly later date, contemplated acquiring Provisional Orders for the same area, but no active steps were taken in the matter of erecting a station. In September, 1889, the Electric Light Committee of the municipal authorities addressed letters to these companies, stating the intention of the authorities to obtain a Provisional Order, and in the following month Mr. J. N. Shoolbred, at that time the consulting electrical engineer to the Corporation, advised the erection of a continuous-current low-pressure system "for 5,000 lamps of 15 c.p. each." The result was that neither of the three companies proceeded with its Order. Yet, neither did the authorities proceed; and we find that in June, 1892, Mr. W. H. Preece presented a report, in which he advised the erection of a station for 10,000 lamps, with an ultimate capacity of 50,000 lamps, the total cost of the initial system to be about £37,000. Tenders for plant were invited, irrespective of a system of supply, and a plot of land adjoining the Birmingham Canal, and fronting on Commercial-road, was purchased for £1,928. The total area of this land is 4,066 square yards, and upon a portion of it the existing station has been built. A large number of tenders were received from various firms, amongst which were two tenders from the Electric Construction Company. One of these tenders was for an alternate-current system; the other covered a complete system of high-pressure continuous-current supply. The second of these schemes, to cost £28,772. 10s., was tentatively accepted by the Electric Light Committee; but shortly afterwards the entire question of electric supply was "hung up" by the Corporation, owing to the pressure of other municipal work.

**Table I.**—*Tenders accepted for the Wolverhampton Electric Supply System, prior to the commencement of supply.*

| Nature of contract. | Name of firm contracting. | Sum paid for contract. |
|---|---|---|
| Buildings for generating station. | H. Wilcocks & Co., Wolverhampton. | £5,000 0 0 |
| Buildings for three sub-stations. | H. Wilcocks & Co., Wolverhampton. | 372 0 0 |
| Overhead traveller at generating station. | Bedford Engineering Co., Bedford. | 187 10 0 |
| 3 Lancashire boilers, setting, economiser and 2 feed pumps. | Thompson & Son, Wolverhampton | 2,410 0 0 |
| 2 large and 1 small horizontal "Corliss" steam engines, rope-geared to continuous-current dynamos, with exciter dynamos, &c. | E.C.C., Wolverhampton. | 4,804 0 0 |
| Steam and exhaust pipes. | E.C.C., Wolverhampton. | 758 15 0 |
| Ejector condenser. | E.C.C., Wolverhampton. | 253 0 0 |
| Condenser pipes. | J. Oake and Co. | 115 2 2 |
| 6 continuous-current transformers. | E.C.C., Wolverhampton. | 2,239 0 0 |
| Water softener. | ... | 150 0 0 |
| Switchboard at generating station. | E.C.C., Wolverhampton. | 300 0 0 |
| Switchboard at Town Hall sub-station. | E.C.C., Wolverhampton. | 435 16 0 |
| Storage battery at generating station. | Epstein Electric Accumulator Co. | 153 3 2 |
| Storage battery at Town Hall sub-station | Epstein Electric Accumulator Co. | 410 0 0 |
| High and low pressure cables. | Callender's Bitumen & Telegraph Co. | 5,709 0 0 |
| 36 arc lamp posts. | Bailey, Pegg & Co., Brierly Hill. | 207 0 0 |
| 5 arc lamp brackets. | Bailey, Pegg & Co., Brierly Hill. | 13 15 0 |
| Arc lamps. | Johnson and Phillips, Charlton. | 553 10 0 |
| Double and single arm carriers for arc lamps | Bailey, Pegg & Co., Brierly Hill. | 260 16 9 |
| Meters, &c. | Messrs. S. Z. de Ferranti, London. | 300 0 0 |

In May, 1893, the Corporation acted wisely in appointing Mr. F. Harman Lewis to be their municipal electrical engineer. Mr. Lewis had acted in a similar capacity at Hull, and at that place had carried out, on behalf of the Hull Corporation, the erection of their electric supply station and outworks. As one of the oldest and most experienced municipal electrical engineers in the United Kingdom, it was not surprising that Mr. Lewis should, immediately on his appointment, subject the tentatively adopted scheme to a most exhaustive and critical examination. The result was that a revised scheme was drawn up and presented by Mr. Lewis to the Corporation, costing some £10,000 less than the original scheme. Accordingly it was decided to split up the tenders for plant; and the revised tender of the Electric Construction Corporation for only a portion of the plant was accepted. Table I. gives a summary of the tenders which were accepted, and which formed the basis of the system at the time of its commencing work.

The buildings for the generating station were erected to designs supplied by Mr. A. P. Brevitt, by whom the electric supply station at Oxford was also designed. From the foregoing data it will be found that the Wolverhampton supply system started work with an expenditure on plant, buildings, &c., of about £27,000, and with a capacity of 5,000 lamps of 8 c.p., and about 40 arc lamps. On January 30, 1895, the station was formally opened by Lord Kelvin, since when supply has been continuously maintained.

*The Station and Out Works.*

**The System of Supply.**—Before describing further the station and its out-works of sub-stations and mains, it will be well to give some account of the system of high-pressure continuous-current supply which is in use. In its general design, save that it works at twice the pressure—viz., 2,000 volts—the Wolverhampton system closely resembles the system in use at Oxford, which is commonly called the "Oxford system." An account of the Oxford system appeared in *The Electrician*, Vol. XXIX., p. 254. The chief points of departure of the Oxford system from other high-pressure continuous-current systems are (1) in the use, between the high and low-pressure mains, of motor transformers, which, having a higher efficiency than batteries, at heavy loads, enable a high efficiency of distribution to be maintained; (2) in the use of a small amount of storage battery plant, for working the system when the load is very low; (3) in charging the sub-station batteries from the low-pressure side of the transformers; (4) in running the street arc lamps in a series system off the same high-pressure mains as supply the transformers; and (5) in controlling all the sub-station transformers from one central sub-station. At Wolverhampton the main generating station is situated at some considerable distance from the area of supply; and there are three sub stations, one of which—viz., that at the Town Hall—does duty as a central sub-station. The positions of these stations with respect to the network of mains are shown in the map, Fig. 1. The three sub-stations supply the same network of low-pressure mains, and each sub-station supplies at a point immediately outside the sub-station only.

**Present Equipment of the Generating Station.**—The generating station is a large red brick building situated on a plot of land between the Birmingham Canal and the Commercial-road. A portion of this land immediately adjoining the canal is used as a coal store, and over this space the condenser in-take and ejection pipes have had to be laid. Fig. 2 shows a plan of the station grounds and buildings. Since the inauguration some extension has taken place, including a third large engine and dynamo set. Further extension of the generating plant is provided for, and can be effected by removing the temporary end of the machinery room, and building upon the spare land in the direction of the canal; and a similar extension of the boiler house can be made. In order to prevent vibration, the foundations of the generating machinery have been laid separate from those of the buildings, with a narrow space between.

**Equipment of the Boiler House.**—A plan of the boiler house is given in Fig. 3, and shows the arrangement of the three

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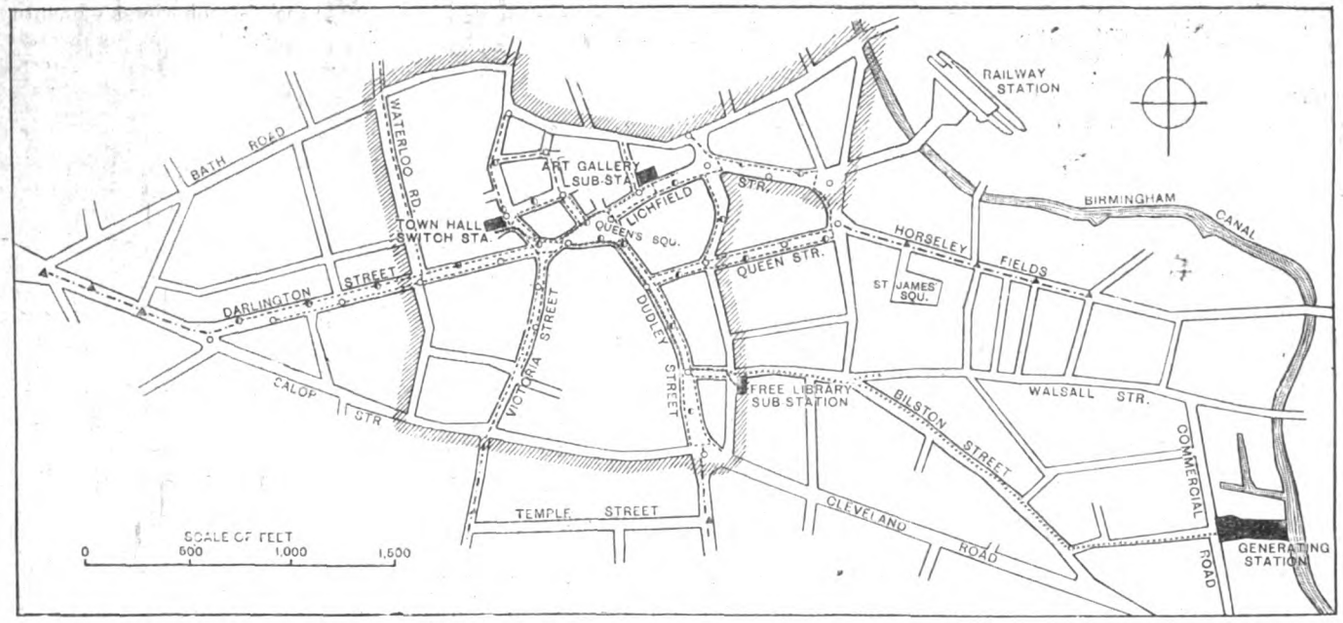
Lancashire boilers, two economisers, pumps and piping for the feed water, steam, &c. In this plan the boilers are not shown, but merely their setting. The three boilers are set at 11ft. pitch between centres; they are fed with hot and cold water from two feed mains ranging along over their fronts, and blow-off into a common blow-off main ranged below the front floor plates. They supply steam each through one stand pipe and branch pipe to the steam ring. Each boiler is 30ft. in length, with a shell 8ft. in diameter, and with two internal flues each of 39in. diameter. There are five "Galloway" cross-circulation tubes in each internal flue, or ten in each boiler. The flues are set with the hot gases discharging into the bottom flue from the internal flues at the back: and with the bottom flues discharging into the split side flues, at the front. From the back end of the side flues the gases pass to the two economisers, or through the by-pass flue to the chimney. Steam is generated at 160lb. per square inch. The boiler mountings include a dead-weight safety valve, a lever high-steam-and-low-water safety valve, and a steam collector pipe and stand pipe, with stop valve. These are of the usual Hopkinson type.

The economiser plant is divided into two distinct parts, which are so set that either half or the whole may be thrown out of action. The entire economiser comprises 192 pipes, each 9ft. in length, It was built by Messrs. E. Green and Son, and is of the usual pattern of "Green" economiser. A small steam engine mounted over the by-pass flue drives the economiser scrapers. From the economiser the hot gases pass directly to the chimney, which stands close to that end of the boiler house. The chimney is 100ft. in height, is of circular section throughout inside, with a diameter of 5ft. at the base; the exterior is square at the base, 13ft. 6in. side, but for the greater part of its height it is circular.




Boundary of Compulsory Area.
Low-pressure Distributing Mains.
High-pressure Trunk and Feeder Mains.
Low-pressure and High-pressure Mains.
Extensions.

FIG. 1.—Map showing the Generating and Transformer Stations and System of Mains of the Wolverhampton Electric Supply System.

All-night Street Lamps.
Street Lamps Extinguished at Midnight.
Extensions in Arc Lamps.
Generating and Transformer Stations.

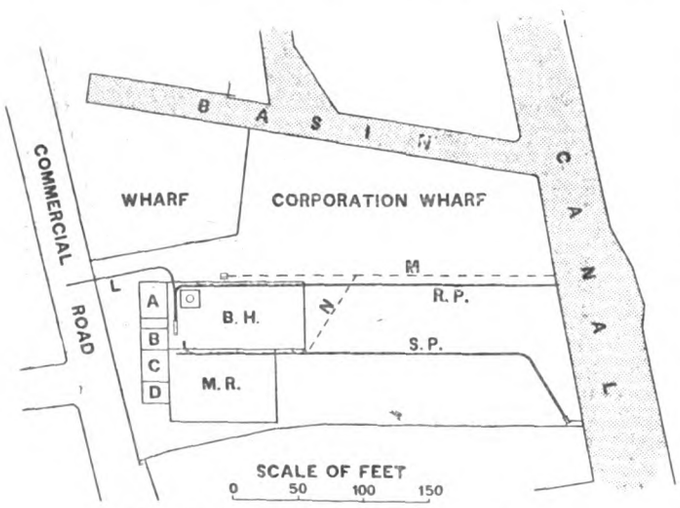



FIG. 2.—Plan of Generating Station and Grounds.

M.R., Machinery Room.
B.H., Boiler House.
S.P., Condenser Suction Pipe.
R.P., Condenser Return Pipe.
M, Blow-off Pipe.

A, Test Room.
B, Engineer's Office.
C, Stores.
D, Workshop.
L, Water Supply Pipe.

Water for the boiler feed is taken through a 3in. pipe from the town main in Commercial-road, and is led through a meter to the water softener, whence it passes into a capacious rectangular wrought-iron tank. The softener has a maximum duty of 300 gallons per hour. Two suction pipes draw water from the tank, and both these pipes lead to the feed pumps; but thence one of these pipes passes directly to the boilers, giving cold feed, while the other leads through the economiser, and gives hot feed. The two feed pumps were built by Messrs. Evans and Co., of Wolverhampton, and are of their well-known vertical ram type. These are shown in plan in the general plan of the boiler house (Fig. 3). It will be seen that either pump can independently supply either through the hot or cold feed main, and the complete reduplication of the parts minimises the risk of breakdown of this section of the plant.

**Equipment of the Machinery Room.**—The main steam ring is one half in the machinery room, and one half in the boiler house and condenser annexe. As the floor level of these last two departments is some 6ft. lower than that of the machinery room, the steam ring is tilted up on an inclined plane. This main steam pipe is of wrought iron, 7in. in diameter, with 13½in. steel flanges and with copper bends. It is bracketed to the wall of the machinery room, and the branch pipes to the engines are carried in a bend of large radius, and drop vertically down to the engine stop valves. A plan of the machinery room is shown in Fig. 4, and indicates the steam and exhaust connections. The main exhaust pipe is carried beneath the floor plates in a trench. The pipe is of cast iron 15in. in diameter. From the trench in the machinery room the exhaust main passes to the condenser annexe, a plan of which is also shown in Fig. 4.

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There are four complete generating sets, each comprising a horizontal coupled compound condensing engine and a separately excited continuous-current dynamo with a rope-driven exciter, by the Electric Construction Corporation. Three of the sets are of 140 kilowatts capacity, and the smaller one is of 65 kilowatts, all four developing 2,200 volts. All the sets are rope-geared, 15 ropes of 1¼in. diameter being used for the large sets and eight ropes of the same diameter for the smaller set. There are five exciters, four of which are driven by ropes from the main generators, the fifth being rope-coupled to an auxiliary vertical steam engine, by Messrs. Bumsted and Chandler. This auxiliary exciter set is shown in Fig. 4. It is used to replace any one of the four other exciters, also to charge the small battery which is used for the station lights. Each of these exciters develops 28 amperes at 100 volts, but can be magnetised to give 135 volts for charging the battery. The speed of the exciters is 720 revolutions per minute, that of the 140-kilowatt dynamos is 400 revolutions, while that of the 65-kilowatt dynamo is 500 revolutions per minute. The contractors inform us that all the dynamos, with the exception of the exciters, have been armature-wound on the "Eickemeyer" wire-coil system. The machines are of the two-pole inverted type, and are constructed so that the armatures can be lifted vertically out by the handy and well-designed overhead traveller built by the Bedford Engineering Co., of Bedford.

The cylinders of the larger engines are 14½in. and 25in. respectively, and the stroke is 32in. The cranks are of the disc pattern, and are set at 90deg. apart. The admission of steam is controlled by Proell two-valve trip gear, while ordinary Corliss valves control the exhaust. The smaller engine is of similar type, with cylinders of 10in. and 17½in. diameter, and with 24in. stroke. All the engines, together with the dynamos, are lubricated by a complete system of continuous forced lubrication, and the oil is passed from the bearings through a system of return pipes to the filter, and thence to a reservoir.

In the condenser annexe one set of condensing plant is at present provided, and is sufficient to deal with all the exhaust steam at full load. This set comprises a Ledward ejector condenser, and a centrifugal pump direct-coupled to a Bumsted and Chandler vertical steam engine, for raising the condensing water from the canal. A considerable quantity of canal water has to be used, owing to the high temperature of the canal, especially at times when the neighbouring factories are also at work. Indeed, so extensively is the canal water used by the manufactories in the vicinity that profuse steaming from its surface commonly occurs.

Returning again to the main generating room, we must notice the switching arrangements. Fig. 5 is an elevation of the switchboard, showing the interconnections. It is almost an essential feature of the "Oxford" system that the switching arrangements at the generating station should be less complex than those at the central sub-station, and this is the case at Wolverhampton. Fig. 5 is self-explanatory.

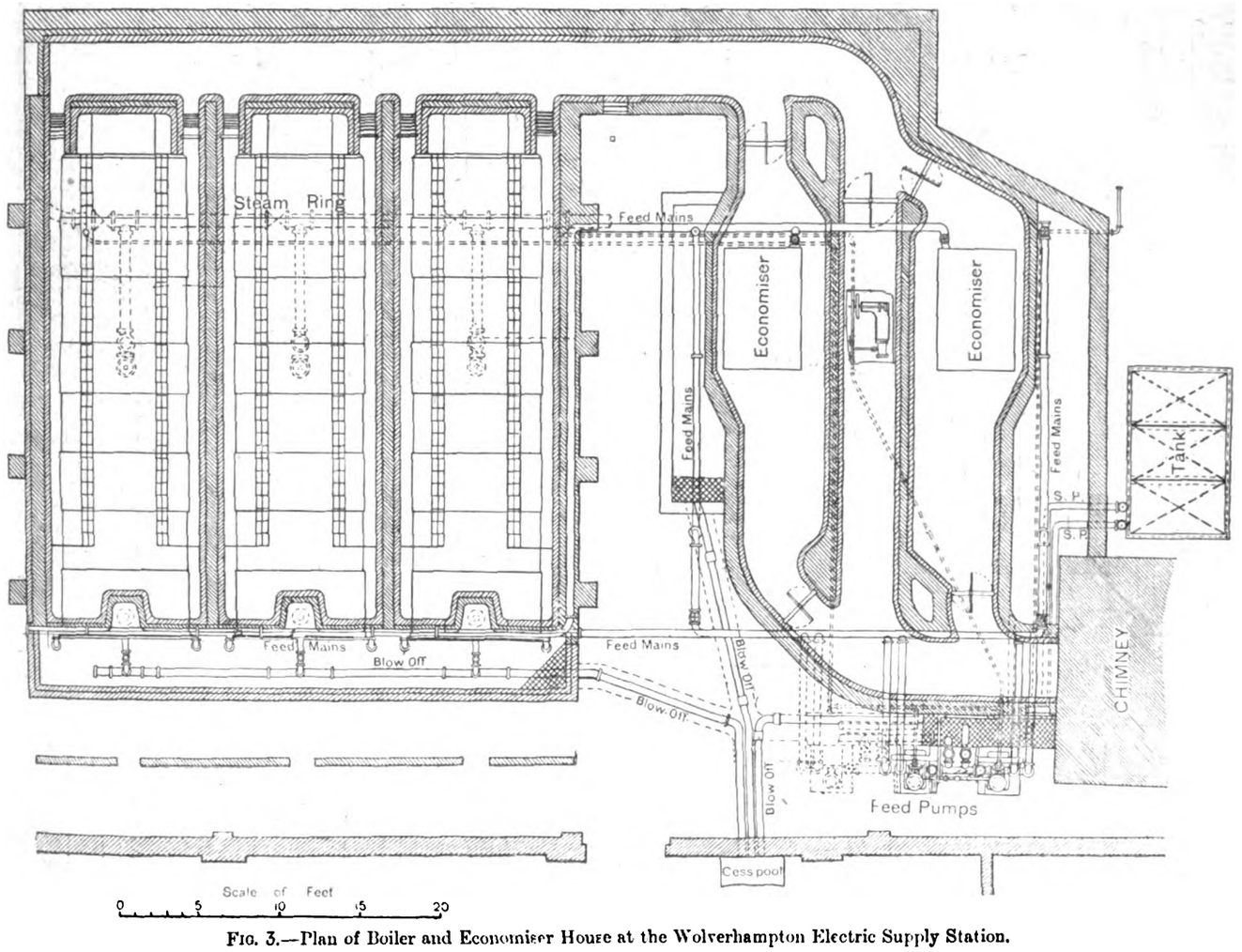


FIG. 3.—Plan of Boiler and Economiser House at the Wolverhampton Electric Supply Station.

Mention has already been made of a small storage battery which is used for the station lights. This is erected in a small room adjoining the main building. The battery consists of 55 Epstein cells of the "T 7" type in glass vessels. It has a storage capacity of 140 ampere hours at 20 amperes discharge, ranging down to 100 at 50 amperes discharge.

**The High and Low-Pressure Mains.**—A map of the system of high and low-pressure mains showing their positions relatively to the station and sub-stations and the public lamps is given in Fig. 1. The entire system of cables has been carried out by Callender's Bitumen Telegraph and Waterproof Company. All the high-pressure cables consist of vulcanised bitumen cables laid in cast iron troughs on the Callender solid

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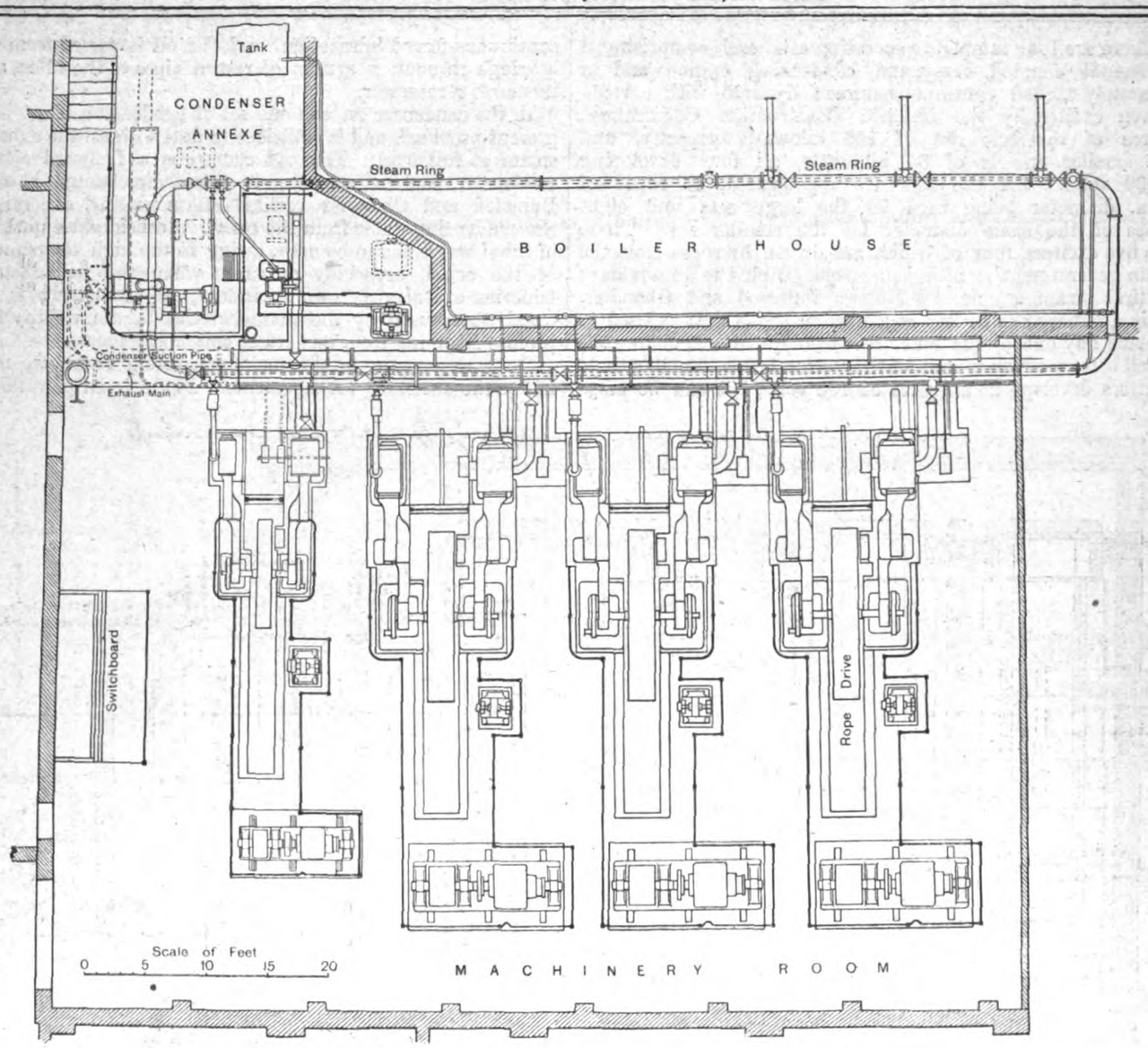


FIG. 4.—Plan of the Machinery Room at the Generating Station.

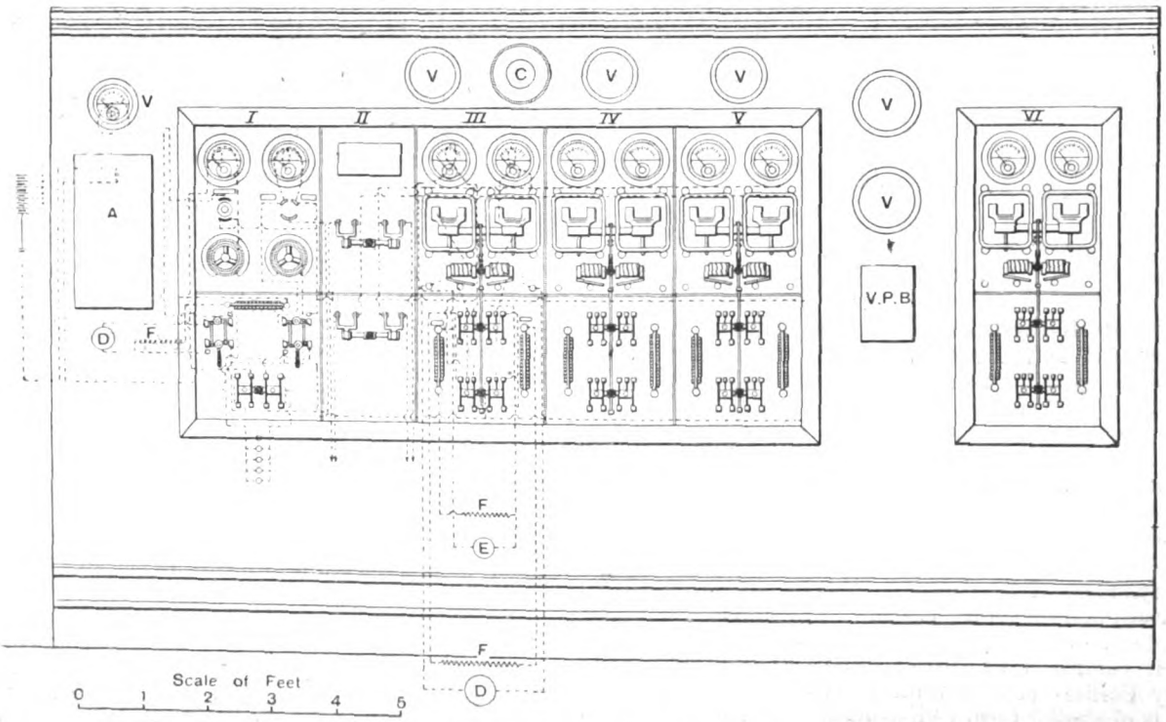


FIG. 5.—Generating Station Main Switchboard, showing Connections.

A, Aron Ampere-hour Meter. C, Clock. D, Dynamo. E, Exciter. F, Field. V, Voltmeter. V.P.B., Voltmeter Plug Board. I., Battery Board. II., Main Trunk Board. III., IV., V., VI., Main Dynamo Boards.

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system, the troughs being filled in with bitumen and closed with a watertight iron lid. All the low-pressure cables are armoured, single-conductor cables buried in the ground.

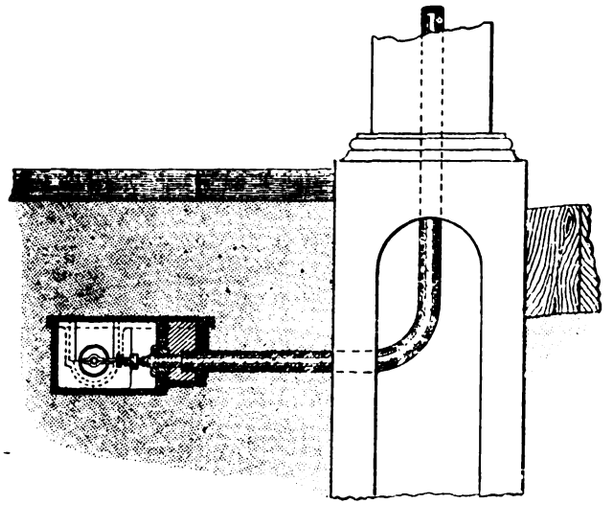
The trunk main from the generating station to the Town Hall central sub-station is 1,410 yards in length, and consists of two pairs of cables each of a strand of 37/16 = 0·122 sq. in. section. Each of the two other sub-stations is connected independently with the Town Hall sub-station by two pairs of high-pressure cables, each cable consisting of 19/18 strands, and having a section of 0·035 sq. in.

For the arc lighting current 7/16 concentric lead-sheathed and armoured cable is used, there being two circuits aggregating 6,500 yards in length. The lamps are connected in series on the inner conductor, the outer conductor forming the continuous return.

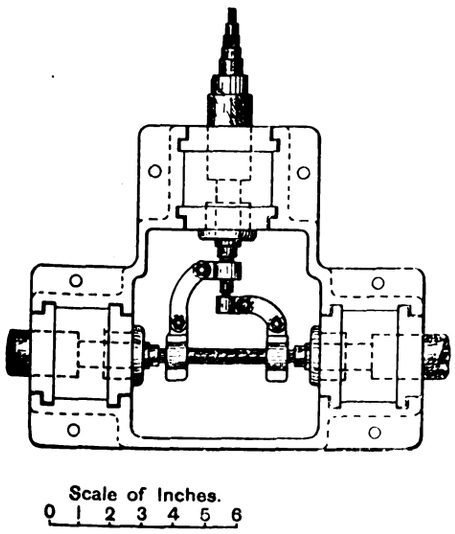
the "Oxford" system. The pilot or control wires are in three forms, and are lead sheathed and steel armoured. The three forms consist of two, four and six conductors, respectively each of 7/22 strand.

Details of the cables and connection boxes, &c., are shown in Fig. 6.

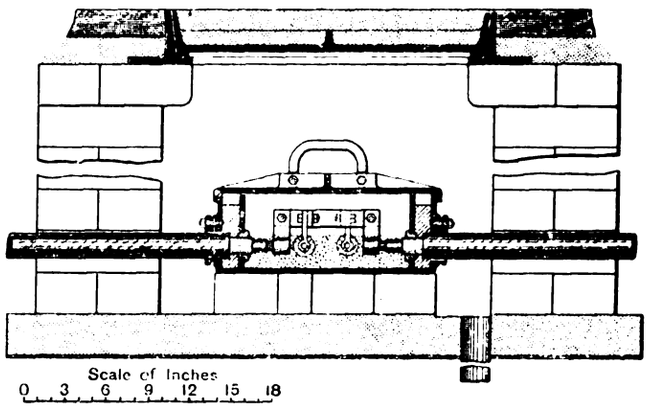
**The Central Sub-Station.**—The sub-station at the Town Hall performs a quadruple duty. It serves as a central switching station, it takes its share of the transforming station work, it controls the arc lighting circuits, and it is a battery station. We will deal separately with these duties, which, however, it may be noticed, are not essentially, in the "Oxford" system, allotted to one station. Before doing so it will be well to consider the construction of this sub-station. The Town Hall sub-station is situated in a spacious vault



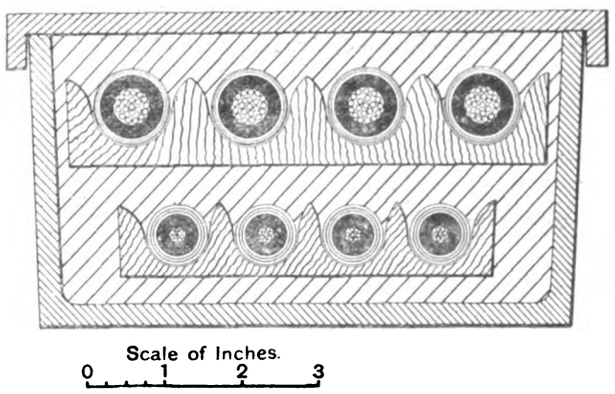

Arc Lamp Connections. Elevation.



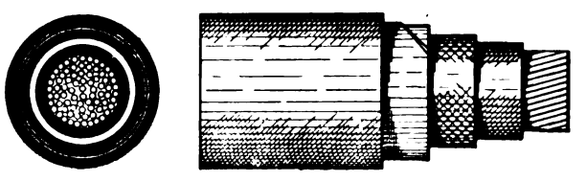

Arc Lamp Connections. Plan.




Junction Box in Distributing Network.




Section of Callender Solid Bitumen Conduit and High-pressure Mains.



Armoured Distributor. One-third full size.

FIG. 6.—Details of Mains and Conduits.

About 6,000 yards of distributing mains have now been laid. For these, cables of 0·25 and 0·5 sq. in. copper section have been employed. There are short lengths of cable of 1in. section connecting the low-pressure network with the sub-stations. All these cables are of the single-conductor, lead-sheathed, steel-armoured type, and are buried directly in the ground.

Besides this system of high and low-pressure supply mains, there is a system of pilot or control wires connecting the generating station and the three sub-stations. There is also a private telephone line, which is almost an essential feature of

beneath the municipal building, a portion of the vault being partitioned off to serve as the battery room. Plan and sectional elevation of the sub-station are shown in Fig. 7. A small hand overhead traveller enables the machinery to be handled expeditiously during repairs, and the armatures of the transformers can be lifted vertically out from between their poles. A railed-in platform runs partly around the chamber, and is raised slightly above the main floor level. This serves as a switch platform, and the switchboards are placed against two adjacent walls, the two panels on the extreme left being at right angles to the rest of the board. The inter-connections

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of the switch panels are shown in Fig. 8. Commencing at the extreme left end, the panels are adapted as follows :—

*Panel I.*—Low-pressure board for connections between the two supply transformers at the Town Hall, and the low-pressure network. Equipped with double-pole electro-magnetic cut-outs, switches and ammeters. Controls 90 kilowatts.

*Panel II.*—Main trunk board. Equipped with two double-pole hand switches for connecting the trunk mains to the transformer boards. Controls the whole supply. The switches on this panel are locked in the "on" position.

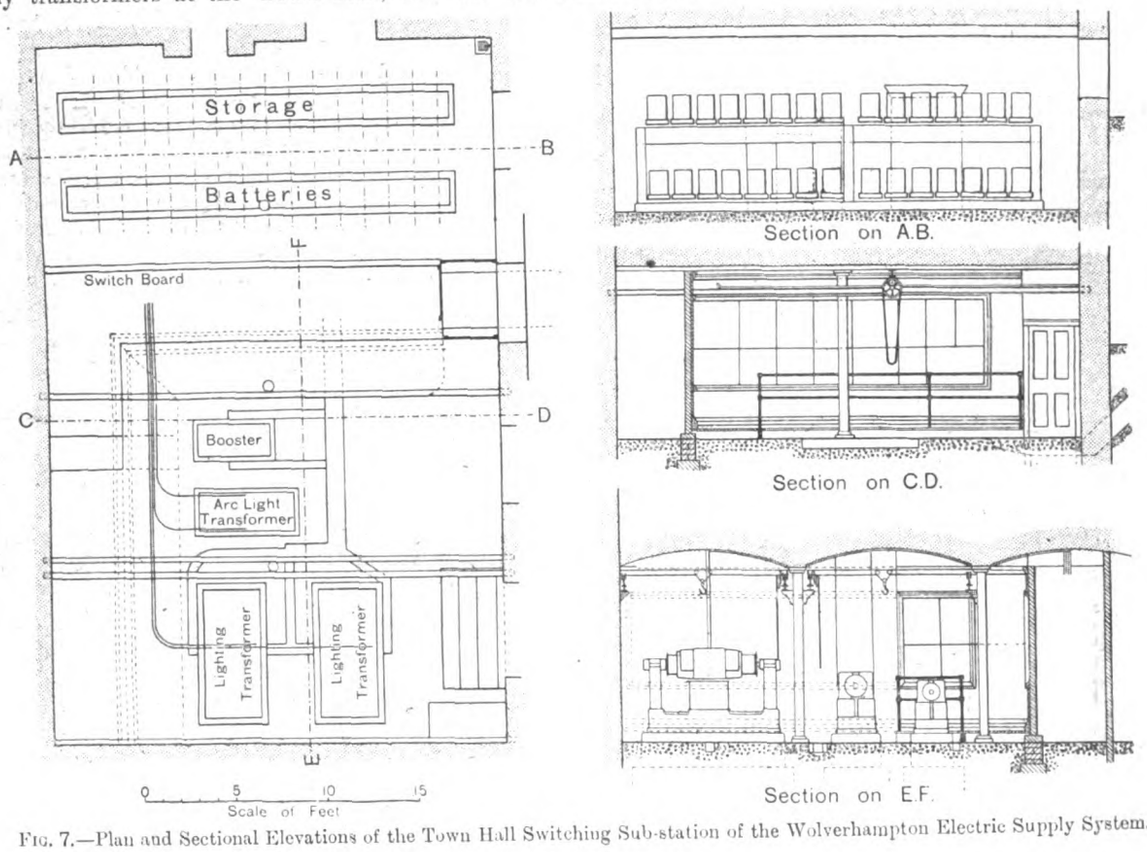


FIG. 7.—Plan and Sectional Elevations of the Town Hall Switching Sub-station of the Wolverhampton Electric Supply System.

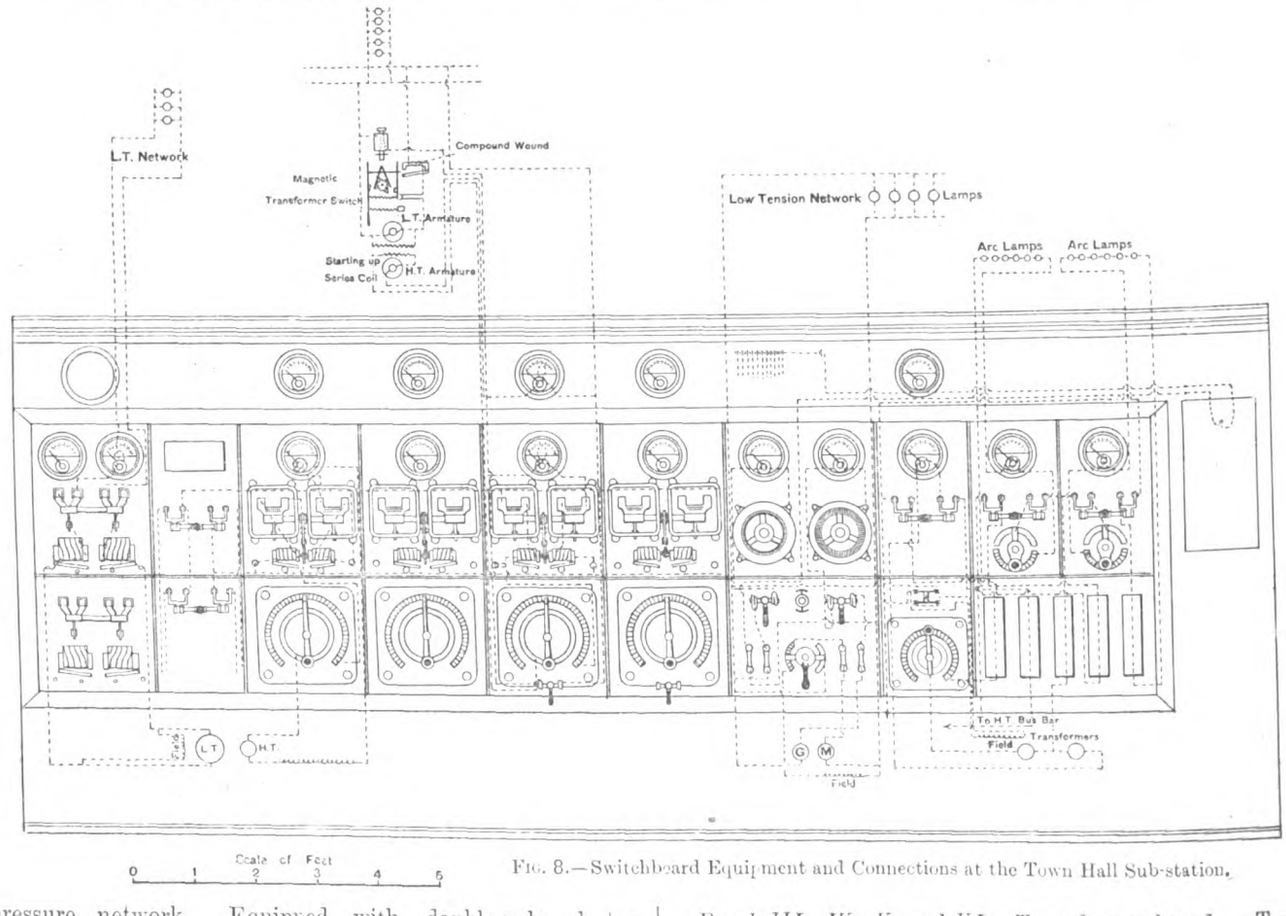


FIG. 8.—Switchboard Equipment and Connections at the Town Hall Sub-station.

*Panels III., IV., V. and VI.*—Transformer boards. Two of these panels control the high-pressure supply to the two Town Hall supply transformers; and the other two control the

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supply to the distant sub-stations. At the top of each panel is an electrostatic voltmeter, giving the high-pressure voltage; below this is the ammeter; still lower down is the combined electromagnetic cut-out and hand double-pole switch, and at the bottom the regulating rheostat. Each panel controls about 45 kilowatts.

*Panel VII.*—Accumulator board. The upper part of this panel is divided into two sections; that on the left controlling the discharge, and that on the right the charge, of the Town Hall station battery. At the top of the panel are the discharge and charge ammeters. Below these are the switches for regulating the number of cells in circuit, each switch provided with an "off" stop. Immediately below these are the hand switches, between which is the voltmeter switch; and at the bottom are the fuses, and the regulating switch for adjusting the extra volts from the low-pressure booster which "boosters" up the low-pressure supply for charging the battery.

*Panel VIII.*—Arc lighting transformer board. Connects the arc lighting transformer to the 2,000-volt mains on the one hand, and to the two 1,000-volt arc lighting panels on the other hand. Equipped with an electrostatic voltmeter, ammeter, double-pole hand switch, throw-over switch, and regulating switch for starting.

*Panels IX. and X.*—Arc lighting boards. Each panel controls one of the two arc-lamp circuits, at 1,000 volts. It is equipped with an ammeter, double-pole hand switch, and a regulating switch.

In addition to these switching arrangements, we may notice, at the extreme right end of the switchboard, an Aron meter. This is used for measuring and regulating the charge of the battery. The discharge current works the meter in a positive direction; and every day a charging current is passed until the reading has worked back to zero, and is continued until there is a negative reading sufficient to compensate for the battery losses.

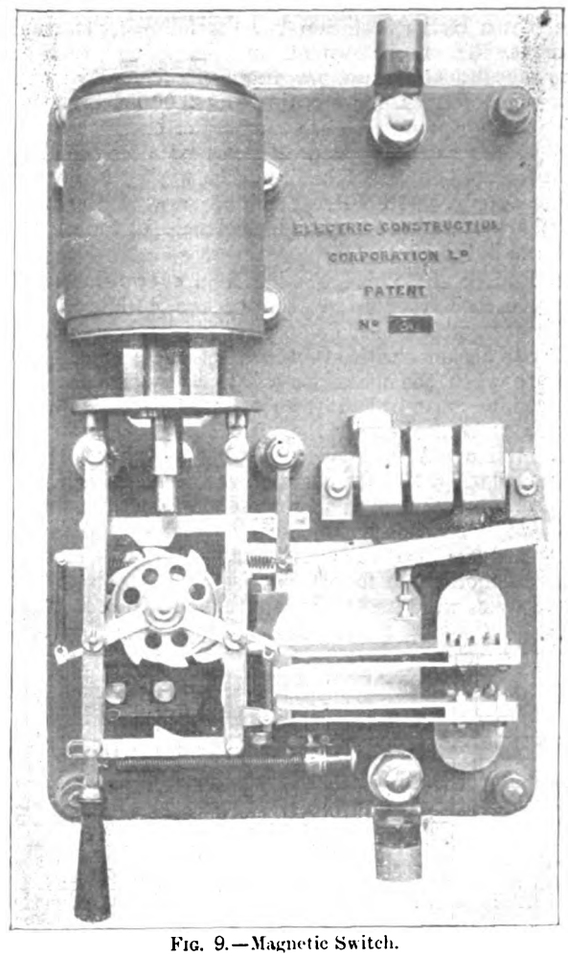
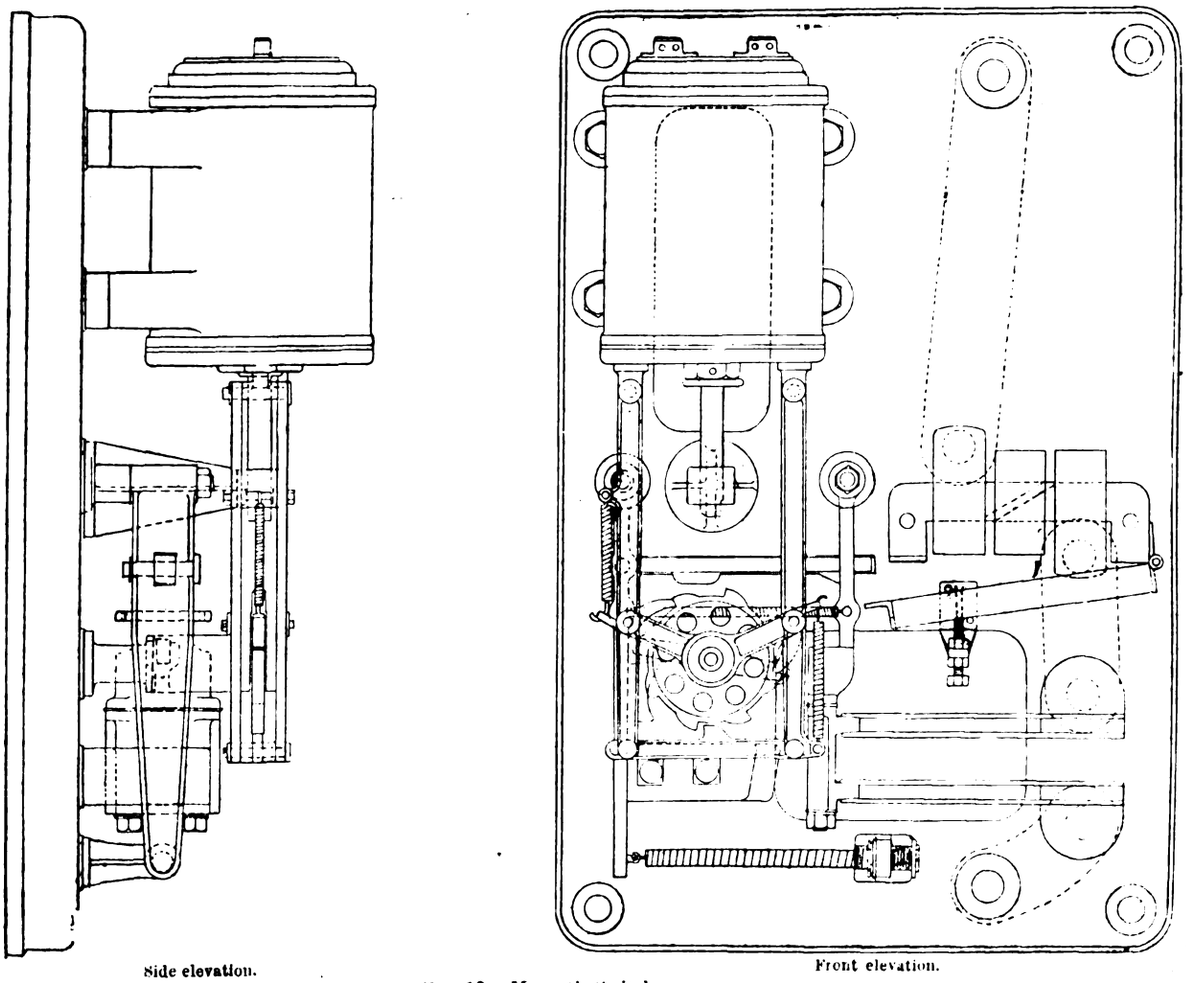



FIG. 9.—Magnetic Switch.



Side elevation. Front elevation.

FIG. 10.—Magnetic Switch.

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The Town Hall sub-station has the following transformer equipment. There are two motor transformers, each giving 42 amperes at 110 volts, for the general supply; one arc lighting transformer, for splitting the 2,000 volts into two 1,000 volts on two separate series arc circuits; and one "booster," for supplying some 40 volts extra for the charging current for the battery. The booster is worked from the low-pressure supply. All these machines are of the two-pole inverted type, and have very high efficiencies of transformation at full and half-load.

**The Branch Sub-Stations.**—There are two branch sub-stations, each having a capacity of two 45-kilowatt motor transformers, which feed directly on to the supply network. In order to dispense with attendance at these sub stations at the times when the machines are to be started or stopped, each machine is controlled by an automatic switch, the action of which is controlled by the attendant at the Town Hall switch station. A front view of this switch is shown in Fig. 9, while Fig. 10 shows scale drawings of the front and end elevations. When it is required to start a transformer the double-pole switch on the proper panel of the Town Hall switchboard (*see* Fig. 8) is closed. This starts the transformer as a series motor, the field being feebly magnetised by a few turns of series winding. Of course this operation is done with

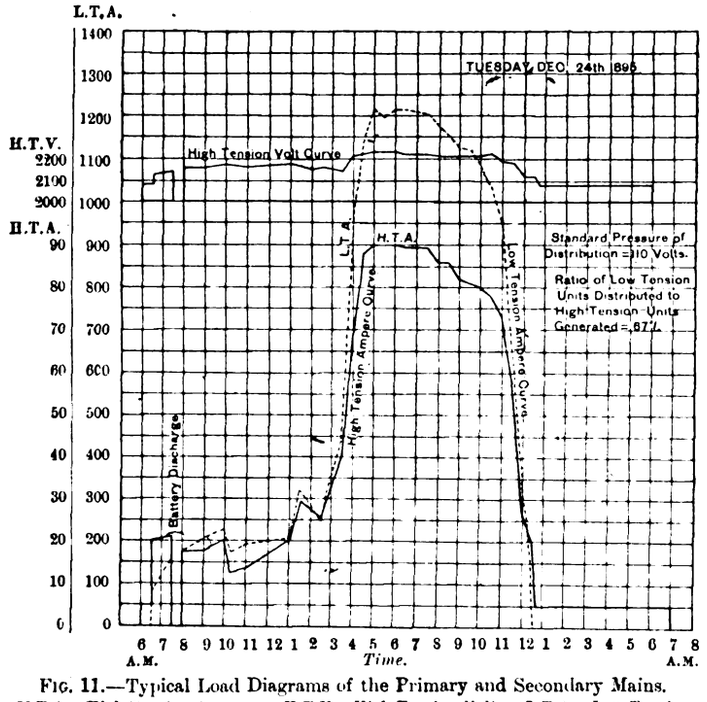


FIG. 11.—Typical Load Diagrams of the Primary and Secondary Mains.
H.T.A. = High Tension Amperes. H.T.V. = High Tension Volts. L.T.A. = Low Tension Amperes.

a large resistance in the rheostat in circuit, the resistance being gradually reduced as the armature runs up to speed. By this time the shunt excitation will have been developed, and the generator windings will be developing full voltage, though as yet there will not be any load on the machine. In order to throw the generating part into circuit with the supply network the automatic magnetic switch (Figs. 9 and 10) must be started. To effect this a small hand-switch at the Town Hall switchboard is momentarily closed. This short-circuits the voltmeter on the pilot circuit connecting the main and the branch sub-stations, and as the solenoid of the automatic switch is included in this circuit, the strong current which is momentarily developed suffices to throw this apparatus into action. Thereby the ratchet and wheel shown in the illustrations are put in motion, and the generator side of the transformer is switched on to the mains. When wishing to throw out any transformer precisely the same operation is performed, the action of the ratchet and wheel then being to open the transformer switch and throw the machine out of circuit. Resistance is then thrown into the field circuit, and the primary side of the machine shut down. In the transformers which have been added since the commencement of supply some departure from the field winding described has been carried out, the proportion of shunt to series winding being altered so as to minimise the drop which occurs when starting one of these machines.

*Results Obtained.*

Pending the publication of the full official report for the last year, some few figures giving the results achieved during the period of working of the Wolverhampton electric supply system will be of interest. At the commencement of this year, or rather on January 31st of this year, there were 8,270 lamps, or their equivalent, including arcs, on the mains. A total of 172,207 units had been sold during the previous 12 months, the average price realised having been 4·9d. per unit. From the public arc lighting a revenue of £20 per lamp per annum had been derived; while the revenue per private 8 c.p. lamp had been 7s. 1d. Table II. gives the items of expenditure per unit sold:—

**Table II.**—*Works and Management Expenditure per Board of Trade Unit sold.*

| Item. | Cost per unit sold, in pence. |
|---|---|
| Coal | 0·58 |
| Water, oil and stores | 0·20 |
| Wages and salaries | 0·78 |
| Repairs and maintenance | 0·31 |
| Rent, rates and taxes | 0·16 |
| Management expenses and salaries | 0·86 |
| Total works costs | 1·67 |
| Total costs | 2·89 |

The percentage of the costs to the revenue for this period of twelve months was 59·26 per cent.

Finally, in Fig. 11, we have a typical load diagram, or set of primary and secondary load diagrams, of the Wolverhampton supply system. It will be observed that on the particular day when these diagrams were taken, December 24, 1895, the efficiency of distribution, or the ratio of the low-pressure units distributed to the high-pressure units generated, was 67 per cent.

Our thanks are given to Mr. Harman Lewis, for his courtesy in placing at our disposal the plans, drawings and other information upon which this article is based, and for the personal assistance he has rendered to us. We are also indebted for some of the information to the various firms of contractors for the Wolverhampton plant.

## BERNE OFFICIAL VOCABULARY OF CODE WORDS.*

Your Council, following up the action indicated in the last report, decided early in the year to do everything in their power to secure at least a thorough revision of the Berne Vocabulary before its compulsory application, if they could not succeed in their efforts to obtain its complete abandonment. Members of your Chamber, who, by the nature of their business, were interested in the question, were invited to give their opinion of and the results of their experiences with the Vocabulary, with the consequence that abundant evidence was placed before your Council of the unsatisfactory character of the Berne publication, and of the inconveniences and dangers which its enforcement would entail upon the transaction of cable business. The Vocabulary being the result of the decision of the International Telegraphic Conference held at Paris in 1890, it was obvious that the best way to attain the end in view was to endeavour to obtain the support of the various States forming the Conference. Your Council decided, therefore, to approach the Foreign Chambers of Commerce, and to call their attention to the serious defects of the Vocabulary in order to induce them to address protests to their respective Governments against its compulsory application. On March 25th a circular letter to this effect was forwarded to all the Continental Chambers of Commerce. Action was limited to the Continent because the question of the enforcement of the Vocabulary was raised only as regards the European system—the date for such enforcement being January 1, 1898—and the question of extension to the extra-European system was left by the Paris Conference open for future consideration. It appearing from

* From the Fourteenth Annual Report of the Council of the London Chamber of Commerce.

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the replies received that in most foreign countries very little was known either of the nature or of the effect of the Vocabulary, an exhaustive article was published in your journal* for the month of July, giving the reasons which had induced your Council to take the matter up. A detailed letter in English and French, accompanied by a reprint of this article in English and French, was then forwarded to the most important Continental Chambers of Commerce in the beginning of September. Numerous inquiries and requests for copies of the text and translation of the letter and article followed from Chambers of Commerce and other associations and from private firms on the Continent, especially from Germany, France and Belgium. The net result, in so far as Continental Chambers are concerned, was as follows: Your Council received answers from 62 Chambers. Of these 54 supported the action of your Council in objecting to the Vocabulary, and addressed to their respective Governments letters of protest demanding either its withdrawal or its revision by the Budapest Conference of 1896; five stated that they were considering the question, but up to the present have not informed your Council of the result of their deliberations; two did not think it advisable to take any action, and one only approved of the Vocabulary in its present form.

[Then follows a table showing by countries the Chambers which favoured the Council with replies, and the nature of the replies.]

A further proof of the anxiety which is felt in commercial circles all over the world at the prospect of the enforcement of the Berne Vocabulary is to be found in the numerous communications which your Chamber has received from Chambers of Commerce, Boards of Trade, Exchanges, and other commercial associations, and also from private firms in countries which were not immediately threatened, viz., the Colonies, India, the Straits Settlement, China, Japan, the United States of America, Brazil, and the South African Republic.

Whilst thus prosecuting this campaign abroad, your Counci were also taking steps to secure the co-operation of British Chambers and of the British Post Office. The late Government, through Mr. Arnold Morley, had promised to inquire fully into the matter; and when Lord Salisbury came to power, Mr. Hanbury, Secretary to the Treasury, on behalf of the Duke of Norfolk, Postmaster-General, in reply to remarks by Mr. A. D. Provand, M.P. (Glasgow), during the discussion on the Post Office vote, made the following important declaration, which your Council think should find place in this report:—

"He was glad to be able to tell the hon. member that to some extent he was pushing against an open door. The Post Office was largely in sympathy with the views expressed by the hon. member. He could assure him that every precaution would be taken to see that the interests of the country did not suffer. The adoption of this Code was a matter which would not be definitely decided until next year. A conference would be held in the autumn of 1896, when the question of final confirmation or rejection of the Code would be gone into, and he could assure the hon. gentleman that during the time that would elapse between now and then, the Government would give very careful consideration to all the arguments adduced by the hon. member. He could assure the hon. gentleman that the Post Office authorities were alive to the defects of the Code, and he might rest assured that, being aware as they were, in the first place, of the inadequacy of the Code, and in the second place that it might have the effect, to a certain extent, of damaging the interests of the country, the fullest consideration would be given to the arguments adduced against it with such cogency by the hon. gentleman."

On September 6th a circular was addressed to the Chambers of Commerce of the United Kingdom, asking their co-operation. Replies were received, your Council regret to say, only from 26 out of some 105 Chambers, whose attention was called to a matter of such great importance to British International trade. Of these, 22 supported the action taken by your Council, and wrote to the Postmaster-General protesting against the compulsory application of the Vocabulary; two advised that they were considering the matter; one declared itself incompetent to discuss the matter; and one did not find anything serious to object to in the Vocabulary.

[Then follows a table showing the Chambers which replied, and the nature of their replies.]

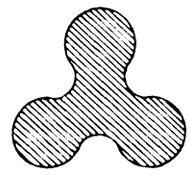
Public interest in the question is also testified to by the correspondence on the subject which took place in *The Times* during the months of April and November. The action of your Chamber having been impugned by a correspondent, your Council decided that an answer should be published stating fully the attitude of the Chamber on the question, and the reasons which had led it to take up that attitude. This answer, which appeared in *The Times* of November 23rd, will be found in Appendix B.

With a view to obtaining a satisfactory declaration from the Postmaster-General as to the action which the British Post Office intended to take at the Budapest Conference, an influential committee was formed in November, with the Hon. Alban G. H. Gibbs, M.P., in the chair. Some correspondence passed between the Chairman of that Committee and the Postmaster-General, with the result that assurances were given to your Committee "as to the practical certainty that the next Telegraphic Conference would not enforce the use of the new book for European telegrams, and still less extend it to extra-European telegrams." Your Council, therefore, considering that such assurances could hardly have been given by Her Majesty's Postmaster-General without some understanding on the subject having been arrived at with a majority at least of the States constituting the International Telegraphic Convention, feel that they have reason to congratulate the Chamber on the success of their efforts to secure international co-operation in a matter of international interest.

* See *The Electrician*, Vol. XXXV., August 2, 1895, p. 452.

## TRIPLE SECTION TROLLEY WIRE.*

Something new in the way of trolley wire for high-speed roads, or those with unusually heavy cars, is being manufactured by an American firm. It is called the triple section, and its form is apparent from the accompanying engraving. The greatest difficulty



found with the special forms of trolley wire heretofore used is that it is difficult to get the kinks out when unreeled. The "triple section," it is stated, can be kept smooth and straight when reeled and unreeled as easily as common round wire, as it is symmetrical in cross-section about its axis, and when reeled rests with one of its grooves resting on one of the ribs of the convolution next below. There are consequently no lateral waves or kinks. The triple section also gives a long line of contact with the trolley wheel, amounting to as much as one inch when the wheel is cast or has become worn to fit the wire.

* From the *Street Railway Review* of Chicago.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**To-day) FRIDAY, June 12th.**

MUNICIPAL ELECTRICAL ASSOCIATION.

*10:15 a.m.* General Meeting of Members and Associates only for the election of President, &c.

*4 p.m.* Reception by the Electric Lighting Committee of the Brighton Corporation.

*5 p.m.* Visit of Inspection to the Brighton Electricity Works.

PHYSICAL SOCIETY.

*5 p.m.* Meeting at Burlington House. Papers to be read: (1) "On the Measurement of very Large and of very Small Alternating Currents," by Albert Campbell; (2) "An Exhibition of Improvements in Apparatus for the Measurement of Electrical Resistance," by E. H. Griffiths; (3) "Two Communications on Röntgen Rays," by Prof. S. P. Thompson and Dr. Shettle.

CITY AND GUILDS OF LONDON INSTITUTE.

*8 p.m.* Conversazione at the Central Technical College, Exhibition Road.

**MONDAY, June 15th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*4 p.m.* Special General Meeting at 28, Victoria-street, S.W.

**WEDNESDAY, June 17th.**

ROYAL METEOROLOGICAL SOCIETY.

*7:30 p.m.* Ordinary Meeting at 25, Great George-street, Various Papers to be read.

ROYAL MICROSCOPICAL SOCIETY.

*8 p.m.* Meeting at 20, Hanover-square, W.

SOCIETY OF ARTS.

*9 p.m.* Conversazione at the South Kensington Museum.

**FRIDAY, June 19th.**

ROYAL INSTITUTION.

*9 p.m.* Friday Evening Discourse: "The Utilisation of Niagara," by Thomas C. Martin.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.



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# The Electrician.

**The Oldest Electrical Journal (1861—1878.)**

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## THE ELECTROLYTIC DISSOLUTION AND DEPOSITION OF CARBON.

The search for means whereby the chief available source of energy in the earth's crust—carbon, to wit—may be turned to immediate account in less clumsy a manner than it now is, grows daily keener. Regarding the issue as chiefly utilitarian, all attempts up to the present must be chronicled as failures, but taking a less limited view, good and useful outcome may be claimed for many. Had it so happened that living organisms were supplied with and were constructed to thrive in an atmosphere of chlorine contaminated, let us say, with a fractional percentage of zinc chloride, the former serving for the respiration of animals composed largely of zinc, and the latter sufficing for the nourishment of zinc-liberating plants, the difficulties now experienced would not have arisen, because the electrolytic dissolution of zinc is a simple matter. But with carbon as the mainstay of the world the conditions are more onerous. The electrolytic dissolution of carbon is a feat which has only lately been accomplished, and there are not wanting those who deny that accomplishment. The present position of affairs may be gathered from the following exposition of a polemic now current.

Prof. VOGEL's criticism of Dr. COEHN's researches on the dissolution and deposition of carbon in and from an electrolyte naturally led us to expect a spirited rejoinder,

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and it has been not long in coming. Both the original Paper and the objections raised to the conclusions contained therein, have been transcribed into these columns, and it is unnecessary to recapitulate the arguments of the eminent adversaries (see *The Electrician*, Vol. XXXVI., April 3rd, p. 756; also *The Electrician*, May 8th, p. 49). Dr. COEHN's present pronouncement is given prominent position in the *Zeitschrift für Elektrochemie*, and we propose to reproduce its substance.

Dr. COEHN begins, as is too common with the criticised physicist or chemist, by reference to labours about to be accomplished, pending the completion of which the objections of his critic might well have remained unanswered. We can discover no sort of justification for such defence. When a public statement is made, it is, in colloquial language, put there to be shot at; and though he who published it has a perfect right to keep silence when he is criticised, he must not complain if the public interpret his silence in their own way. However, in the present case Dr. COEHN is content to suggest this passive attitude, and, having done so, assumes a sufficiently vigorous defensive position. He begins to minimise the effect of Prof. VOGEL's somewhat formidable array of authorities by pointing out that the source of the quotations made is no more esoteric than the indexes of WIEDEMANN and the BERICHTE, and further that he (Dr. COEHN) actually quoted the names of BARTOLI and PAPASOGLI—much relied on by his opponent—as those whose work formed the starting point of his own. After this preliminary skirmish, Dr. COEHN settles down to the discussion of the more important questions raised by his critic. Dr. COEHN was, and apparently is, of the opinion that he is the first to succeed in obtaining a deposit of carbon at the cathode of an electrolytic cell; Prof. VOGEL, on the other hand, contends that Dr. COEHN has been anticipated by MATTEUCCI, VON BABO, and BRANDE. With regard to the last-named, Dr. COEHN adduces the following statement:—BRANDE electrolysed carbon compounds, using a mercury cathode, and obtained a deposit—a circumstance to be attributed to the presence of small quantities of calcium in the organic electrolyte. The succeeding paragraph is quoted from BRANDE's own Paper (*Pogg. Ann.*, XXII., 1831, p. 303):—"On the hypothesis that different results might be obtained when soluble salts of morphine, cinchonine and quinine were electrolysed with mercury as a cathode, experiments were made with the sulphates of these bases. In this case no metal-like deposit was observed, provided the salts were pure. The addition of an alkali, even in small quantity, gave the same dubious appearances as had been previously noted with quinine which contained a little lime." If this be the passage relied on by Prof. VOGEL, we can only say that it seems scarcely *ad rem*. Dr. COEHN proceeds to cite VON BABO concerning an actual deposit of carbonaceous matter obtained by that observer, who says (*Journal für prakt. Chem.*, LXXII., 1857, p. 75): "The liquid exposed to the action of the zinc pole had suffered actual change. A considerable quantity of a resinous substance had separated; this substance was, with difficulty, soluble in water, but readily in alcohol; it was also soluble in nitric acid." If this be the best evidence that Prof. VOGEL can put forward of the deposition of carbon prior to Dr. COEHN's researches, we are not greatly impressed by the strength of his case. At this point of the controversy however, it may, be permitted us to point out that the actual analytical figures from which Dr. COEHN deduces that the deposit obtained by him was carbon associated with nothing but the elements of water, are still wanting, and, failing their publication, the force of his conclusions is much impaired. Passing to the next stage, it is pleasing to find that the disputants are at one as to the uncertainty of the existence of ionic carbon in the sulphuric acid electrolyte used by Dr. COEHN; but it is disappointing to discover that no attempt seems to have been made to ascertain, by means of analysis, the nature of the carbonaceous material colouring the solution, and serving as a source of the carbon deposited.

Dr. COEHN makes a spirited defence of his original statement—categorically denied by Prof. VOGEL—that he has succeeded in dissolving carbon by electrolytic means. He points out that the difference between himself and his critic may be partly verbal, for possibly by an electrolytic solution of carbon Prof. VOGEL understands one in which carbon is present as such, and he playfully remarks that trial might then well be made by evaporating or freezing the solution to deposit the carbon it contains in the form of diamonds. Moreover—he goes on in the same vein—is copper dissolved in sulphuric acid to be regarded as a solution of the metal as such? When a solution of common salt is evaporated or frozen does sodium separate out? Carbon is only behaving like other elements when it forms a compound substance in the act of dissolution, which compound has the capability of splitting into ions, as is apparent from its conductivity and electrolytic decomposition. The nature of the ion-forming substance can be determined by the usual chemical and physical methods, involving an investigation in which Dr. COEHN is now occupied.

Finally, Dr. COEHN turns on his critic and displays erudition of his own in chemical literature. According to MENDELÉEFF (who does not quote a reference) "diamond powder is deposited on the negative electrode when a weak galvanic current is passed through liquid chloride of carbon"—a statement sufficiently startling. It is possible that MENDELÉEFF refers to the work of DESPRETZ (*Comptes Rendus*, XXXVII., p. 869) who found, according to Dr. COEHN, that a small current passed for two months through slightly acidulated water deposited diamond powder on the cathode. Whence the carbon, asks the sceptic? The same author less incredibly states that a weak current passed for six months through chloride of carbon diluted with alcohol gave greenish crystals on the positive electrode and on the negative brownish warty masses, showing a few reflecting surfaces and approaching the diamond in hardness. It is also a matter of common knowledge that metals deposited electrolytically sometimes contain traces of carbon. With this curious miscellany does Dr. COEHN defend himself from the charge of ignorance of the literature of the subject.

Touching this last point as the beginning of our endeavour to arrive at an appreciation of the merits of the respective views of the rivals, we may say that, considering the quality of the bulk of the previous work quoted by both controversialists, as judged by the excerpts which they give, we are by no means sure that a hearty catholic ignorance of the whole is to be altogether despised. Speaking plainly, it is poor stuff; much of it *dilettante* experiment expounded by *obiter dicta*, better unread and decently forgot. Putting all such quotations aside as weapons for pretty sparring, and not much more, the facts of the case may be examined. On the one side, Dr. COEHN has brought forward observations which are certainly remarkable, and appear to be novel; on the other, Prof. VOGEL has rightly insisted that some of the evidence adduced is not inexpugnable. Failing counter-experiment by Prof. VOGEL, we are bound to accept Dr. COEHN's results, but we are free to require of the latter such further investigation as will fill the gaps indicated or made by his very ingenious and penetrative critic before the conclusions which he comes to can be hall-marked as grounded on plain, full and reliable data. We cordially hope that this work, upon which Dr. COEHN states he is now engaged, will be brought speedily to a successful issue.

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# THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 171.*)

INSULATION TESTING OF HIGH-PRESSURE MAINS DURING WORKING.

The testing of a connected-up high-pressure network is not so useful as the testing of a low-pressure network. Usually a fault is not detected until it is a dead earth. The normal insulation resistance of a high-pressure cable is at least several hundreds of megohms per mile, whilst that of the switches, cut-outs and transformer terminals combined is, owing to surface leakage, rarely more than 10 megohms per connection. In practice, before a fault has become bad enough to make an appreciable difference in the measured insulation resistance of the connected-up network, it will spark across and burn itself into a dead earth. Many concentric systems are exceptions, however. A well-insulated concentric system has its outer main at a comparatively low potential, owing to "condenser effect." Then if a fault occur on this main it gradually lowers the resistance of the main, the potential of the main also gradually decreases, and a daily test of the network would detect the fault before it had become a dead earth.

Mains which feed substations are also exceptions. These have, as a rule, only two ends each, and consequently their normal insulation resistance is comparatively high. A fault in such a main will often be detected before it attains a dangerously low resistance. Whether such a fault can be found before then is another matter.

But even if the test only indicated the dead earths, it is not to be despised, for it can happen that a cable sparks to earth without blowing the fuse. Sometimes, on the other hand, the dynamo takes cognisance of the state of the mains; and, on a cable sparking to earth, the machine will do likewise with a howl of defiance, and do itself considerable damage. Although cable manufacturers may assure us that they now never make cables that could spark to earth, even if subjected to five or six times the strain they are subjected to under normal working conditions, and, although it may be only in a few cases that a fault can be detected before it interrupts the supply, yet, even for such exceptional cases, it is worth while to make a daily test of the mains.

In the case of a system, one main of which is permanently earthed at one point only, the potential at various points of the earthed main may be measured occasionally by a voltmeter connected between the cable and earth, and thus the occurrence of a dead earth on this main would often be noticed. A fault in the other main would not be detected until it was a short-circuit or had blown a fuse.

*Method* 5.—Continuous-current high-pressure net-works, which are not permanently earthed, may be conveniently tested by method 1. A voltmeter should be used, and a well-insulated high resistance must be inserted between the voltmeter and the main, the other end of the voltmeter being connected to earth. As before, the insulation-resistance of the system will be given by the formula

$$F = g\left(\frac{V}{d_1 + d_2} - 1\right),$$

or the fault resistance of each main by the formulæ

$$f_1 = \frac{g\{V - (d_1 + d_2)\}}{d_2},$$

$$f_2 = \frac{g\{V - (d_1 + d_2)\}}{d_1},$$

$g$ being the voltmeter resistance *plus* the resistance inserted in series with it, $d_1 + d_2$ the arithmetical sum of the readings, and V the potential difference between the mains.

Tests with temporary connections on high-pressure circuits are always more or less dangerous. By having a few more switches on the switchboard, or, better still, an independent switchboard for testing purposes, no connection need be made with loose wires. Fuses should also be inserted between the mains and the testing apparatus, both the switches and fuses being of a type intended for high pressures.

A "turn-over" or "hatchet" switch is very suitable to use for this test. The connections are shown diagrammatically in Fig. 11. Some incandescent lamps in series may be used for the resistance in series with the voltmeter. But then, as when a hot-wire voltmeter is used, the calculated insulation resistance will not be absolutely accurate, owing to the lamps having different resistances for different currents passing through them.

Some engineers object to the above method because, by earthing one main, an undue strain is put on to the other main and the dynamo and transformers or arc lamps. The only alternative is to measure the potential between each main and earth daily (or continuously) with an electrostatic voltmeter, as explained later—method 6. The two potentials are, in a continuous-current network, proportional to the fault resistances of the respective mains. The actual insulation resistance of the network cannot, however, be calculated from these voltmeter readings.

The Hartmann and Braun leakage indicator, which has already been described and is represented in Figs. 3 and 4, is also made in a form very suitable for testing high-pressure continuous-current mains. The high-pressure instrument is similar to the low-pressure one, except that the parts are better insulated and that it has a higher resistance. The instrument for 1,000 volts pressure gives scale readings from

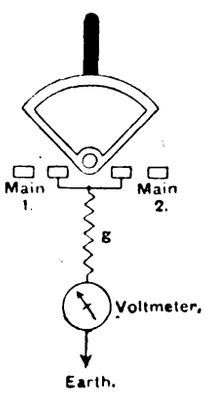


FIG. 11.

1 megohm to 80,000 ohms; the instrument for 2,000 volts gives readings from 2·7 megohms to 150,000 ohms. The resistance of the active coil of the latter is about 16,000 ohms, and a dead resistance of 100,000 ohms is inserted in series with it. As before, the reading gives the correct insulation resistance directly, if a deflection is obtained in one position of the switch only. If deflections are obtained from both mains the formulæ 15 must be used to deduce the fault resistances. Where high-pressure continuous-currents are used for lighting, in conjunction with continuous-current transformers, the normal insulation resistance of the high-pressure mains and connections will be higher than a megohm or two, so that the instrument would become a direct-reading leakage indicator pure and simple, in fact just what is wanted in this case. At 2,000 volts pressure a main will sometimes spark to earth before the resistance of the fault is as low as two megohms, but at 1,000 volts this is very rare. In series arc-lighting circuits just the opposite conditions hold, the normal insulation resistance being as a rule much lower than a megohm. For testing these the voltmeter method 5 is just as good, as the formula for the insulation resistance of the network is a more convenient one to use.

In the case of alternate current high-pressure systems which are not earthed, the potential of the mains should first be measured when the mains are known to be in good condition, and the test should be repeated daily; the readings from day to day ought always to be the same. The actual potential of each of the two mains is not, as in a continuous current two-wire system, proportional to their relative fault resistances, but depends also to a great extent on their capacities. If the

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potential of one main is always nearly zero it does not at all follow that its insulation has broken down; in fact the outer conductor of a well-insulated concentric system has usually zero potential. But if one day the potential of a main is much nearer to 0 than on the preceding day, while the potential of the other main has risen, then it is correct to infer that a fault has developed in the former main. When a new section of main has been connected up to the network, the relative potentials of the two mains may alter considerably, owing to the change in their capacities. A new section of main is, however, always tested at a pressure higher than the working pressure before it is permanently connected to the network, so that one knows that the new readings are "all right," and they are duly registered as "what ought to be" until another new section is connected up.

There are three ways in which the potential of each main can be measured:—

*Method* 6.—By means of an electrostatic voltmeter connected between each main and earth. The advantage of using an electrostatic voltmeter is that it can always be left connected to the main. It is only necessary to take a reading from one main, as the sum of the two potentials is equal to the working pressure if the insulation resistance of the voltmeter be high compared to that of the mains. Having an instrument on each main has only the advantage that the two readings check one another. If one voltmeter only be used it is best to have it on the main which gives the lower reading, as a lower reading instrument is more sensitive to small changes in pressure.

*Method* 7.—By means of a vacuum tube, one end of which is held in the hand or otherwise connected to earth, the other end being placed against the main. This method can be used

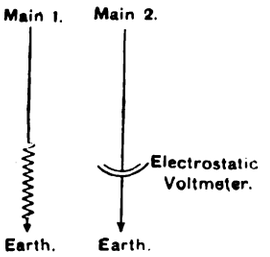


FIG. 12.

very well in the case of a side-by-side system, but not always for a concentric system. In a side-by-side system the normal fault-resistances of the two mains are about equal, and the two have also equal capacities. They will therefore, normally, have equal potentials, and the vacuum tube will glow when connected between either main and earth. If a fault occur on one main there will be no glow, or less glow, from that main, and a brighter glow from the sound main. In a well-insulated concentric system the normal potential of the outer main is very much less than the potential of the inner main, and in consequence the tube will not glow when connected to the former, whether there were a fault in it or not.

*Method* 8.—By an electromagnetic or hot-wire voltmeter in series with a high resistance. The connections are the same as in Fig. 11. Tests may be taken from each main with different voltmeters, or with the same voltmeter and different resistances in series with it. It is only necessary that the same resistance and instrument be used for the same main each day. A number of incandescent lamps connected in series forms a very convenient resistance.

*Method* 9.—Sometimes it is preferred to make the test as shown in Fig. 12. The reading of the voltmeter is taken when the connections are as on the diagram, and then the electrostatic voltmeter is connected to main 1 and the earth resistance to main 2. As in the last method, there is no need to have the resistance $r$ the same for both mains. This method is perhaps the best for concentric systems. Both this and the preceding method are open to the objection that, by earthing one main, an undue strain is put on to the other main and the machinery and transformers.

*The Cardew, Drake and Gorham Leakage Indicator.*—This instrument is practically two electrostatic voltmeters or gold-leaf electroscopes. They are not direct-reading in volts, and they give an indication of the condition of the mains by method 6. This instrument is shown on Fig. 13. To each main is connected a plate, against which lies a thin foil fastened to it at one end. The case of the instrument is connected to earth. When the mains are "live" the foils diverge from the plates. The makers also supply a resistance coil and switching arrangement so that the instrument can be used for method 9.

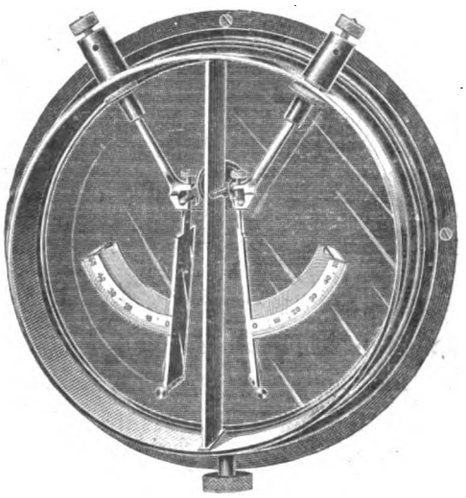

FIG. 13.

## GENERAL METHODS OF FAULT LOCALISING.

In this section will be considered the methods of fault localisation applicable to electric-light networks. The methods will first be described, and then their relative advantages and disadvantages will be discussed in connection with the various cases occurring in practice.

### *Loop Methods.*

For these methods it is necessary to have a complete circuit of cable, from the testing station, through the faulty section, and back to the testing point. This circuit is called the "loop." The different sections of cable forming the loop need not be of the same sectional area; it is only necessary that there be two independent paths of good insulation

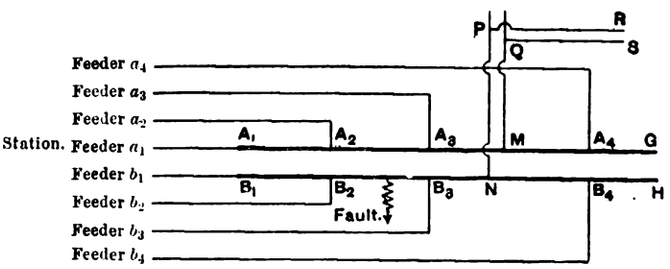


FIG. 14.

resistance from the testing point to the fault. The simplest way to get this is to connect the faulty cable with its fellow cable at one end of the faulty section, and to test at the other end; but it is not always necessary to make a short-circuit to obtain the requisite loop. In the case shown in Fig. 14 the loop may be made up in any of the following ways:—

Feeder $b_2$, $B_2$ $B_3$, feeder $b_3$;
Feeder $b_2$, $B_2$ $B_4$, feeder $b_4$;
Feeder $b_1$, $B_1$ $B_3$, feeder $b_3$, &c.

Or G and H may be short-circuited, and the loop used may then be:—

Feeder $a_1$, G H, feeder $b_1$,
or Feeder $a_2$, G H, feeder $b_2$, &c.

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Or R and S may be short-circuited, and the loop Feeder $a_4$, $A_4$ M, M Q S R, R P N, N $B_4$, feeder $b_4$, may be employed.

A pair of "ring-mains" is shown diagrammatically in Fig. 15, the points A, B, C, &c., being house-connections. This arrangement of main is much used on high-pressure systems, and makes very convenient loops. In the case of a ring-feeding-main as in Fig. 16, a system used for some low-pressure networks, the test may be made in the station through two feeders of like polarity, the continuity of the ring being broken at some point, or the test may be made from any point on the ring.

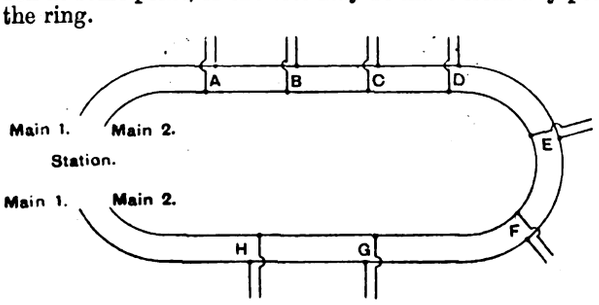


FIG. 15.

So as to have the diagrams as simple as possible, they have been made to represent two-wire systems.

If the loop is made up of several lengths of cable of different sectional area, to facilitate calculations the length of the loop should be reduced to the equivalent length of the size of cable in which the fault is, that is to say, to the length of this sized cable which would have the same resistance as the loop. If $a$ and $b$ be the sectional areas of two conductors A and B, the length

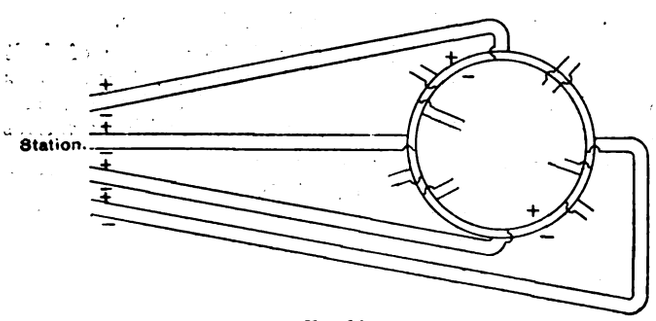


FIG. 16.

of B, which would have the same resistance as unit length of A, is $\frac{b}{a}$. The following example shows this process. A loop is made up of 340 yards of 19/18 cable, 105 yards of 37/16 (the faulty section), 84 yards of 19/16, and 529 yards of 19/18, as shown in Fig. 17A.

The sectional area of 37/16 cables is $37 \times 0{\cdot}003217$ sq. in. The sectional area of 19/18 cables is $19 \times 0{\cdot}001810$ sq. in.

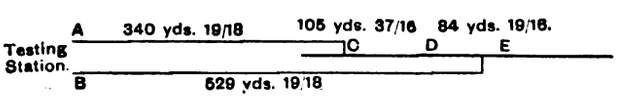


FIG. 17A.

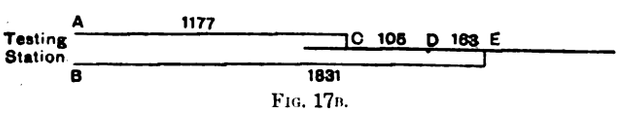


FIG. 17B.

Therefore the length of 37/16 cable, which would have the same resistance as 340 yards of 19/18 cable, is

$$\frac{340 \times 37 \times 0{\cdot}003217}{19 \times 0{\cdot}001810} = 1{,}177 \text{ yards.}$$

The piece of 19/16 cable is equivalent to

$$\frac{84 \times 37}{19} = 163 \text{ yards of } 37/16 \text{ cable.}$$

The next piece of 19/18 cable is equivalent to

$$\frac{529 \times 37 \times 0{\cdot}003217}{19 \times 0{\cdot}00180} = 1{,}831 \text{ yards of } 37/16 \text{ cable.}$$

This is shown on the diagrams (Figs. 17A and 17B). The length of the loop taken for the calculations of the test is then $1{,}177 + 105 + 163 + 1{,}831 = 3{,}276$ yards. If the result given by the localisation test is that the fault is 1,270 yards from the end A, the position of the fault will be $1{,}270 - 1{,}177 = 93$ yards from the point C.

In cases in which it is not known which is the faulty piece of cable, the length is taken as the equivalent length of the cable of largest section. Suppose, for example, that there is a fault in loop just considered (Figs. 17A and 17B), and that the position of this fault works out to 1,380 yards from the end A. Then it is apparent that it is in the section D E, and at the equivalent distance of $1{,}380 - 1{,}177 - 105 = 98$ yards from D. But as this section is of 19/16 cable, and not of 37/16, the actual distance from D will be less, in fact

$$\frac{98 \times 19}{37} = 50 \text{ yards.}$$

When, in describing the methods following, the length of loop and the distance from the end of the cable are referred to, the "equivalent length" as just described is always meant.

*(To be continued.)*

## THE ELECTRICAL AND GENERAL ENGINEERING COLLEGE.

At the invitation of the principal, Mr. G. W. de Tunzelmann, we recently paid a visit to the Electrical and General Engineering College, Penywern-road, Earl's Court, and we were much struck by the resources of the establishment, and the good use to which they are put. The College possesses laboratories, class-rooms, and workshops. In the basement there are an engine and dynamo room, machine shop, and accumulator room. On the ground floor are the physical and experimental laboratories, drawing office, pattern room, &c., and above there is a well-arranged chemical laboratory. Steam is supplied from an 8 H.P. semi-fixed locomotive-type boiler (with pump and injector feed) to a Marshall horizontal engine running at 50 revolutions, and indicating 25 H.P. at 80lb. pressure. This engine drives a counter shaft, and from this are driven by belting, several continuous and alternate-current dynamos. The switch board has been designed and built by the pupils, and is a very creditable piece of work. The machine shop, a view of which is given in the accompanying illustration, contains, amongst other appliances, six small lathes, two being driven by a monophase alternate-current motor, invented by Mr. Walter Langdon-Davies, a side-planer working over a surface 6ft. by 15in., and driven by a Johnson and Phillips continuous-current motor, an 8 H.P. screw-cutting lathe with 12ft. bed, also driven by a motor, a vertical boring and turning machine by the Richards Machine Tool Company, driven by an alternate-current motor, a 14in. emery tool-grinder by Pfeil and Co., driven by alternate-current motor, a punching machine by Pfeil and Co., various drilling machines and the usual benches and vices. In an adjoining room there is a portable forge with suitable appliances for making tools, &c. The physical section contains excellent instruments for research work and some admirable models illustrating physical laws.

Although we are not all agreed as yet as to the best method of training an engineer, there is a general consensus of opinion that the time-honoured practice of a seven-year workshop apprenticeship fails to meet modern needs. Engineering is, at the end of the nineteenth century, too intimately connected with physical science for anyone to hope to make his mark in it unless well grounded scientifically. In no branch of engineering is scientific training more pressing than in the electrical branch. Systematic training in physical science, and in the scientific methods and ideas underlying any particular

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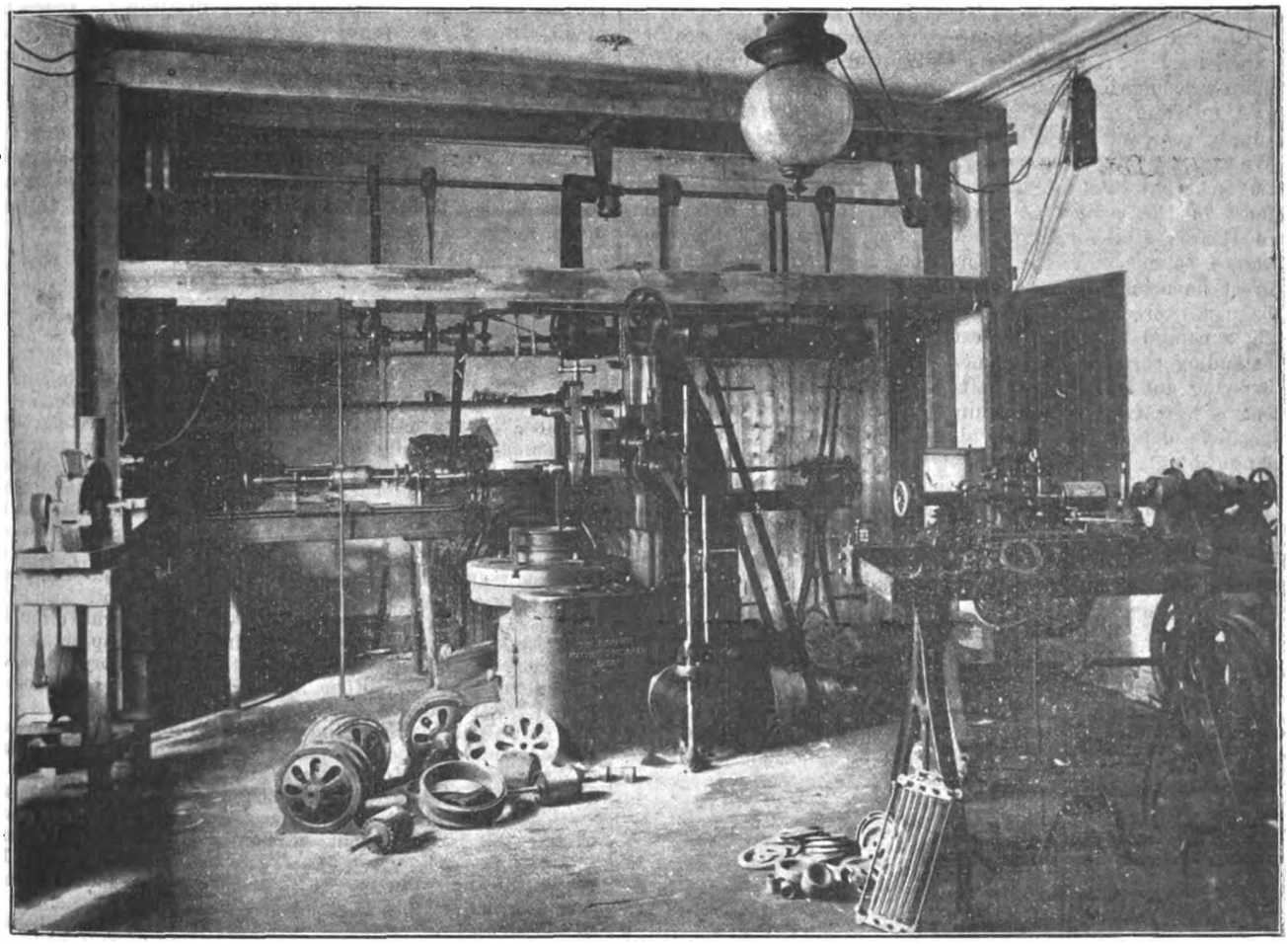
branch of engineering, is obviously impossible in the workshop. There are now in this country numerous large and well-equipped colleges, which offer unrivalled facilities for acquiring special technical knowledge. But a private institution, run on independent lines, is a welcome rarity; the more welcome in this instance since the general arrangements seem to permit of much good educational work; that is to say, work likely to *teach* the lads concerned. Here we see the essential difference between working in a technical school and in the workshops proper. In the former the aim is, or should be, to give a pupil the maximum of instruction; in the latter the aim is to turn out work cheap and expeditiously. Excellent practice no doubt, but of little educational value to the premium pupil who plays his little part in it.



View of Part of Machine Shop.

## AUSTRALIA AS A FIELD FOR ELECTRIC SUPPLY.

BY J. A. DAWSON, A.I.E.E

It may be of some interest to your readers to hear a little on the above subject from an Australian standpoint. There are several important factors to be considered when entering into the question of electricity supply in any part of the world, the chief ones being, I think, the cost of fuel and the selling price of gas, the first having an important bearing upon cost of production of electricity, and the second upon the price per unit which can be charged to successfully compete with our old-established rival.

Now, so far at any rate as the Eastern colonies are concerned, these conditions are decidedly favourable to the electricity supply company. We have an unlimited supply of cheap fuel, and the ruling price of gas is very high. Our principal coal-producing districts are Newcastle and Bulli, in New South Wales, and Gippsland in Victoria. The latter mines have only been opened up of late years, and produce a very good coal, though not equal to the Newcastle coal for steaming purposes, by about 25 to 30 per cent, yet it will probably be put on the market in the near future at such a rate as to make it cheaper for Victorian consumption than the imported coal which at present is principally used in all the Colonies, and is now supplied at the seaboard at from 12s. 6d., and inland at 18s. to 25s. and 30s. per ton, according as the distance from the seaboard increases. Then again in most of the Colonies there are supplies of good firewood sufficient for generations to come, the inland cities and towns being practically surrounded by forests, and experience shows that for steam raising purposes 4 tons of, say, Victorian firewood are equivalent to 1 ton of Newcastle coal, which is our standard. This firewood can be delivered at the works at from 3s. per ton in some districts to 5s. per ton in others, so that in the far inland towns, where coal would cost, say, 30s. per ton, firewood is substituted which actually gives us fuel equal to coal at 12s. to 18s. per ton, thus keeping the cost of production of electricity very much lower than it would otherwise be. This cuts two ways, as our gas competitor must bring his coal by rail from the seaboard at the higher rate, and must charge a high price for gas—in many places it is 10s. and 12s. 6d. per 1,000ft.—while the Board of Trade unit could be produced at a comparatively low figure, and sold at a high one, say 1s., thus giving the electricity supply company a double advantage. In the provincial cities of Victoria gas is not less than 7s. per 1,000ft, and best steaming coal 18s. to 20s. per ton. Electricity should be produced in these cities for, say, 3d., and sold for 7d. or 8d. per unit, and at that rate easily compete with gas and show a good margin of profit. Then, again, many of these cities and



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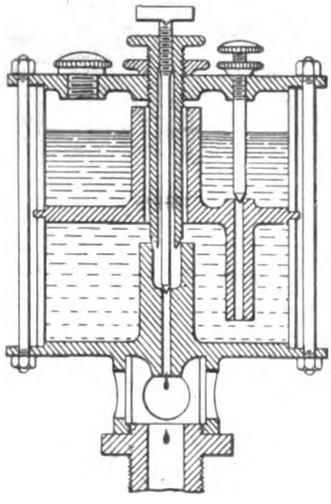
towns are important mining centres, with numbers of large payable mines abutting on the leading streets along which supply mains must pass, and these will undoubtedly become consumers both for light and power, and, what is of great importance, will give a steady day load, and thus materially assist in maintaining a good "load factor."

Climatic conditions also are favourable, the hot weather experienced in the Colonies making the electric light much more welcome than gas.

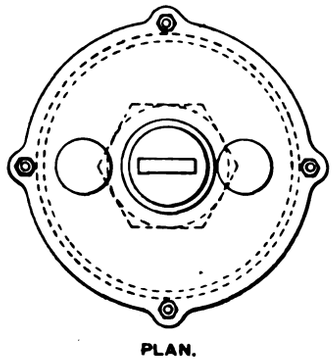
A question which is sometimes asked is, Are the existing supply companies in Victoria paying? Detractors say, No. We say, Yes; they are paying, not dividends to shareholders, but a high rate of interest to the banks from which most of the companies have borrowed a large proportion of their capital—a circumstance due to some of the companies commencing operations just about the time of the great financial collapse. Their annual reports show a credit balance over working expenses of from 8 to 10 per cent. on their capital outlay, and each year these companies are extending their mains—to meet the increasing demand—and carrying out other works, all of which have to be paid for *out of revenue*, and this during a period of financial and business depression, when almost every other industry is languishing. With the return of prosperity, of which there are evident signs, and under the recent Electric Light and Power Act of Victoria, giving supply companies a tenure of 30 years, with option of renewal or selling to Local Authority at the expiration of that time, electricity supply companies will take their right place, and, on the whole, their outlook for the future is very bright.

## A SELF-FILTERING LUBRICATOR.

The accompanying illustrations show the elevation and plan of a sight-feed shaft lubricator, designed and made by Messrs.



VERTICAL SECTION.



PLAN.

Boswell and Carter, of Salford. The special feature of this lubricator is that it is constructed so as to strain or filter the oil, separating the pure and lighter oil from the heavier and dirty oil. It will be seen that the lubricator consists of an upper and a lower oil chamber, separated by a diaphragm plate in which there is a tube leading to the bottom of the lower chamber. From the upper part of this same chamber, the lighter oil passes through the regulator valve to the tube leading to the bearing which is to be lubricated. If the flow of oil through the pilot valve in the communicating tube should be interrupted, this will be shown by the accumulation of air at the top of the lower chamber, and the lubricator can then readily be cleaned. As affording an additional means for purifying the oil passing down to the shaft, this form of lubricator might be found serviceable in conjunction with a good oil filter; but we do not consider that it would suitably replace the oil filter. The action is simple, and if used with oils of moderate thickness it ought to be reliable.

## THE TESTING OF LUBRICANTS.*

The great difference that exists between various lubricants has doubtless been impressed upon all in charge of machinery, and therefore the practical value of an apparatus for making tests of oils cannot but be fully recognised. To make such tests, however, even with the most carefully designed and constructed apparatus, and obtain concordant results is, however, far from a simple matter. The coefficient of friction thus obtained includes two factors—the coefficient of oil and of the journal and bearing surface—while, if the temperature is not fixed, a third one is introduced. In any event it is preferable, instead of accepting a coefficient derived from a test as an absolute quantity, to consider it as merely comparative and its bearing determined by reference to other tests made with the same apparatus under the same conditions. Even to obtain satisfactory comparative results, certain precautions should be observed, as follows: The journal should be hollow and ground to surface. The first requisite is necessary in order that in different tests the same temperature shall be maintained; experience has shown that the slightest irregularity of the surface of the testing ground may produce such discordant results that no precautions should be neglected on this score. The bearing surface should be preferably genuine babbitt (this with sufficient antimony to make the molten metal run freely). It is doubtful if genuine babbitt has ever been exceeded by any alloy in anti-frictional qualities, and a bearing of this material is easily kept in good condition. The utmost care should be used to scrape the bearing to fit the journal. Before every test both journal and bearing should be most thoroughly cleaned, and the journal should not be permitted to remain in place when the testing apparatus is not in use. The journal should not be rigidly coupled to the driving shaft, but driven by means of pins. The load on the journal should approximate to the actual load on the bearings with which the oil tester is to be used; it has been found that an oil which will stand an excellent test under one pressure will give very poor results under another. For roughly comparative results a solid journal may be used, and the rise in temperature of the bearing noted for equal amounts of work, the temperature readings being taken from a thermometer immersed in mercury contained in a hole bored in the bearing. In any event every set of tests should include one to determine the action of the oil at higher than the normal temperature and pressure. Every steam plant of any size should use two grades of oil—one for light pressures, and another for main bearings, as the oil suitable for one of these purposes is not the best for the other. For condensing cylinders the use of any other than a pure mineral lubricant should not be permitted, while for non-condensing cylinders a mineral lubricant is preferable, owing to its greater cleanliness. By mineral lubricants is not meant the 20-cent oils sometimes purchased, but a high fire-test and well-refined oil. It is poor economy to use cheap oils in a cylinder, particularly as with oil of good quality a surprisingly small amount is required. In fact, it is questionable if any lubricant at all is needed in the cylinders of vertical engines.

**Telephone Wire Cutting.**—The Ludlow Corporation have followed the Guernsey example, and cut the telephone wire from the Exchange Vaults to the warehouse in Church-street, in consequence, it is stated, of the National Telephone Company refusing to enter into an agreement with the Town Council. The owners of the other wires paid the required sum asked by the Corporation.

* From the *Electrical World* of New York.

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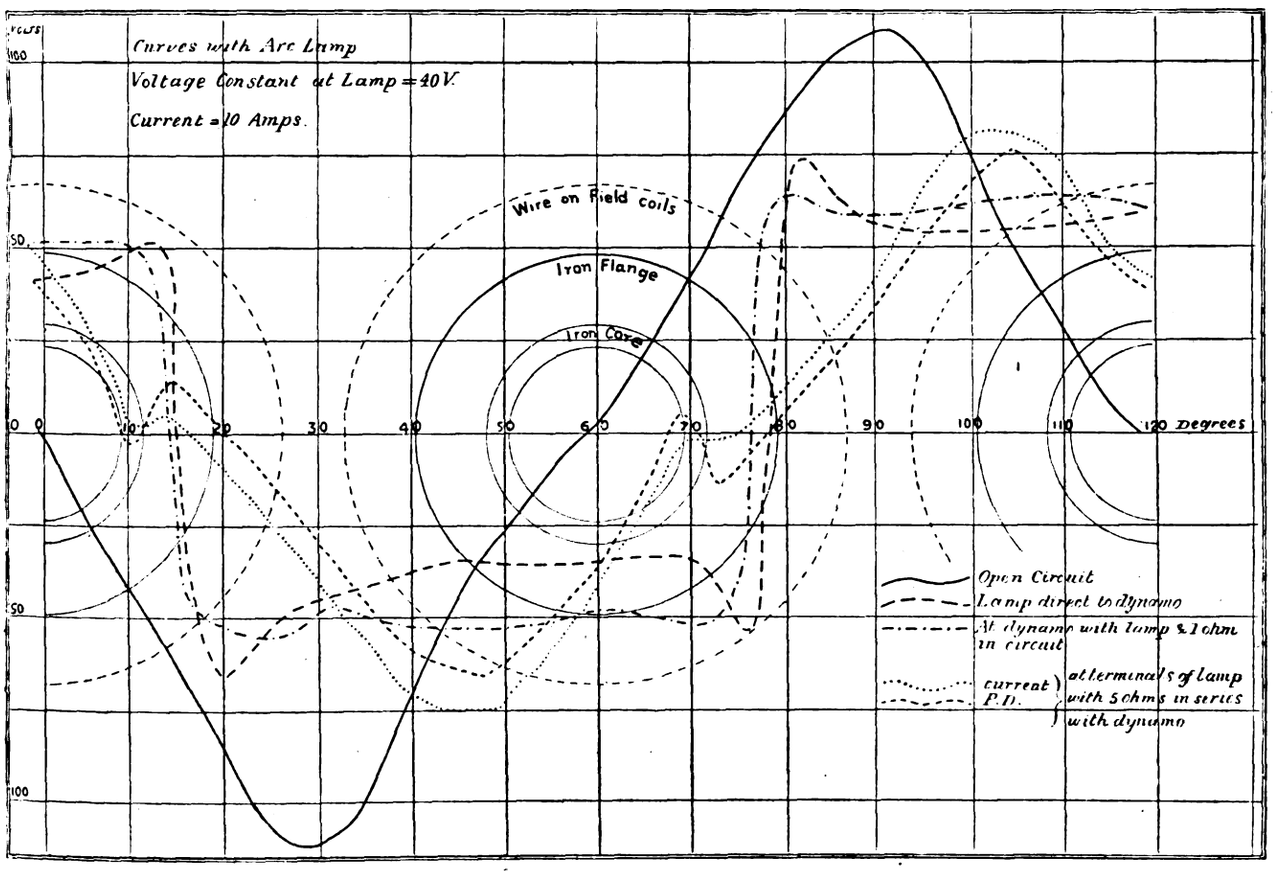
## THE EFFECT OF WAVE-FORM ON THE ALTERNATE-CURRENT ARC.*

BY JULIUS FRITH.

In the Paper by Dr. Fleming and Mr. Petavel, recently read before the Physical Society, on "The Alternate-Current Arc,"† I think too little attention was paid to the wave-form of the alternate current used. It is known that if the arc is allowed to exert a preponderating influence at all on the alternate-current circuit it alters the wave-form of both the current and the P.D. in a very marked degree.

As an illustration of the change produced in the wave-form by the character of the external circuit I give some curves for alternate-current arcs, taken from a Paper which I read before the Manchester Literary and Philosophical Society in March, 1894. Here is shown, first the E.M.F. curve of the machine on open circuit, which is rather more peaked than a sine curve, and involves the third harmonic largely. Next is shown the curve obtained under the same conditions, but with an arc lamp taking 10 amperes at 40 volts joined direct to the machine. The lag recorded is due to the self-induction of the machine, which was a "Wilde" alternator, the armature of which contained iron. It will also be noticed that the first ordinates of the curves are not quite equal to the last ordinates; this is due to the curve being slightly asymmetrical. The whole period is only one third of the revolution of the alternator (shown as 120deg. in the figure). In one complete revolution this lack of symmetry would, of course, disappear.




It is seen that the arc alters the wave-form from a peaked curve to a very flat topped curve, changing sign almost instantaneously, and with two small maxima, which occur respectively just before and just after each reversal. The next curve shows the effect of adding a resistance of 1 ohm in series with the arc. This smoothes out the two maxima, but otherwise does not affect the shape materially.

The current and P.D. curves with 5 ohms in series with the arc are next shown. Both waves now assume much more the form of the E.M.F. curve on open circuit, except at the zero line. Here the P.D. curve crosses the line twice in each direction, and the current curve runs parallel to the zero line for some way before crossing it.

These curves show, I think, the great effect that the arc has on the wave-form, and also how this effect can be destroyed by placing resistance in series with the arc.

In a Paper by Rössler and Wedding, which appeared in *The Electrician* for August 31, 1894, it was proved that an alternate-current arc is more efficient, that is, gives a higher candle-power for the same electric power consumed, when the alternating current feeding it has a flat-topped than when it has a peaked wave-form. Rössler was, however, mistaken, I think, in assuming that the machine was making that curve. Indeed, this mistake runs through the whole of this otherwise most valuable Paper. Rössler took three machines giving, as he thought, wave forms from the extremely peaked to the extremely flat wave, and determined the efficiencies of the same arc lamp for each of them. Whereas exactly the same results might have been obtained from one machine alone on causing it to give a higher voltage by increasing the field excitation and then absorbing the excess of voltage in resistance, exactly as in the case of the Wilde alternator above referred to. I understand that in the experiments described by Dr. Fleming and Mr. Petavel there was always a resistance amounting to 7 ohms outside the arc, and hence a wave form was forced upon the arc which, as Rössler has proved, is not the most efficient one, and which the arc would convert into a form better suited to itself if it had been allowed to do so, as it is in commerce. This consideration must affect, not only the efficiency, but also the curves which Fleming and Petavel obtained for the variations in the luminous intensity.

Further, this action of the arc in modifying the wave-form may throw some light on the discrepancy between the efficiency of alternate-current arcs as determined in the laboratory and that stated to be obtained in practice. When an arc is run in the laboratory a large resistance is almost certain to be put in series with it to ensure that degree of steadiness which is essential to exact measurement, and hence the arc cannot alter the wave-form. In the commercial use of arcs, on the contrary, the circumstances are widely different. In this case, for economic reasons, the arc must form a large percentage of the total "reactance" of the circuit, and therefore can easily alter the wave to the form required for the greatest efficiency.

It is interesting to note that the wave-form giving the best result for the arc is almost exactly the opposite to that giving the best efficiency for transformers. In the former case a flat-topped wave is best, while for the maximum efficiency of transformers an exceedingly peaked wave is best, as lately found by Dr. Rössler. This points to the building of alternators for use with transformers in

* Communicated to the *Phil. Mag.* by the Physical Society; read April 24th, 1896.

† *Supra*, p. 315.



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such a way as to give peaked wave-forms. In the case of the arc the building of machines to give the most efficient wave-form is not so necessary, since, generally, the arc itself has the power of automatically converting *any* wave form into the one best suited to its requirements. Nevertheless, when the arc has to run in series with a large resistance it is of the utmost importance for obtaining the best efficiency that the machine should give a flat-topped wave.

## PRECAUTIONS NECESSARY IN THE USE OF ELECTRICITY IN COAL-MINES.*

BY H. W. RAVENSHAW.

Although the use of electricity for lighting and the transmission of power in coal-mines is becoming more general, and many of the plants have been running for some years, no serious accidents or explosions have within the experience of the author been traced to its adoption. In some districts, however, where the seams are very fiery, colliery proprietors have refrained from adopting it, preferring to use less efficient or convenient methods than to run the risk of an explosion. Some writers on this subject have inclined to the view that there is little or no risk of the ignition of gas by the spark caused by the rupture of a cable through which the current is flowing. This, however, remains to be proved, and it is much better to guard against a possible danger than to run the risk of losing even a single life. As a matter of fact, the risks are few and easily guarded against, and there is no reason why electric motors should not be used in the most fiery mines, if proper precautions are taken in putting down a suitable plant and keeping it in an efficient state of repair. It is proposed in this Paper to offer a few suggestions, the carrying out of which may serve to minimise the risk both from shock and fire.

*Shocks.*—A very unpleasant shock can be obtained from a 600-volts circuit, even on dry ground, and the results might be very serious to anyone who was standing on a wet floor or in water. A shock may also cause a man to fall without directly injuring him, and for this reason gear-wheels and other moving parts should be well guarded in the neighbourhood of any switches, resistances or motors, which might have to be handled during the running of the machinery. All parts of the electric circuit should be covered, so that it is not possible to touch them without deliberately taking off the protecting covers, and the metal cases of switches and junction-boxes should always be connected permanently to earth by a stout wire, either through the tramroad rails or to water-pipes in the vicinity. Motor bed-plates should also be well earthed, especially if the machines be fixed on timber foundations. An instance has come before the author where a shock was obtained from a hauling-rope, the hauling-engine having been fixed to heavy timbers in a very dry pit, and an accidental contact having occurred between the motor and the frame of the hauling-engine.

Where parts such as brushes have to be handled while the circuit is alive, a sound dry timber floor, with perhaps a rubber mat, and a wooden handrail for the man to steady himself by, are the best protection. India-rubber gloves are most uncomfortable and clumsy, they are liable to be pierced by small chips of metal, in which case they are worse than useless, and, except in awkward situations, they are not to be recommended.

Even with a low voltage it is possible to obtain a very severe shock, owing to the high pressure which is momentarily obtained in breaking the circuit of an electro-magnet. The author cannot give any instance where loss of life has been traced to this form of shock, but the experience of anyone who has accidentally broken the circuit of even a small magnet, and whose body has remained as a shunt to the break, is one to be remembered for a lifetime. Great care should therefore be taken in handling the wires connected to the field magnets.

The question of prevention of shocks, although little danger to life is presented, is of importance, as the machinery is much more likely to be well looked after if the attendant is not afraid to touch it.

*Main Conductors.*—Where the shaft is wet, the cable should be run in cast or wrought-iron pipes having joints and junction-boxes made thoroughly watertight. These protecting pipes should be carried as far into the mine as is necessary to get clear of the water. Where, however, there is no water, armoured cables may be used, care being taken that they cannot be readily damaged by any accident to the cage.

The usual method of carrying the cables from the bottom of the shaft to the motor is to suspend them from the timbers by means of insulators. In fixing them in this way there is great danger of the cables being damaged either by falls of the roof, breaking of the timbers, or by runaway waggons. In most cases, however, the cost of protecting the cables would be so great that this simple method is to be preferred, especially as they are accessible for inspection and repair.

Several schemes have been suggested, and some have been tried, for preventing the occurrence of a spark or flame on the breakage of a cable. None of these arrangements have been generally adopted, and it is very doubtful whether any device can be relied on whose action must necessarily depend on the accurate adjustment of comparatively delicate apparatus.

Personally, the author is very much in favour of the use of concentric cables, the external conductor being connected to earth at frequent intervals, if not continuously. There are some drawbacks to this arrangement, especially in the switches and motors, but these can be guarded against, and the risk from fire in case of damage to the cables is enormously reduced. In some cases the outer conductor is used for the protection of the cable, no other insulation being used on the outside. It is, however, advisable to make the cable perfectly watertight by means of leaden covering, and again to protect it with iron armouring. In damp places it may be necessary to cover the armouring with insulating material to prevent corrosion from electrolysis. A number of installations have been fitted up with the outer or return wire uninsulated or connected to earth. This, of course, has the disadvantage that the chance of breakdown from defective insulation is doubled in fact, on the cable being damaged a short circuit will be almost certain to occur on the particular section affected. This drawback is, however, really counterbalanced by the fact that defects at once show themselves, as the safety-fuse breaks the connection in a part of the mine where the resulting spark can do no harm. It does not appear possible for the concentric cable to be broken without the inner wire coming in contact with the outer, causing a short circuit, cutting off the current at the fuses before the wires are severed, and preventing a big flash at a place where a fall of roof may have liberated gas.

*Junction-boxes.*—Branches and joints should always be made in cast-iron junction-boxes, in order that soldering may be avoided. These boxes should contain good solid terminals mounted on slate or porcelain, the opposite poles being well separated from each other. The cable should be taken through stuffing-boxes, and the wire so fixed to the terminals that it is impossible for the cables to be drawn out accidentally. The boxes must, of course, be watertight, the covers having faced joints, so that loose packing is not required, as this always gets displaced in time

*Switches.*—Where a branch occurs, a switch should be fixed in order that the circuit can be broken for testing, or in case of accident. With concentric wiring, a single-pole switch is only required, which will break the circuit of the inner wire. In double wiring, however, both poles should be provided with switches. Where switches are enclosed in metal cases they must be perfectly airtight. Stuffing-boxes for the cables are always liable to leak, and it is advisable where there is gas to have a separate box carrying the terminals, into which the cables can be brought, the connections to the inside of the switch being sealed up with bitumen or similar material.

Resistance frames in connection with starting and regulating switches are always liable to cause contact with the earth. When porcelain insulators are used the frame to which they are fixed should also be insulated, so that in case of a broken insulator the wire which it has supported will not make contact to earth. Wire coils are often used for resistances, and are usually flexible and liable to knock against each other or against their supports. They should be so spaced that it is impossible for them to touch surrounding objects. In some cases, as on coal-cutters, it would be impossible to fit resistances which would be capable of carrying the current continuously. In this case the switch must never be left in an intermediate position; in fact, it should be made so that it is impossible to leave it in any position except wholly on or wholly off. Water resistances in which the circuit is broken between the surface of water or a weak alkaline solution, and a metal or carbon contact, are very suitable for starting motors gently, as they can be made so that there is no spark between the contact and the surface of the water. As, however, the water is decomposed, these switches should not be enclosed in such a way that the explosive gases generated can accumulate. This form of switch is very simple and is not liable to get out of order.

*Motors.*—Where a large number of motors are in use on the same installation it is usual to put down either shunt-wound or compound-wound machines which work in parallel. Where, however, only one motor is used, it is advisable to have both motor and dynamo series-wound. If these machines be properly designed, the speed regulation of the motor, given a regular speed of the dynamo, will be good; and this combination has the great advantage that, when the motor is switched off, the dynamo gives no volts and takes little or no power. Series motors have, in many cases, been used in parallel with other machines for driving pumps. These work well so long as the load is constant, but the motor tends to race if the pump loses its water, and it is advisable for this

* Abstract of a Paper read before the Federated Institution of Mining Engineers.

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reason to use a compound-wound motor designed so that it will start readily under load, and will not run away when the load is taken off.

*Motor Magnets.*—With a series motor the field magnets are very simple. Shunt-wound and compound-wound motors are formed with thousands of turns of fine wire, and when the coils are connected across a circuit having a pressure of, say, 600 volts, the wires on adjacent layers have a considerable difference of potential between them. The breakdown of the insulation between the wire and the frame of the machine is another source of trouble. The author has seen otherwise well-made machines with only a sheet of Willesden paper between the metal former carrying the coil and the wire itself. There should always be at least ¼in. space between the wire and the metal parts of the machine, mahogany or teak being used to separate the winding from the metal former.

When the circuit of an electro-magnet is broken a very high pressure is momentarily produced, which will find out any weak places in the insulation, besides causing a bad spark where the circuit is disconnected. This danger can be avoided, however, by using a switch which will insert a resistance in parallel with the magnet to be broken, just before breaking, the resistance being left in parallel so that the magnet coil can discharge itself at its leisure. In certain cases the switches can be so arranged that the magnets are permanently left in parallel with the armature. It is, however, always advisable with large motors to use a switch and resistance as above described, and it is usual to excite the magnets of the motor a minute or two before the armature current is turned on. Series-magnet coils will also cause sparking at the switch when the motor is cut off, consequently both motor and dynamo should be fitted with a resistance permanently connected in parallel with the series-magnet coil. This resistance absorbs very little power, and reduces the spark on breaking the circuit to a very small amount.

*Motor Armatures.*—The use of geared wheels has been one of the most fruitful causes of expense, the rapid vibrations transmitted to the armature being certain to eventually destroy the armature. In certain cases where the speed of the armature is below 500 revolutions per minute, and where the construction is particularly good, an armature will run for many months without repairs; but wherever it is feasible belt-driving or worm-gearing should be used for the first reduction of speed. It is a remarkable fact that in many cases under heavy vibration an armature gives way mechanically while the insulation remains intact. Consequently the armature and commutator should be fixed to the shaft by the most efficient mechanical means possible.

Two forms of armature are commonly used, having respectively the Gramme or the drum-winding. Apart from a somewhat greater liability to short-circuit, and in some cases less facility for repair, the drum-armature has many advantages over the Gramme, some of which are enumerated below. The armature can be made smaller and lighter for the same work. There is much less liability to spark at the commutator. The armature is a good deal cooler, especially in the larger sizes (this is most important where enclosed machines are used); and mechanically the armature can be made stronger, the charcoal-iron plates being keyed direct on to the shaft without the intervention of a gun-metal spider. In the estimation of the author, however, the greatest advantage lies in the fact that on the occurrence of a short circuit a drum, armature stops at once and refuses to turn round; this causes a great rush of current which blows the fuses and disconnects the circuit at once. As the current is cut off automatically, a drum-armature is seldom badly burnt, as the time during which the current is flowing through the short circuit is too short for much damage to be done. With a Gramme winding, however, the armature may continue to revolve for a long time after a short circuit has occurred, in which case the armature will be badly burnt, and dangerous sparks or flames given off.

*Enclosed Motors.*—In fiery mines it is usual to enclose the armature or the commutator in gas-tight covers, so that an accumulation of gas may not be fired by the sparking at the commutator. It has been contended that it is impossible to fire gas from these sparks; but although a good dynamo will run perfectly at the brushes, there is always a chance of sparking, owing to the brushes chattering, or to a damaged section of the commutator. The author has designed a large number of enclosed motors during the last few years, and in his opinion, so long as the covers are really well made, and the joints are kept perfectly gas-tight, they will afford ample protection. There is, however, a great danger of the covers being taken off, or the joints being improperly made, and it is a question whether they are to be relied on. In large motors there is some difficulty in getting sufficient surface to dissipate the heat which is transmitted from the armature to the covers, and water or compressed air circulation has been used with good results. Where compressed air is available, a constant pressure may be kept up inside the covers, which will effectually exclude any gas which may be about. In any case, it is advisable to thoroughly ventilate the chamber in which the motor is placed, and if this be done, it is doubtful whether it is necessary to enclose the armature. The greatest safeguard against accident is, however, good supervision and careful daily testing.

In advocating the use of concentric cables and drum armatures, it must be pointed out that both of these systems have been in extensive use in collieries for some years, and their efficiency has been proved. By their use any defect at once shows itself, and the supply of current is automatically cut off before a fire can occur. As continuous-current motors have been almost entirely employed for the transmission of power in this country, it has not been thought advisable to discuss the use of alternating-current motors.

## LONDON COUNTY COUNCIL.

*Tramways Syndicate.*

At the weekly meeting of the London County Council held on Tuesday at the County Hall, Spring-gardens, Sir Arthur Arnold presiding, the report of the Highways Committee on the proposals of the Tramway Syndicate came up again for discussion. Briefly the proposals are that the Syndicate should act as an intermediary for the acquisition of the several companies' undertakings, and that the Council shall, after purchase, lease the whole to a company to be formed by the Syndicate for a term of 28 years. The Syndicate further propose that an underground system of electrical traction shall be adopted on all the lines in lieu of the present horse traction.

When the report last came before the Council, Mr. Hoare moved that the proposals be referred to the Finance Committee for recommendation, as an amendment to the Committee's proposal that the proposals be not accepted; but, as reported at the time in *The Electrician*, the debate came to an abrupt conclusion on the motion of Mr. Clark to adjourn the report.

Mr. HOARE now asked leave to withdraw his amendment, and this was agreed to.

The Hon. EVELYN HUBBARD expressed the opinion that the Finance Committee should certainly consider the proposals, and moved "That the further consideration of the Committee's recommendation be adjourned, and that the Finance Committee be instructed in the meanwhile to consider and bring up a report on the financial bearings of the proposals of the Syndicate." He said it was a matter of great magnitude, and it was most advisable to have further advice from the financial authority of the Council.

Mr. WESTACOTT (Chairman of the Committee) expressed his willingness to accept the amendment.

Mr. JONES suggested that the Finance Committee should obtain for the Syndicate an offer based on a lease of 14 years, the same period that the North Metropolitan Tramway Company was willing to accept.

Lord MOUNTMORRES asked if the most recent proposals of the Syndicate had been considered by the Committee.

Mr. WESTACOTT replied that in the last report sent out by the Committee it was distinctly stated that all questions had been considered.

Mr. BERESFORD HOPE considered the proposal to refer the report to the Finance Committee a most reasonable proposition.

Mr. BENNING said it would be most inadvisable for the Council to bind itself for a period of 28 years.

The amendment was carried by 32 votes to 13.

Mr. HOARE said he hoped the Finance Committee would be able to consider the matter at its next meeting the following day.

*New Thames Tunnel.*

The adjourned report of the Bridges Committee for the construction of a new tunnel from Greenwich to Millwall again came up for consideration. The recommendation was: "That the Council do apply to Parliament for power to construct a foot passenger tunnel between Greenwich and Millwall at an estimated cost of £70,500, and that the Parliamentary Committee be instructed to prepare the necessary Bill to be introduced in the session of Parliament of 1897." It is proposed to use electricity for lighting the tunnel, and also for working the ventilating and pumping machinery. When last before the Council the recommendation was adjourned for the Committee to supply further information, and the Committee now submitted a supplemental report giving such information.

Mr. BULL (Chairman of the Committee) spoke in support of the proposal, and said the tunnel being lighted with electricity would be perfectly sanitary.

Dr. WHITE considered that it would be useless to make a tunnel unless it was capable of being used for vehicular traffic, while he considered that at the present time it was inexpedient to spend such a sum as would be necessary to enlarge the tunnel. He moved that the report be referred back.

Lord MOUNTMORRES seconded the amendment.

Mr. CHARLES HARRISON, M.P., contended that the tunnel should be made the same size as the Waterloo Electric Railway, in order, that if circumstances needed it, the tunnel might be used for the purpose of a railway.

Mr. BULL, replying, said that lifts would be supplied so that the spiral staircase need not be used. He might inform Mr. Harrison that the tunnel was the same size as the Stockwell Railway, which went under the Thames, and might be used as suggested at any time in the event of its failure for foot passengers.

The recommendation was agreed to.

*Building and Supply of Electricity.*

On the recommendation of the Building Act Committee it was agreed that approval be given to the plans for the construction of additions and alterations to a special building to be used as a generating station on the

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site of Nos. 13 and 17, Chapel-place, Knightsbridge, as submitted on behalf of the Kensington and Knightsbridge Electric Lighting Company (Limited), subject to the usual conditions.

*Erection of Fire Alarms.*

Dr. LONGSTAFF has given notice of the following motion :—"That it be an instruction to the Fire Brigade Committee not to erect posts for fire-alarms upon or adjoining any park, public garden or common without first consulting the authority having the control thereof."

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May 29, 1896.*

**The American Institute of Electrical Engineers.**—The general meeting of this Institution was held in the Electrical Exposition Building in New York, on May 19th and 20th, when Dr. Louis Duncan, of Baltimore, was re-elected President. The report of the Council shows a total membership at the close of the year ending April 30th, of 1,035—a net gain of 91 during the year. The Sub-committee on Standards of Light made its report. The Committee concludes, from a summary of previous photometric researches and from the report of its own work, that of all the standards thus far used, candles are the least reliable; that it seems likely that many of the difficulties which are unavoidable with flame standards may be overcome by the adoption of a standard consisting of some surface electrically heated to a standard temperature; that the definition of the degree of incandescence of such surface appears at the present time to offer almost insuperable difficulties, but the Committee is at work upon a method for the measurement of the temperature of incandescent carbon, which may lead to results looking toward the solution of the problem. It has also in progress experiments looking to the production of a light standard, in which not only the burning material, but also the atmosphere, shall be of known and definite chemical composition. The Paper on "Vacuum Tube Lighting," read by D. MacFarlan Moore at the regular meeting of the Institute on April 22nd, was discussed. Mr. Steinmetz criticised the Paper, and stated that the make-and-break method adopted by Mr. Moore was precisely the same as that used in the early days of the Ruhmkorff coil, with the only exception that the interrupter was placed in a vacuum. The absence of a secondary coil was not new, and the use of external electrodes in vacuum tubes was old. In general, Mr. Steinmetz regretted that a large part of the Paper was written in a style more befitting a sensational newspaper than a scientific or even technical society. Several other gentlemen discussed the Paper from different points of view, and, in reply, Mr. Moore stated that, with reference to the economy of the light, vacuum tube light has undoubtedly been proved to be economical over previous systems in which a break in an electric circuit in the open air was used, in order to produce a secondary current which would have certain properties necessary to produce the agitation in the tube and cause the light. The only basis to calculate from as far as power was concerned was the fact that at no time was more than 2 amperes consumed by the tubes, and that objects could be better distinguished with that light than could be done with 25 incandescent lamps. Mr. Joseph Wetzler gave the results of some tests made on these tubes. The tests showed that the tubes consumed from 42 to 53 watts. This test was afterwards independently verified by Prof. Anthony, Prof. E. L. Nichols and Mr. N. W. Perry. The report of these gentlemen showed that the power consumed by each tube was about 49·28 watts. Other Papers read at the meeting were "An Analysis of Transformer Curves," by Charles K. Huguet; "The Effect of Temperature on Insulating Materials," by George S. Sever, A. Monell and C. L. Perry.

**Electrical Exposition.**—This is meeting with increasing popularity, and large crowds are in attendance every afternoon and evening. The exhibition will close Saturday of this week. After the close a dinner will be given to the managers by the exhibitors as a testimony of their appreciation of the good work done by those in charge.

**Electric Traction on Brooklyn Bridge.**—The trustees of Brooklyn Bridge have authorised the expenditure of $100,000 for increasing the electrical equipment of the bridge. A new power house will be built.

## LEGAL INTELLIGENCE.

### Electric Construction Corporation v. South Staffordshire Tramways Company.

In the Chancery Division on Tuesday Mr. Justice Romer gave judgment in this action, which was fully reported in *The Electrician* on May 1st and 8th. It will be remembered that the action was brought for the payment of sums of money due under an agreement entered into between the parties in February, 1892. The defence was that the agreement was, under the circumstances, so tainted with fraud that the Court would not enforce specific performance. The defendants further counterclaimed that the agreement was not binding upon them, and they asked for rescission and other relief by way of damage.

Mr. Justice ROMER, in delivering judgment, said that seeing how disastrously to the defendants the contract in question had resulted, he was not surprised that the shareholders should view it with reluctance, and endeavour if possible to escape from its provisions; and having regard to the way in which the defendants had been, as it would appear, defrauded by their officer Wain and their solicitor Ebbsmith, that they should imagine it was brought about by sinister influences and dishonest purposes, and that it was not in the true interests of the defendant Company. But the contract had been carried out by the plaintiffs, and ought not to be set aside unless the defendants established a case that would justify the Court in refusing to hold it binding upon them. That the defendants had not done to his satisfaction, and notwithstanding his sympathy with the Company he must hold the contract binding. The main defence to the action and ground for the counterclaim was that the contract was fraudulently brought about, that it was onerous to the defendants, that it was impossible for them to carry it out, and that it was *ultra vires*, and could not be enforced. But the defendant's counsel had not been able to show him sufficient reason for holding it to be *ultra vires*. It was urged by them that the £15,000 debentures were issued and taken by them at a discount, but the contract would not on that account be *ultra vires*. Reliance was also placed on the fact that the tramways were parted with by the defendants before the plaintiffs had done any work under the contract. Though that might show indifference on the part of the Directors of the defendant Company it could not be held as invalidating the contract. The main contention broadly urged before him was that the contract was brought about as part of a far-reaching fraudulent scheme by Wain and Ebbsmith. No doubt Wain and Ebbsmith had defrauded the Company, but he could not say that the contract was a fraudulent one. Its terms were the subject of careful consideration by both Companies, and considerable negotiation between them, which seemed to have been fairly and honestly conducted. The contract was not a profitable one to the plaintiffs, and probably would not have been entered into but from the hope that it would lead to more beneficial arrangements. No doubt it was onerous to the defendants, but they could not have carried out the work without some such contract; and having regard to the risks run by the plaintiffs, he could not say on that account the full terms of the contract were unduly onerous. It might have been more prudent not to have adopted an electric system, and no doubt all concerned were too sanguine as to the beneficial results likely to follow its adoption. It was easy to be wise after the event, and for experts to come forward now and say it was a contract that could not be carried out by the defendants. But at that time electricity as applied to tramways was practically a novelty in this country, and it could not be seen that it was not likely to prove beneficial and to be carried out to the satisfaction of both Companies. On this part of the case he did not think that reliance could be placed on Mr. Parker's present memory that he advised the Directors of the plaintiff Company that the contract could not be carried out. It was contradicted by Mr. Courtenay, whose evidence he accepted, and he thought that Mr. Parker's opinions were better explained by his letter of December, 1891. The defendants were advised on the matter by Mr. Dickenson, their engineer, and notwithstanding the reflections made upon him he saw no reason for holding that Mr. Dickenson did not honestly advise them at the time. The only provision in the contract to which strong objection was taken was that enabling the plaintiffs to bring the agreement to an end if the Directors of the Company should otherwise than by death or voluntary resignation cease to be Directors; but at this time the frauds of Wain were not known—he was regarded as a gentleman of high character and skill as a tramway expert. Though the provision was one which might have worked hardly against the defendants, it was one in favour of the plaintiffs, which they could and did waive, as it never had been acted upon. Under these circumstances it appeared to him impossible now to make the existence of the provision in the contract a ground for upsetting the contract or refusing to enforce its other provisions. With reference to the payments to Mr. Dickenson, the view urged by the defendants had not been established before him; he did not see that these payments were a bribe to him, or that he had not done his duty by the defendants during the maintenance of the contract. It appeared to him a proper arrangement that they should employ the engineer of the defendant Company who had to look after the other sections of the line, and to pay him for his services. He had now dealt with the main questions, and all he need further consider was a minor detail on Clause 16 of the contract. It was said on behalf of the

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defendants that the cost of working the electric tramways was about 3d. per mile travelled, and that to pay 4½d. per mile under Clause 16 was excessive, and must be regarded as in the nature of a penalty. But the clause spoke of 4½d. as an agreed sum, and it appeared to him it was in no way in the nature of a penalty, because if bound to exercise the power of bringing the agreement to an end the risk or loss to them would or might have been very great, and he thought the 4½d. might be properly taken as the sum compensating them under the circumstances, as under Clause 16 the plaintiffs might not obtain the £16,000 therein mentioned, but might find themselves saddled with what might be to them useless land, cars, &c. It was admitted there must be an account taken of what was due on the contract, and he therefore declared the contract to be binding upon the defendants, and that under Clause 16 it was ended on December 14, 1894, and on that footing he directed the account to be taken, the defendants undertaking to account for all costs occasioned by them. He would adjourn further consideration to Chambers, with liberty to apply, and with liberty to apply generally. As to the costs up to and including trial, the defendants must pay the plaintiffs' cost of the action. The counterclaim wholly failed, except as to the sums the plaintiffs had undertaken to account for; he therefore ordered the defendants to pay the costs of the counterclaim, except so far as they had been increased by the plaintiffs not admitting the sums to be accounted for by them, and in respect to those he ordered the plaintiffs to pay them and for them to be set off.

Mr. OSWALD, Q.C., said that as this was a matter of life and death to the defendant Company he would ask for a stay of execution if the appeal was brought within a reasonable time.

His LORDSHIP directed the account to proceed, but if taken before the appeal was heard, gave liberty to apply again.

### Rooper v. Holmes.

At the Stafford County Court last week Mr. W. O. Rooper, electrical engineer, of Stafford, claimed from Messrs. F. H. Holmes and Son, of the same town, £37. 7s. 2d., balance of account for goods sold and delivered, &c. The defendant counterclaimed £34. 12s. 10d., and paid £21. 14s. 8d. into court. For the defence it was stated that the parties had tried to come to some agreement but failed. There was a difference of about £14 between them, and one of the points in dispute related to a claim for labour in connection with some electric lighting work. The defendants engaged the plaintiff to put in an installation of 19 lamps for £15, and there was also a contract for wiring for £7. 13s. 10d. The defendants' contention was that all the labour charged for was included in the estimate for the work. Judge Jordan pointed out that the items in the plaintiff's bill were mostly for time. It was unfortunate that there was no contract in writing. The main question was whether the plaintiff was entitled to charge for the extra labour. Mr. Rooper stated that the defendants engaged him to wire their premises for 19 lights at a cost of £15 in view of their taking up an electric lighting agency. This they declined to do, and he afterwards supplied and erected fittings as required. He made out his account on the day work system and not on the contract basis, because he thought it was fairer to the defendants. If he had made out his bill on the contract system it would have been £2. 10s. more. He made the alteration in charging because there were so many extras and the nature of the work was so changed. The judge remarked that the time charged for came to £14. 11s. 6d., or nearly as much as the original contract price. Mr. Rooper said the time charged for was consumed in putting up the 19 lights, fixing a switchboard and 11 extra lights after the contract was finished. A verdict was ultimately given for £28. 14s. 8d., including the amount paid into Court, without costs, the judge saying there was no suggestion that Mr. Rooper's charges were at all exorbitant, nor any reflection whatever on his conduct in the case. He had merely made a mistake in law, and made out his bill in a wrong way.

### Frazer v. London and Provincial Supply Corporation.

At the Westminster County Court, on Wednesday, the plaintiff in this case, an electrical engineer carrying on business at Cecil-court, Charing Cross-road, London, sued to recover a balance of account in respect of two arc lamps supplied and fitted to defendants' order, and for other electrical work. The plaintiff stated that he agreed to fix the arc lamps for a sum of £10, which, together with some incidental expenses, amounted to £11. 10s. Other work was also done to the defendants' order, and when completed an account was sent in. Later the defendants paid £5 on account, but had since refused to pay the balance, on the ground that the lamps would not work properly.

The defence was that the lamps were totally useless, as the defendants' dynamo would not work them. The plaintiff, before doing the work, saw the dynamo, and ought to have known what sort of lamps it would work. The defendant was called, and said he was quite willing to pay if the plaintiff would complete the work; but the lamps at present were quite useless.

Mr. DADGE, a late partner in the plaintiff's firm, said he had tested the lamps in question and found them in good working order.

His HONOUR gave judgment for the plaintiff for £1. 7s. 6d., but said it was clear the work was more or less defective.

**London Chamber of Commerce.**—The total membership of the London Chamber of Commerce now amounts to 3,732. The income for 1895 amounted in round figures to £6,280, and the expenses to £6,229.

## CORRESPONDENCE.

### RÖNTGEN RAY EXPERIMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In his interesting article on this subject in your issue for June 5th Prof. Oliver Lodge calls attention to the fact that an insulated platinum disc supported midway between the anode and cathode of a Crookes tube is always charged positively, no matter how the connections or current are reversed.

I had already observed this while experimenting with an alternating current upon the double-focus tube you illustrated in your issue for May 8th, page 87, and have further noticed that, except in the very immediate vicinity of the cathode, any connection to the interior of the tube is positively charged. Indeed, nearly the whole of the outside of the glass is also positively electrified. My object, however, in now writing is to point out that a very complete investigation of this phenomenon is to be found described in Prof. Crookes' presidential address to the Institution of Electrical Engineers, pp. 20 to 25, Vol. XX., of the Institution *Proceedings* for February, 1891, where it is very clearly demonstrated that with the exception of the cathode stream itself, and a small space surrounding the cathode, the whole contents of the tube are positively charged. This explains the reason why in most forms of Crookes tube, as, for instance, in those first used for the Röntgen photography, the position of the anode is of small importance, seeing that it is merely a connection between the source of positive electricity and the positively charged conducting rarefied gas inside the tube.

It has been generally noticed that when focus tubes become much blackened, presumably by volatisation and deposition upon the glass of the platinum of the anode, they cease to be effective, owing to the apparent increase in their internal resistance. This is generally attributed to increase in the vacuum due to the occlusion of the residual gas by the platinum black. This may in part be the true explanation, but another is to be found in the following curious fact discovered by Prof. Crookes, which is described in his presidential address. He says: "It appears that the greater the phosphorescing power of the substance surrounding the poles, so much easier does the induction spark pass. Surround the poles with Bohemian glass or yttria—two phosphorescent non-conductors of electricity—and the induction spark passes easily; immediately I surround the terminals with a non-phosphorescent conductor" (a film of deposited silver) "the current refuses to pass." Very possibly the deposited platinum in an old or overworked focus tube has a similar effect to the silver in Prof. Crookes' experiment. I have recently had experience with a tube of special form which was much blackened, and which appeared to have an enormous internal resistance, though its blue appearance and other indications pointed to rather a low vacuum, which seems to show that this is the case.—Yours, &c.,

66, Victoria-street, London, S.W., A. A. C. SWINTON.
June 8, 1896.

### LOW-FALL WATER-POWER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was much interested by Mr. Steiger's Paper on water-power, and by your remarks on the same. It is very curious to notice how people talk of water-power for nothing.

I quite agree with Gen. Webber's remarks, and believe that there are, as he says, hundreds of places in this country where water-power might be used for electric lighting purposes, with both financial and technical success.

There are, however, other forces at work peculiar (I think) to this country, and one of the principal is that no sooner is a workable scheme got out than it is opposed tooth and nail by those who (*a*) hope to dislodge the engineer responsible for it, and get their own services engaged, or (*b*) those who hope to bleed the capitalist embarking on the scheme; and there is the lack of enterprise of the inhabitants of many small towns, who appear to divide their time between talking scandal and sleeping.

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The variation of speed common on low falls may be overcome in a number of ways. One of the best, but expensive, is that of dividing the turbine into a number of concentric rings as described by Mr. Steiger.

In hilly country, however, a system of storage of water-power is possible, and from a careful examination which I have made of the subject, I am convinced that it is a system at once economical and satisfactory, and disposes at once of any trouble from variation of head on the main turbines, though, of course, this system is not universally applicable.—Yours, &c.,

81, Harrow-rd., W., GEO. T. PARDOE.
June 5th, 1896.

## AN ELECTRICAL TREVELYAN ROCKER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am obliged to Mr. Rollo Appleyard for the references and information he gave in your last issue *re* the Electrical Trevelyan Rocker, which references I am unfortunately not able to avail myself of at present. However, there appears to be an essential difference between the vibrations which the spring in my apparatus makes, and those which a tuning-fork could possibly make. The upper portion of the spring vibrates in a *horizontal plane* and the current is *not* interrupted; there is no "make and break," one of the essentials to the success of the experiment being that the spring shall press against the rod with sufficient force to maintain its contact in spite of the vibrations of its upper portion. I may say that although I have only recently investigated the subject, I first observed the phenomenon twenty years ago, and exhibited it then to Mr. C. J. Woodward at the Birmingham and Midland Institute, and also to his assistant, Mr. Russell.—Yours, &c.,

Sutton Coldfield, June 5, 1896. T. A. VAUGHTON.

## THE HEATING OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In my article on the heating of dynamos in your issue of October 11th last, it has been pointed out to me that Figs. 3 and 4 do not agree. I find that in Fig. 4 the thickness of the plates should read 1·39mm., 2·78mm., and 4·17mm., instead of 1mm., 2mm. and 3mm. respectively.

This will not alter the conclusions arrived at in the Paper, but it will slightly alter the figures in Table I.—Yours, &c.,

King's College, London, W.C., E. WILSON.
June 8, 1896.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

TENDERS INVITED.—The Corporation of Leeds require tenders for an electrical installation sufficient for working by the overhead system a double track of tramway seven miles in length. The work is divided into seven contracts, details of which will be found in our advertisement columns. Tenders have to be sent in to the Town Clerk, Town Hall, Leeds, not later than June 22nd, and particulars, plans, &c., can be obtained from the City Engineer, Municipal Buildings, Leeds, or from Dr. John Hopkinson, F.R.S., 5, Victoria-street, Westminster, London, S.W.

——— The Corporation of Cardiff invite tenders for the construction, supply, delivery and fixing of evaporative condenser and concentric cables. Specifications can now be obtained on application to Mr. W. Harpur, borough engineer, and tenders must be sent to Mr. J. L. Wheatley, town clerk, Town Hall, Cardiff, not later than 25th inst. Our advertisement columns contain some further particulars.

——— The Shoreditch Vestry invite tenders for the supply of insulated conduits, cables, switch and fuse boards and all sundry fittings and materials for installing the electric light in their new dust destructor and electricity supply station. Tenders must be sent in to Dr. H. Mansfield Robinson, Vestry Clerk, Town Hall, Old-street, E.C., by 4 p.m. on Tuesday next.

——— The Corporation of Burnley invite tenders for the supply and delivery of armoured concentric underground cables. Tenders to the Chairman of the Electric Lighting Sub-Committee, Town Hall, Burnley, by Wednesday, the 24th inst.

TENDERS INVITED.—The Corporation of Leeds invite tenders for the supply of two steel boilers and accessories at the generating station for the projected electric tramways. Tenders to the Town Clerk's office by 22nd inst.

——— The Directors of the Caledonian Railway Company require tenders for twelve months' supplies of a quantity of stores, including telegraph and electric appliances, tools, &c. Tenders to the Secretary (Mr. J. Blackburn), at the Company's offices, 302, Buchanan-street, Glasgow, by Monday next.

——— The Highland Railway Company invite tenders for various stores, including copper plates, sheets, bars, tubes, ingots, &c., indiarubber goods, mineral lubricating oils, telegraph instruments and fittings, telegraph construction materials, &c. Particulars can be obtained of Mr. J. G. Bulmer, storekeeper, Inverness, and patterns can be seen at the stores warehouses. Tenders must be sent in by the 20th inst.

——— Owing to the impending expiration of the concession of the Jamaica Street Car Company, who own about 12 miles of horse tramways in Kingston, tenders are invited for a licence to establish and work a system of rapid transit in the island of Jamaica. Tenders to the Clerk of the Privy Council, Kingston, Jamaica, by July 31st.

——— Tenders for the supply of the following material are required by the French Telegraph Department: 125 tons of galvanised iron wire, 3,000 iron cross rods, 1,000,000 screws, 225,000 cramp hooks and 8,000 iron supports. Samples may be seen and tenders are to be sent to the Sous-Secretariat d'Etat des Postes et des Télégraphes, 103, Rue de Grenelle, Paris, by 15th inst.

——— Tenders are invited by the Vestry of St. John, Hampstead, for an extension of the electric lighting station at Lithos-road. Tenders to Mr. A. P. Johnson, Vestry Clerk, Vestry Hall, Haverstock Hill, N.W., by 4 p.m., of June 25th.

——— Tenders are required for the erection and equipment of an electricity supply station at Utrera (Spain) for the Municipal Council, to whom tenders must be sent by July 1st.

——— The Municipal Authorities of Ecija invite tenders until July 2nd for the electric lighting of the town. Tenders to El Secretario del Ayuntamiento de Ecija, Spain.

——— The San Sebastian Tramways Company require tenders by July 1st for the conversion of the tramway system of the city into electric lines.

——— Tenders are invited until the 17th inst. for the contract for the conversion into electric lines of the following "Vicinal" steam railways:—Manage-Joliemont, Pont-Brogniez-La Louvière, Joliemont-Carnières, Pont-Brogniez-Maine St. Pierre, and Pont du Sart-Houdeng-Bracquegnies. The lines have a total length of about 20 kilometres. Tenders to Société Nationale des Chemins de Fer Vicinaux, 26, Rue de la Science, Brussels.

TENDERS ACCEPTED.—The Vestry of St. Mary, Newington (London), have accepted the tender of Messrs. J. F. Clarke and Sons, 49, Moorgate-street, London, E.C., for engineering work and electric lighting at the new public baths and washhouses in Manor-place for the sum of £6,579.

——— The tender of Mr. G. A. Steinthal, Bradford, for the installation of electric lighting at the Cliffe-road refuse destructor works has been accepted by the Bradford Town Council.

——— The tender of Messrs. Peers and Co., Manchester (amounting to about £500), for installing the electric light at the Free Library, Rochdale, for the Town Council, has been accepted.

——— The Edinburgh Corporation have accepted the tender of Messrs. James Waldie and Sons for the supply of coal to their electric light station, this firm being the only one who accepted the conditions set out in the tender.

——— The following tenders have been accepted by the Wallasey Urban District Council:—

High and Low-Tension Concentric Cables—British Insulated Wire Company (Limited).

Transformers—Electric Construction Company (Limited).

Engines, Dynamos, Exciters, Switchboards and Accessories—Messrs. S. Z. de Ferranti (Limited).

——— The Paisley Town Council has accepted the Brush Company's offer for wiring the Town Hall for £344.

——— Messrs. E. Green and Son's tender for the supply of a fuel economiser of 160 tubes at £225, less 5 per cent., has been accepted by the Cheltenham Town Council.

TENDERS RECEIVED.—The Corporation of Cork have referred the three lowest tenders received for the electric lighting of the pumping station in Lee-road to the city and resident engineers for consideration. The amounts of the tenders are £187, £178 and £165.

SALE BY AUCTION.—Messrs. Percy Huddleston and Co. notify in our advertisement columns that they will sell by public auction, on Tuesday, the 16th inst., the contents of the Acme and Immisch Electric Works, Ferdinand-street, Chalk Farm, N.W., comprising

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dynamos, motors, electrical instruments and apparatus, engines, boilers, &c., and lathes, punching and shaping machines, tools, &c.

APPOINTMENTS VACANT.—The Electric Lighting Committee of the county borough of South Shields invite applications for the post of assistant and draughtsman to the borough electrical engineer at a salary of £100 per annum. Some further particulars are given in our advertisement columns, and applications for the post have to be in by 10 a.m. on Thursday, the 25th inst.

——— The Leyton Urban District Council invite applications for the post of resident engineer to the electric lighting installations now in course of construction.

——— Forty-one applications have been received by the Shoreditch Vestry for the post of resident electrical engineer. From these six have been selected. The final decision of the Vestry will be made known at its next meeting.

BUSINESS NOTICES.—Mr. G. E. V. Thomas, of Singapore, informs us that, whilst still retaining his Government appointment as electrical engineer, he has decided to utilise the privilege attached to this appointment, allowing him to accept practical work, and he has, therefore, opened an office in the business part of the town (1, Change-alley), and has obtained the agency for the Straits Settlements, Malay Native States and Java for Messrs. Holmes and Co.'s "Castle" plant. Mr. Thomas is also negotiating for the revival of the agency held by his brother, Mr. O. V. Thomas, for Thomson-Houston plant in the same districts.

——— Messrs. Chamberlain and Hookham (Limited), of New Bartholomew-street, Birmingham, inform us that they have appointed Mr. J. G. Statter to be head of their dynamo factory. The firm have taken over the goodwill and manufacturing connection of Mr. Statter's business, and also the patterns and drawings. Messrs. Venner and Sillar, of 10, Delahay-street, London, act as selling agents throughout Great Britain and Ireland for Messrs. Chamberlain and Hookham's manufactures.

DISSOLUTION OF PARTNERSHIP.—The partnership hitherto existing between Messrs. William Fox, Albert Jeffery and Thomas E. Rowe, electrical engineers, 64, Fountain-street, Manchester, has been dissolved so far as regards Mr. Albert Jeffery.

PERSONAL.—Mr. Reginald P. Wilson, of 3, Prince's-mansions, Victoria-street, London, S.W., notifies that he has severed his connection with the British Thomson-Houston (Limited), and proposes to continue the consulting work in which he has been engaged for some years.

BANKRUPTCIES.—A receiving order has been made against George Henry Barnes and Albert Thomas Barnes, trading as G. H. Barnes and Co., makers of electric light fittings and chandeliers, at Bissell-street, Birmingham.

——— The discharge in bankruptcy of George F. Rogers, electrical engineer, 41, Maxilla-gardens, Notting Hill, and 5, Great Winchester-street, London, has been suspended for three years.

——— The list of creditors of Charles G. Stewart, jun., electrician, 11, Roseburn-place, Edinburgh, includes Cox-Walkers Darlington, £56. 2s.; and Messrs. Smith and Co., Edinburgh, £15. 10s. The debtor's liabilities are £147. 2s. 6d.; assets, £15.

——— In the failure of Philip Crosby Pope, electrical engineer, 6, Castle-street, Hapton, near Burnley, Lancs., a first and final dividend of 1s. 11¼d. will be payable on and after 17th inst. at the Official Receiver's Office, 14, Chapel-street, Preston, this dividend being substituted for that of 1s. 10¼d., notified in the "London Gazette" of April 3rd, and not paid.

LIQUIDATIONS.—The petition presented by Mr. A. R. Reeves for the winding up of Leete, Edwards and Norman (Limited), engineers and electricians, 366 and 368, Euston-road, London, will be heard at the Royal Courts of Justice on 15th inst.

——— At a meeting at the office of Messrs. Deacon, Gibson and Metcalf, 9, Great St. Helen's, London, on May 28th, it was resolved to wind up the Carboid Oi-less Bearing Company (Limited). Mr. Killingworth Hedges was appointed liquidator.

MESSRS. QUEEN AND CO.—A meeting of the stockholders of this well-known American firm of electrical instrument makers was recently held for the purpose of presenting a testimonial to Mr. John P. Gray, a member of the Company who two years ago was appointed assignee of its affairs. It was pointed out at the meeting that so well had Mr. Gray handled the assets of the Company that the creditors had been paid in full and the estate had been reassigned to the Company with a surplus exceeding $200,000.

ALTERNATE CURRENT TRANSFORMERS.—The Consolidated Telephone Construction and Manufacturing Company are devoting a portion of their extensive new works at Coventry to the manufacture of transformers, main switchboards, &c. Several new features are to be introduced, by which it is claimed the transformer will be made one of the most economical in the market. Mr. S. Sudworth, the new works manager, who was for many years associated with Mr. Gisbert Kapp, will have control of the manufacture of these transformers. The Company announce that already their workshops are fully engaged with orders for telephones and switchboards of various kinds, and that a new and enlarged catalogue of telephones and accessories with reduced prices is shortly to be issued. Extensions at the works are already in contemplation.

"THE QUARRY."—The important industries connected with the stone, marble, slate, lime and cement trades are now catered for by a paper with the above title. A number which has been forwarded shows how important the quarry industry is, and what a large field the paper has before it. There are several journals, like the *Daily Tenders and Contracts*, the *Contractors' Chronicle*, the *Contract Reporter*, &c., which cater for contractors and others in a very comprehensive way; but a feature which we do not remember to have seen in any journal before is a list of works contemplated, and for which tenders have not yet been sought. This should prove very serviceable.

"LONDON MANUAL."—It is not surprising to learn that the "London Manual," previously noticed, has so soon reached a second edition. The object of the publication is to explain the functions and describe the work of all the public bodies in the metropolis and the suburbs, and to serve as a reference book to those having business or other relations with the public authorities. It is published at the office of *London*, 125, Fleet-street, E.C., price 1s., and contains nearly 300 pages well printed and arranged. Some useful London maps are given.

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AYR.—As soon as tests of the electric lamps are made, the gas lamps in the area now lighted by electricity will be removed. Extension of the electric light mains to Seafield, at a cost of £606, has been approved. A discussion at the last meeting of the Council as to the retention of the services of Mr. R. Hammond as consulting engineer resulted in the Electric Lighting Committee's recommendation that Mr. Hammond's services be continued being approved after a lengthy and somewhat acrimonious debate.

BALLYMENA.—Some temporary lighting by electricity of a few of the principal streets of the town is suggested, and a Committee has been appointed to arrange the details.

BELFAST.—At the last meeting of the Corporation the consideration of Mr. V. A. H. M'Cowen's report in regard to the provision of an additional supply station for the city was postponed. In connection with the utilisation of the town refuse a deputation is to inspect the Shoreditch combined electric light and refuse destruction station, and to prepare a report upon the adaptability of the system to Belfast.——A deputation of ratepayers has been appointed to wait upon the Post Office Authorities to ascertain upon what terms telephonic communication between Ballymena and Belfast can be established.

BIRMINGHAM.—The tramway question is becoming as acute in Birmingham as in London. A protracted meeting of the Public Works Committee of the Town Council was held on Tuesday to discuss the subject, and the recent proposals with respect to the renewal of the leases of the lines of the Central Tramway system to a syndicate who are seeking to acquire the interests of the present Company. The proceedings were private, but it is understood that the committee consider that the public interests can be best served by arrangements for leasing the lines. It was decided to ask from whatever body might be selected to work the lines a condition that no overhead wires should be used in electric traction systems. There is a strong feeling, however, on the part of several public bodies that the Birmingham tramways should be municipalised, and the steps taken in this direction by Glasgow, Leeds, Huddersfield, Blackpool, &c., are brought forward as strong arguments in favour of this course being adopted. The matter is to be again discussed at the meeting of the committee on the 16th inst.

Messrs. G. E. Belliss and Co., owing to the extent of orders in hand (chiefly for plant for electric light work), have been compelled to considerably extend their premises at Ledsam-street.

BRADFORD.—The ceremony of laying the foundation stones of the new electricity station in Valley-road took place on Friday last, and was performed by Messrs. W. C. Dixon and T. Speight, Chairman and Deputy-Chairman respectively of the Gas and Electricity Committee. The Mayor, who was present, referred to the unqualified success of the Bradford electricity scheme, and pointed out that, although the first year's working showed a loss of £1,200, the third year brought a profit of £1,385, and the present year's working was expected to realise a profit of £3,280. The estimated cost of the new station is £31,368.

BRAY.—The total output of the Township Commissioners' electric supply station now represents an equivalent of 2,000 8 c.p. lamps, and as soon as the Commissioners are in a position to meet the demand for current it is estimated that this output will be doubled.

BRISTOL.—The report of the Electrical Committee was before the Town Council at its last meeting. In the course of the report the Committee call attention to the services rendered by Mr. H. Faraday Proctor, the electrical engineer to the Council, and to the fact that

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Mr. Proctor's salary of £260 per annum has received no increase since his appointment, in 1892, to superintend the erection of machinery and plant for the electric light undertaking. In December, 1893, on the completion of the works, Mr. Proctor was appointed electrical engineer to the Council. He has since conducted the engineer's department of the undertaking, and superintended the construction of works involving large expenditure to the entire satisfaction of the Committee, who recommend that the salary should be increased to £400 per annum, increasing by annual increments of £25 to £500, Mr. Proctor undertaking not to determine his engagement for three years from the time of the increase being granted. The services of Mr. J. R. Blaikie, Mr. Proctor's chief assistant engineer, were also referred to in the report, which recommends that Mr. Blaikie's salary be increased from £130 to £175 per annum, increasing to £200 at the expiration of one year, Mr. Blaikie's engagement being for two years from the time of the increase being granted. Increases to the salaries of other officers in the electricity department were also discussed. Councillor Pearson moved the adoption of the Committee's report, and spoke in the highest terms of the efficient services rendered by Mr. Proctor and his assistants. The report, seconded by Mr. Alderman Dix, was approved unanimously.

BURNLEY.—At the meeting of the Town Council, Alderman Greenwood presented the annual statement regarding the finances of the Corporation, and stated that every department had more than realised the amounts anticipated, the receipts for electric lighting being £130 above the estimate. The Electric Lighting Committee was authorised to lay cables along Church-street and Ormerod-road with a capacity of 2,000 lights, at an estimated outlay of £1,000.

BURY ST. EDMUNDS.—The gas lighting of this town has long been considered inadequate, and Mr. F. H. Medhurst has prepared several reports, each of which has been carefully considered by the Electric Lighting Committee, which now recommends that the complete scheme, which provides for both public and private lighting, should be adopted; and that Mr. Medhurst be appointed consulting engineer at a fixed fee of £1,000 with an additional £100 for Clerk of the Works. The estimated total cost of the work is £21,400, less £2,500 to be repaid by the gas company. The Committee's recommendations were discussed at last week's meeting, and the views of the majority of the members were favourable. The further discussion of the matter is, however, adjourned for a month.

CADIZ AND TENERIFFE CABLE.—The cable between Cadiz and Teneriffe is interrupted. During the interruption telegrams for Senegal and the Canary Islands can be forwarded by the Eastern Company's route. Telegrams for Teneriffe can be forwarded by post from Cadiz on the 3rd, 18th and 30th of each month.

CHELTENHAM.—Sanction has been given by the Local Government Board to the borrowing of £23,355 by the Town Council for electric lighting extensions. The Lighting Committee's report, presented at the last meeting, recommends a number of extensions involving considerable outlay, all of which have been approved by the Council. Mr. Alderman Norman, in presenting the Committee's report, referred to the application from Mr. M. H. Kilgour, the borough electrical engineer, for an increase of salary from £200 to £260 per annum, with £20 increases up to £300 per annum, with a further request that his department should be independent and he alone be responsible to the Committee for the work of that department. In speaking on this subject Mr. Alderman Norman pointed to the fact that in all advertisements now appearing in the electrical journals for candidates for such appointments as that held by Mr. Kilgour salaries less than £300 were most exceptional. Mr. Kilgour's salary was only £200, and he was bound to say that the increase asked for was most moderate. They were now expending a sum of no less than £25,000, and the man to whom they looked for the judicious expenditure of this large sum was certainly worth all he now asked. Mr. Kilgour had proved himself a most competent engineer, and gave his labours as ungrudgingly, and felt his responsibility as acutely as any officer of the Corporation. The Committee's recommendation that the increase be granted was unanimously confirmed.

COLCHESTER.—A lengthy report of the Electric Light Works Committee was presented at the last meeting of the Town Council. A number of tenders had been received for the works required under the scheme. These tenders were not based upon a scheme or specification prepared by the Council's engineers, but each firm tendering had propounded such scheme as considered by them most suitable. The parties tendering had been requested to name the earliest date at which the works could be completed. The Electric Construction Company, one of the tenderers, undertook to complete the work by January 1, 1897, if the order were given before the 1st July next. The tenders received had been carefully considered, and the committee unanimously recommend the acceptance of the specified tenders of the Electric Construction Company on condition that the company give any guarantee required by the Council in regard to the works and on the condition that the sanction of the Local Government Board be obtained for the borrowing of the necessary funds. In recommending the adoption of this report, Mr. Babbitt stated that the scheme of the Construction Company fully satisfied the requirements of their engineer, Mr. Massey, and provided not only for the compulsory area but for some extensions beyond. A long and even-tempered debate ensued, and eventually the Committee's recommendations were adopted by 12 to 4. The following are the tenders received:—

| | A. | B. | C. |
|---|---|---|---|
| *Electric Construction Company | £10,675 | £10,940 | £257 |
| Siemens Bros. and Co. | 11,477 | 11,708 | 375 |
| Brush Company | 12,076 | 12,442 | 186 |
| Christy Bros. | 12,881 | 13,092 | 147 |

* Accepted.

A. Payment of 80 per cent. on completion of works, and balance after six months. B. Payment six months after completion. C. Charge for loan of plant for military hospital.

COVENTRY.—The petition presented by Messrs. B. Verity and Sons for the compulsory winding up of the Coventry Electrical Engineering Company was down for hearing on Tuesday, but an arrangement was made adjourning the hearing till next court day.

DEWSBURY.—The salary of the Corporation's electrical engineer, Mr. J. B. Mitchell, has been increased from £175 to £200 per annum. Extensions involving the outlay of £540 were agreed to at the last meeting of the Town Council.

DUBLIN.—The local papers are full of the success of the electric tramways, especially with the way in which the very heavy Whitsuntide traffic was handled. An addition of 20 cars is to be made to the plant, five of which have already arrived. When the whole of the additional carriages are available a two-minute service will be established.

EALING.—The Electric Lighting Committee's report states that lamps now on order are equivalent to 7,144 8 c.p., of which 6,036 are connected.

EDINBURGH.—Prof. A. B. W. Kennedy's report to the Electric Lighting Committee as to the working of the electric lighting undertaking was submitted to the last meeting of the Town Council. From careful examination so late as April 25th last, the plant and mains are reported to be in satisfactory working order and condition, and the economy in working continues, giving every evidence that the cost per unit during the second year's existence of the station will be considerably below that of the first. The report states that 51,900 incandescents and 247 arcs are actually connected, making an equivalent of 56,400 8 c.p. lamps for which current has to be provided. The number of consumers is 445. The financial success of the enterprise has corresponded with the great demand for light. The total income from incandescent lighting, including meter rents to May 15th, will be about £13,300, and from arc lighting £3,500, or £16,800 in all. Station expenses amounted to £4,500, standing charges, including interest and sinking fund, to about £9,450, a total of £14,000, leaving a profit balance of £2,800, out of which depreciation has to be allowed for. The sinking fund is 3⅓ per cent. per annum, or one-thirtieth of the whole capital expenditure. Under these circumstances, Prof. Kennedy does not consider it necessary that any special further depreciation allowance on any items of expenditure which will last for 30 years need be made. He thinks the Council may consider that all buildings, mains, road work and lamp-posts come under this head, and that, therefore, on these items no further amount of depreciation is required. On plant, however, of every kind it would be well to allow 5 per cent. for depreciation, or, say, 2 per cent. in addition to what is allowed for in the sinking fund. This percentage would run on £24,064 of the expenditure, and would therefore involve an additional allowance of £480. On batteries, instruments, arc lamps, meters, transformers, rectifiers, and one or two other items, on which in all the sum of £7,850 has been expended, a depreciation of 10 per cent., or 7 per cent. more than already allowed, should be provided for. This would require an additional £550 altogether, so that a further allowance of £1,030 for depreciation would leave the undertaking with a clear profit balance of from £1,700 to £1,800. The total number of units sold during the 57 weeks from the start in 1895 until May 15, 1896, was 560,000 to private consumers and 320,000 for street lighting—in all about 888,000. The actual works cost per unit would be under 1·25d., including lamp trimming and carbons; and if this figure is reached, it will be the lowest yet obtained in the country, a result of which the Corporation, and in particular the staff at the station, may be justly proud. In the estimate of receipts for current for the financial year 1896-1897, prepared by Mr. Monkhouse and approved by Prof. Kennedy, the amount is put at £28,000. The reduction of price from 6d. to 5d. in the case of private consumers, and from £20 to £18 in the case of public arc lamps, will make a total difference of about £4,100 on the estimate; but this is expected to still leave an ample margin over expenditure, even without allowing for the fact that the reduction of price will considerably accelerate the rate at which lamps will be put on to the system.

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EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from June 3rd to June 9th, with the ports of destination :—

*Argentina.*—Buenos Ayres, £235; La Plata, £900 (including £601 telegraph material). *Australasia*—Auckland, £45; Brisbane, £6; Sydney, £265; Wellington, £77. *Austria*—Trieste, £1,103 (telegraph material). *Ceylon*—Colombo, £110 (telephones). *China*—Shanghai, £43. *Holland*—Amsterdam, £50. *India*—Bombay, £39; Calcutta, £271. *Nova Scotia*—Halifax, £538 (submarine cable). *Russia*—Libau, £45; St. Petersburg, £217 (including £81 telegraph material). *South Africa*—Cape Town, £160; Durban, £17; Port Elizabeth, £250 (including £112 telegraph material). *Straits Settlements*—Singapore, £17. *Sweden*—Stockholm, £55 (including £37 telegraph material). *United States.*—Vera Cruz, £171 (telegraph material).

*Foreign made Electrical Apparatus and Material.*—Foreign made goods to the value of £9 have been exported from this country to Baltimore (United States).

FAREHAM.—Progress is being made with electric lighting now that the District Council have settled down to their work and seriously accepted the altered condition of affairs brought about by the purchase of the local electric lighting company's undertaking. At the last meeting of the Council it was decided to purchase second-hand Thomson-Houston plant, &c., at a cost of about £2,800, which, together with the outlay of £200 for additional land, makes up a total of £3,000, towards which a further loan will be required of £1,900, and application is to be made to the Local Government Board for borrowing powers. With regard to the purchase of second-hand machinery, one member was bold enough to advocate the purchase of new rather than second-hand machinery, on the plea of economy.

GARSTON.—The District Council have decided to engage the services of an expert to confer with them and report with regard to the establishing of electric supply in the district, the scheme to provide, if necessary, for a refuse destructor.

GRIMSBY.—At the monthly meeting of the Town Council, the Public Lighting Committee recommended that the tender of Messrs. P. R. Jackson and Co. for an additional dynamo at a cost of £144. 10s. for the installation at the Town Hall be accepted. This was met by an amendment that the matter should be referred back for the present on the ground of economy, and this was carried.

GUERNSEY.—In reference to the cutting of the National Telephone Company's wires by the Local Authorities of Guernsey, a question was asked in the House of Commons by Mr. H. C. Richards, to which the Home Secretary replied that the wires had been cut on the ground that they stretched across the public streets and private property without authority. An application by the Company requesting permission to carry the wires across the roadway was now before the State. No question had been raised as to the right of the Post Office to telephonic communication with thei sland.

HACKNEY (LONDON).—The new public baths situate in Lower Clapton-road, and which are estimated to cost about £50,000, have been completely equipped for the electric light by Messrs. Crompton and Co. The installation comprises 430 16-c.p. lamps and batteries capable of running 100 of these lamps continuously for five hours.

HAMPSTEAD.—An exhaustive official report concerning the Vestry's electric light undertaking has just been published, price 6d.

HELENSBURGH (SCOTLAND).—At the last meeting of the Council a report by Mr. Mavor, of Glasgow, on the subject of the proposed electric lighting of the burgh, was read and its consideration postponed.

HOSPITAL LIGHTING.—The cost of installing the electric light at Netley Hospital (estimated at £8,000) is to be included in next year's Army Estimates.

INDIA.—It is stated that the *Simla* municipality have received a number of tenders for lighting the Town Hall and principal thoroughfares by electricity, but that, owing to the cost and to the small encouragement offered by traders and private residents, the scheme is not likely to be carried through.——At *Lahore* it is likely that a public company will be formed to take the electric lighting scheme in hand.——The *Calcutta* municipality have discussed the question of the electric lighting of the city, but have come to no final decision, the matter being referred back to the General Committee.

LIVERPOOL.—At the meeting last week of the Mersey Docks and Harbour Board, the proceedings of the Committee of Works included a recommendation to accept a tender for an electric light installation for the new wool warehouse, Great Howard-street. This was confirmed.

MACHINERY FOR THE NAVY.—Messrs. G. E. Belliss and Co., of Ledsam-street Works, Birmingham, have recently supplied engines to H.M.S. "Swordfish," the first of the two new torpedo boat destroyers built at the Elswick Works of Sir W. G. Armstrong, Mitchell and Co. Both the "Swordfish" and her sister vessel, the "Spitfire," have had satisfactory three hours' full speed runs at a speed of 27¼ knots. The whole of the machinery and boilers, air compressors for torpedo work, electric light plant and other auxiliary machinery, have been built by Messrs. Belliss and Co., and fitted by their staff. The interesting feature of the machinery is that engines of such power can be run at the very high speed of 400 revolutions.

MORECAMBE.—It is stated that Mr. Thos. Parker has been engaged by the District Council to prepare plans and specifications for a public electricity supply system estimated to cost £25,000.

PAISLEY.—In connection with the electric lighting of this town, it has been decided to advertise for a resident engineer at a salary of £200. The services of a consulting engineer are also to be obtained.

POLICE.—An accountant named William Morris, living at Pendennis-road, Streatham, was charged on Monday at Marlborough-street Police Court, London, with stealing sums of money amounting to £210. 7s. 10d. from his employers, Messrs. Elliott Bros., the well-known electrical instrument makers, of St. Martin's-lane, London. It was stated that the prisoner had been in Messrs. Elliott's employ as accountant and cashier for 23 years, and every confidence had been placed in him. Suspicion arose, and he was ordered to produce the cash book. Having sent the lad to fetch the book, he disappeared, taking with him the key of the safe in which the cash was kept. The safe was broken open, and the deficiency was discovered. The books had been cooked, and, so far as at present ascertained, prisoner has appropriated £3,000 of the firm's money. Committed for trial.

PORTSMOUTH.—The extensive swimming baths in this town are to be supplied with a continuous supply of salt water, electric motors providing the necessary pumping power. The success of the Portsmouth installation encourages the Corporation to considerable further extensions, and £10,000 is to be borrowed for increasing the working plant. Among the machinery to be put down is a 1,000 H.P. engine.

ROTHERHITHE (LONDON).—The Vestry have decided to offer no opposition to the London Electric Supply Corporation laying mains in certain main thoroughfares in the district.

SHOREDITCH.—The dispute between the Vestry and the County of London and Brush Provincial Company has been satisfactorily settled, and a working arrangement agreed upon which will obviate any conflict as to the area of electrical supply of each party.

STAGE LIGHTING.—Sir Henry Irving is reported to have brought over from America some new electrical devices for lighting the stage of the Lyceum Theatre.

WELLS.—The Town Council's dispute with the local gas company is reaching an acute stage, but differences have to be patched up for the present, as the contract with the gas company terminates on June 24th. At the last meeting of the Council it was decided that Dr. John Hopkinson should be at once instructed to prepare plans and specifications for the introduction of the electric light into the town.

WOLVERHAMPTON.—At a meeting of the Town Council on Monday the General Tramways Purposes Committee presented a report, and recommended that the acquisition by the Corporation of the lines within the borough should be deferred seven years beyond the date on which they would have the right of compulsory purchase (July 23, 1898), on condition that the Tramway Company carried out certain extensions mentioned by the Committee. The Mayor (Alderman Mander), however, in moving that the report be referred to a special committee, said he thought it would be suicidal to throw away the opportunity of acquiring the system. He recommended the adoption of a narrower gauge, lighter cars propelled by electric power, a more frequent service, and halfpenny fares for half-mile stages. During the past year a million and a-half of passengers were carried by the Company, of which four-fifths were carried within the borough, and he could not see why the Corporation should give up the paying part of the system. He stated that during the year to July, 1895, the Company made a profit of £4. 6s. 2d. per cent. on their net capital, and he thought if Leeds could work the electric trams at 50 per cent. of the receipts (5½d. per car mile) Wolverhampton might do as well, if not better. He further advised that the opinion of an expert be obtained. The Mayor's proposals were agreed to.

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**CONTINENTAL METROPOLITAN TRAMWAYS COMPANY (LIMITED).**—A provisional agreement has been entered into between this Company and the Compagnie Francaise pour l'Exploitation des Procédés Thomson-Houston, for the sale of the interest held by the Tramways Company in the Compagnie Générale Parisienne de Tramways, and also of the freehold property belonging to the former company in Paris, for the sum of £392,800, together with the net profits of the Company to June 30, 1896. A meeting of the shareholders of the Tramways Company is to be held at the Cannon-street Hotel, London, on Wednesday next, at noon, for the purpose of considering this agreement and also the proposals of the Directors in respect to the division of the funds thus placed at their disposal.

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# COMPANIES' MEETINGS AND REPORTS.

## Electric Traction Company (Limited).

The first ordinary general meeting of this Company was held at No. 16, Great George-street, Westminster, on the 5th inst., under the presidency of Mr. R. E. Farrant.

The SECRETARY (Mr. S. G. Burgess) having read the notice convening the meeting,

The CHAIRMAN said: In rising to move the adoption of the report and statements of accounts made up to December 31, 1895, I assume that we must take the small attendance of shareholders as a testimony of their satisfaction at the way in which the Directors are managing the Company. The business to which the Directors are at present devoting their attention is the construction and equipment of the Central London Railway, which, as you know, runs through the heart of London from Shepherd's Bush to the City, a distance of six and a-half miles. This work is undertaken in pursuance of a contract with the railway company, dated June 18, 1895, under which this Company is to acquire the necessary land, and to construct and equip the railway with rolling stock to be worked by electrical power to the satisfaction of the railway company's engineers, the whole to be completed and delivered by December 31, 1898. The dominant feature of the report which we have now to submit to you—and it is a feature which we are justified in regarding with great satisfaction—is this, that having settled the price to be paid for the bulk of the property to be acquired, and having let the contracts for almost the whole of the heavy work, we are satisfied that the undertaking can be carried out within the original estimates, and we have no reason to doubt—unless something altogether unforeseen occurs—that we shall complete the railway within the contract time. The stations will be 14 in number, and they are placed in the best positions to secure the greatest amount of traffic along the line of route. The Act of Parliament authorising the construction of the line prohibits any openings being made in the roadways, so that all shafts must be sunk at the station sites. Our first work, therefore, was necessarily the acquisition of the property required for the stations and the depôt at Shepherd's Bush. The acquisition of valuable properties having frontages to the great—perhaps the greatest—main thoroughfare in London (I think Mr. J. S. Forbes once described this route as the greatest traffic thoroughfare in the world) is by no means a simple matter, because of the many interests involved—freeholders, lessees, sub-lessees, tenants, trade interests; in fact, you may judge of the magnitude of our task when I tell you that in respect of the property required for our station sites and our depôt at Shepherd's Bush, we have had to deal with no fewer than 160 separate claims, amounting in the aggregate to over £700,000. The work of dealing with these claims has been pushed forward with such energy by our surveyors, Messrs. Vigers, and our solicitors, Messrs. Ashurst, Morris, Crisp and Co., that at the present time more than four-fifths of the total number of claims have been settled or have been adjudicated upon by an arbitrator or a jury. I do not think it is expedient that I should state publicly what these settlements have cost us, because there are still some few cases—about 20—to be dealt with. The land estimates were originally framed some years ago, when application was first made to Parliament for a Central London Railway Bill. I think that was in 1889—nearly eight years ago. Since then the cost of investments has, as you know, increased largely, and we have consequently had to pay very heavily for some of our properties of an investment character. You will understand, of course, that the settlement of the amount of a claim does not mean that we at once get possession. The title to the property has still to be examined and accepted by our solicitors before payment of the sum agreed upon is made and possession obtained. This part of the work is well advanced. In about half of the total number of cases the purchases have been completed, and we have to-day full possession of three station sites, so that there is nothing on this score to prevent the actual work of construction from being very shortly commenced. I have explained to you at some length what has to be done in connection with the acquisition of land, because it gives the answer to the question which one is constantly asked: "Why don't you begin the work?" With regard to the work of construction, the line from Shepherd's Bush to the Bank has been divided into six sections. We decided to invite tenders for the shaft and tunnel work of each section separately. Contractors were at liberty to tender for only one section or for as many sections as they liked. We settled with the engineers of the railway company a list of responsible contractors who should be invited to tender, and these invitations were sent out on February 19th last. We received a very fair response to our invitation, and, as stated in the report, we have given the sub-contracts as follows:—Sections 1, 2 and 3, Shepherd's Bush to Marble Arch—Mr. J. Price; sections 4 and 5, Marble Arch to the Post Office—Messrs. Walter Scott and Co.; section 6, the Post Office to the Bank—Mr. G. Talbot. It will be within your recollection that in connection with the railway there is to be constructed under the open space in front of the Mansion House and the Royal Exchange, a system of public subways, which will also give access from the public streets to the Bank Station. The "general idea"—if I may so call it—of this system of subways had been approved by the City authorities some time ago, but before we could invite tenders for the work, we had to settle the detailed plans with the authorities. This was a work which required the utmost care and attention, and it was only after the most careful study of all the details, the preparation of several plans, and interviews with the Commissioners of Sewers, that we succeeded in presenting plans which secured their acceptance. The plans, however, having been settled, we have, after considerable negotiation, given the sub-contract for this work to Mr. Talbot, who also has the contract for section 6, which involves the underground work at this point. It only remains for me to say that I expect the actual work of construction will be commenced very shortly—I think I may say almost in a few days from now. There are, by the way, two matters to which I should refer, namely, the station in the vicinity of Davies-street, and the extension from the Bank to Liverpool-street. They are receiving our attention, but I do not dwell upon them because they are still in the stage of negotiation.

Mr. THEODORE DAVIDSON seconded the motion, which was carried unanimously.

The retiring Directors, Mr. Farrant and Mr. Davidson, were re-elected; and Mr. Singleton was reappointed auditor.

The proceedings then terminated.

## West African Telegraph Company (Limited).

The eleventh ordinary general meeting of the West African Telegraph Company (Limited) was held yesterday at Winchester House, Old Broad-street; Sir Henry C. Mance, M.Inst.C.E., presiding.

The SECRETARY (Mr. John Cambrook) read the notice convening the meeting, and the minutes of the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, when last year I had the pleasure of presenting the report and accounts to you, I had to explain that I was in the chair in consequence of the unavoidable absence of your Chairman on very important business in connection with the general election then going on. To-day I am sorry to say that I occupy his place in consequence of the prolonged and grave indisposition of Sir John Pender. His absence from his accustomed place has been referred to in this building no doubt in terms more eloquent and able than I can command at the present moment, but I can at least on your behalf, and on behalf of my colleagues and myself, express the regret that we all feel that he is not with us to-day. Sir John Pender's services in connection with submarine telegraphy are known to all the world, but it is only those who have been closely associated with him in business who can thoroughly appreciate the wisdom, forethought, zeal and courage which he applied to all those enterprises with which he has been so long and intimately connected. With these remarks I will pass to the accounts. These are almost self explanatory. They are extremely simple, but I may be permitted for a moment to dwell on their most satisfactory feature. The gross revenue for the year ended December 31, 1895, amounted to £74,333, as against £64,761 for 1894, or an increase of £9,572. The increase in the messages is almost entirely due to the receipts derived from the Cape joint purse traffic. The total working expenses for 1895 amounted to £17,474, against £17,286 or an increase of £188. The differences in the items under the various headings making up these totals are so small that it is hardly necessary to compare in detail the various increases and decreases. I may say, however, that notwithstanding the greater volume of traffic to be dealt with, the efficiency of our system has been fully maintained without any material increase in the expenditure. The expenses attending repairs and renewals of cables amounted to £6,298, against £13,473 in 1894, a decrease of £7,175. Particulars will be found in the report of the repairs effected by the ss. "Duplex" to the various sections of our cable system. In the accounts of all submarine telegraph companies this item is necessarily a very uncertain one. Although we have been exceptionally fortunate during the year to December 31st last, we have not been so fortunate since that date. The ss. "John Pender" has lately been engaged on the repairs of the St. Thome-Loanda section, and it was found necessary to expend about 20 or 30 knots of cable in restoring communication. With these facts in our minds, and also taking into consideration the large amount we have been obliged to take from reserve fund in reduction of repairs in 1893, your Directors consider it advisable to carry the sum of £15,000 to general reserve fund, after which they have been able to recommend a final dividend of 3 per cent., making, with the interim dividend already paid, a total distribution of 4 per cent. for the year, and carry the sum of £1,760 forward. Our reserve fund now amounts to £48,350, and you will see that we have only £43,000 actually invested at the present moment in first-class securities. To show how difficult it is to foresee the amount which is likely to be required for repairs and the desirability of accumulating a substantial reserve, I may recall to your recollection the fact that during the last three years the repairs have cost in 1893, £31,234; 1894, £13,473; 1895, £6,298. The most expensive section is the one which passes the mouth of the Congo, and we should have to take into consideration whether it will be advisable to alter that line of cable. The immense volume of water which sweeps out of the Congo damages the cable at enormous depths. There are frequently ravines caused by landslips to which are no doubt due the frequent breakages in our line. I am glad to be able to report that, judging from our present business, there is every prospect that the traffic receipts during this year will be equal to those of 1895. You will understand that should an interruption occur on the East Coast cables the strain of work thrown on the West African cables is very severe. We have therefore decided to adopt duplex working throughout the trunk lines of our system, and the necessary apparatus for this purpose is now in course of being despatched to our superintendent on the coast. I should mention that negotiations are in progress with the French Government, from whom I need hardly remind you we receive a subsidy. These negotiations have for their object some modifications of the existing working arrangements, by which the French Government shall derive more benefit from the important traffic which now passes by the West Coast route than has hitherto been the case. I can assure you that we are considering their suggestions in a liberal spirit; we have no desire to withhold anything to which, judging from the spirit of the concession, they may appear to be entitled. Under these circum-

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stances, I have no doubt that a satisfactory understanding will speedily be arrived at. I now beg to move :—

"*That the report and accounts for the year ended December 31, 1895, submitted to this meeting, be and they are hereby received and adopted, and that a dividend be declared, payable on and after this date, of 6s. per share, free of income tax, making, with the dividend already paid, a total distribution for the year of 4 per cent.*"

Mr. J. DENISON PENDER seconded the motion, which was carried unanimously.

On the motion of Mr. J. D. PENDER, seconded by Mr. ROBERT K. GRAY, Sir Henry C. Mance was unanimously re-elected to his seat at the Board.

Mr. SAUNDERS proposed, and Mr. HARDIE seconded, the re-appointment of the auditors, Messrs. Deloitte, Dever, Griffiths and Co., which was agreed to *nem. con.*; and a vote of thanks having been passed to the Chairman and the other Directors the proceedings ended.

## Bournemouth and District Electric Supply Company (Limited).

The fifth ordinary general meeting of this Company was held at Bournemouth on Tuesday.

The CHAIRMAN (Mr. Aymor H. Sanderson) moved the adoption of the report and accounts. He said that the great increase in the use of electric light in Bournemouth was, he thought, due in some measure to the steps taken from time to time by the Directors to cheapen and popularise the light, while at the same time sparing neither trouble nor expense in order to ensure its quality and reliability. For the purposes of the expansion to which he referred, considerable loans to meet the capital requirements of the Company had been obtained from the County of London and Brush Provincial Company, and the time was not far distant when, in the opinion of the Directors, it would become advisable to incorporate the amount of these loans into the permanent capital of the Company by re-adjustment of the capital account. When this took place, Bournemouth investors would be afforded an opportunity of further increasing their interest in the Company. In a place like Bournemouth there was no reason why the greater part of the Company's capital should not be held locally, and he thought local investors would do well to embrace the opportunity of subscribing for the shares and debentures when the opportunity was offered them, so that the Company might continue to be a local Company in fact as well as in name.

## Electric and General Investment Company (Limited).

The report of the Directors of this Company for the year ended May 31st last, to be submitted to the shareholders at the meeting at Winchester House, London, on Thursday next at 2 p.m., states that the profit and loss account shows a gross profit of £10,105. 6s. 8d., and after deducting all standing charges, the interim dividend already paid on the Ordinary shares, and a provision for contingencies of £2,222. 16s., there remains a net balance of £5,000 available for distribution. The Directors recommend that this sum be applied to the payment of a further dividend at the rate of 30 per cent. per annum for the past six months, making with the interim dividend a distribution of 20 per cent. for the year, and a dividend on the Founders' shares of £20 per share. The trustees for the Founders' shares reserve fund propose to distribute to the holders of such shares a sum of £20 per share out of the proceeds of investments sold, and dividends received in respect of the fund, making, with the before-mentioned dividend, a total distribution of £40 on each Founders' share. The Directors retiring are Mr. George Herring and Mr. B. H. Van Tromp, who offer themselves for re-election, as does the auditor, Mr. G. T. Rait.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**HERMITE INTERNATIONAL ELECTRICAL SANITATION COMPANY (LIMITED).**—This Company was registered on June 6th with a capital of £300,000 in £1 shares, to acquire "Hermite inventions and patent rights," for the purposes of bleaching, electrolysing, disinfecting, purifying, and sanitary and other processes, and the several businesses and properties of Eugene Hermite and his partners and associates, to enter into and carry into effect an agreement with Eugene Hermite, Edward J. Paterson and Charles F. Cooper, and to utilise, grant licences in respect of, and put in practice the said patent rights. The first subscribers with one share each are:—Eugene Hermite, electrical engineer; Charles F. Cooper, civil engineer; Frederick D. Cooper, merchant; Spencer Castle, solicitor; H. Woodburn Kirby, F.C.A.; G. D. Craven, tea broker; Alfred E. Cooper, consulting chemist. The first Directors are to be nominated by the above signatories.

**INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).**—The annual return made up to May 13th, has been filed. 17,000 shares have been taken up out of a capital of £450,000, in £25 shares, and the full amount has been called and paid.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—The annual return, made up to May 28th, has been filed. The capital is £1,500,000, divided into 66,871 shares of £15 each, and 66,258 shares of £7. 10s. each. 66,248 of the former class and all of the latter have been subscribed for, the full amounts have been called and £1,460,655 has been paid. £565 has been paid on 75 forfeited shares.

**WEYMERSCH ELECTRIC BATTERY SYNDICATE (LIMITED).**—The annual return of this Company, made up to December 14th, has just been filed. The whole nominal capital of £20,000 has been subscribed, and 3,000 of the shares have been issued as fully paid. The full amount has been called on the remainder, and £5,000 has been paid.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31 5/16d. per oz. (June 11th). Consols (2¾ per cent.) 112⅞—113⅛ for money, 113—113⅛ for account; 2½ per cent. 106—106½ (June 11th). Stock Exchange Settling Days: Consols, July 1st; Stocks and Shares Continuation Day, June 24th; Ticket Day, June 25th; Pay Day, June 26th; Mining Share Carry-over Day, June 23rd.

**AMERICAN BELL TELEPHONE COMPANY.**—This Company has added an extra 1½ per cent. to the regular dividend of 3 per cent.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).**—Notice is given that an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended March 31st is payable on the 24th inst. The transfer books will be closed from the 17th to the 23rd inclusive.

**BRITANNIA MOTOR CARRIAGE COMPANY (LIMITED).**—A prospectus of this concern has been issued this week. It is incorporated with a capital of £100,000, in £1 shares, and is described as "a parent company directed by practical carriage experts." As the Company is established to acquire the "Britannia" motor, the following "engineering" details will be appreciated by our readers; they are all that are furnished by the prospectus itself, which states that it (the Britannia motor) "Runs 60 to 100 miles continuously, according to size; runs up to a maximum speed of 15 miles an hour; will drive carriages, launches, tramcars, omnibuses, sewing machines, lathes, tricycles, pumps, printing presses, lifts, cranes, mining machinery, &c., with equal facility; requires no new or special carriage; works direct on axle or shaft, no gearing or countershaft being required; can easily and rapidly be fitted to existing carriages or machines; weighs about 62lb. for 1 H.P., and this weight can be still further reduced; costs only £25 for 1 H.P.; costs less for increased horse-power in proportion to the increase; will run slow, half-speed, full speed, or reverse by merely turning two handles; has no heat, smell, smoke, or steam, and may be used by a child with absolute immunity from danger; it therefore meets the requirements of the new Act now before Parliament." Amongst the Directors is Mr. C. O. Bastian, "late engineer, Hampstead Vestry."

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended June 7th were £930, against £904 in the corresponding week of 1895, an increase of £26. The total receipts for the half-year amount to £21,465, against £21,437 for the corresponding period of 1895, an increase of £28.

**CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).**—The Directors have declared an interim dividend on the Preference shares of 6 per cent. for the half-year ending 30th inst. The dividend is payable on and after July 15th.

**COMMERCIAL CABLE COMPANY.**—A quarterly dividend of 1¾ per cent. on the capital stock of this Company is declared payable on the 1st prox.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company in May, 1896, were £24,000, and the total receipts from January 1st to May 31st £114,000, against £105,800 and £124,000 in the corresponding periods of 1894 and 1895 respectively.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 7th inst. amounted to £1,152. The amount for the corresponding week last year (including Whit Monday) was £1,671; decrease, £519.

**MILWAUKEE ELECTRIC RAILWAY AND LIGHT COMPANY.**—During the week Messrs. J. S. Morgan and Co. invited applications on behalf of this Company for $5,100,000 Five per Cent. Consolidated Mortgage Gold Bonds of $1,000 each at a premium of 2 per cent. The present issue is the balance of $7,000,000, secured by a consolidated mortgage dated February 1, 1896, covering all the real and personal estate of the Company, and the principal is payable on February 1, 1926. The share and bond capital of the concern is largely held in this country. The lists opened on Monday and closed on Tuesday. The prospectus states that the volume of the light and power business of the Company on February 1st was equivalent to a total output of 55,313 16 c.p. lamps, the net earnings for 1894 being $436,070, and for 1895 $588,496.

**SCHUCKERT AND CO., NUREMBERG.**—The Directors of this Company have declared a dividend of 14 per cent. for the business year 1895-96. The dividend for 1894-95 was 10 per cent.

**STOCK EXCHANGE NOTICE.**—Application has been made to the Stock Exchange Committee to appoint a settling day in and grant a quotation for the recent issue of 10,000 cumulative six per cent. Preference shares of the County of London and Brush Provincial Electric Lighting Company (Limited).

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended June 5th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,540.

**WESTERN UNION TELEGRAPH COMPANY.**—The Directors of this Company declared on Tuesday last the regular quarterly dividend of 1¼ per cent.

**WILLANS AND ROBINSON (LIMITED).**—The applications for the £100,000 4½ per Cent. First Mortgage Debentures in this Company recently offered for subscription amounted, we are informed, to £250,000. Letters of allotment and regret have been posted.

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## COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share | Last Dividend. | Name. | Previous Week's Price, June 3. | Price Wednesday, June 10. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending June 6. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £4,012,880 | Stock | 12/0 | Anglo-American | 48 50 | 47 49 | 5 2 0 | Jan., Apr., July, Oct. | 48½ | 48¼ |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 92 93 | 91 92 | 5 8 8 | " " | 92⅝ | 92⅛ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 8¾ 9¼ | 8¾ 9¼ | | | | |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 18 1 | January and July | | |
| £250,000 | £10 | | Amazon Telegraph (fully paid) | 10 11 | 10 11 | | | | |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15 15½ | 15 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15⅝ | 15½ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 117 | 113 117 | 4 6 11 | June and December | | |
| 10,000,000 | $100 | $1½ | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 3 6 | Jan., Apr., July, Oct. | | |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 13 | 12 13 | 6 3 1 | February and August | 12⅝ | 12½ |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 19½ 20½ | 19½ 20½ | 4 17 7 | " " | | |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 4 5 | 4 5 | 4 0 0 | April and October | | |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 15 3 | " " | | |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 106% 109% | 108% 109% | 4 4 1 | | | |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10 | 9½ 10 | 4 0 0 | Jan., Apr., July, Oct. | | |
| 400,000 | 10 | 2/6 | Eastern | 17 17½ | 17 17½ | 3 14 4 | " " | 17⅝ | 17 1/16 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 18¾ | 18½ 18¾ | 3 4 0 | " " | 18½ | 18¾ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 130 133 | 131 134 | 2 19 11 | May and November | 133 | 132½ |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 109 | 106 109 | 4 13 3 | February & August | | |
| 250,000 | 10 | 6/6 | Eastern Extension | 17½ 18 | 17½ 18 | 3 17 9 | Jan., Apr., July, Oct. | 17 1/16 | 17½ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 131 134 | 132 135 | 3 0 2 | February & August | 134 | 132½ |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 101 105 | 101 105 | 4 17 4 | January and July | 102 | |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 17 4 | " " | | |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 108 | 105 108 | 3 14 11 | February & August | 107½ | |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 110% 113% | 110% 113% | 3 11 1 | May and November | | |
| 180,227 | 10 | 2 6 | Globe Telegraph and Trust | 10½ 11 | 10½ 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅛ | 10⅜ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17 17½ | 17 17½ | 3 8 7 | " " | 17⅜ | 17⅜ |
| 150,000 | 10 | 10/0 | Great Northern | 23 24 | 23½ 24½ | 4 1 8 | Jan., April, and July | 24 | |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 (issue | 104 107 | 104 107 | 4 14 7 | March & September | | |
| 17,000 | 25 | 37/6 | Indo-European | 52 55 | 52 55 | 4 10 11 | May and November | 53 | |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. .. | " " | | |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 109 112 | 5 8 7 | March & September | | |
| £100,000 | £100 | 1% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 13 3 | | | |
| 11,839 | 5 | 4/0 | Reuter's | 6½ 7½ | 6½ 7½ | 5 8 4 | April and October | 7 1/16 | 6⅛ |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 135 140 | 135 140 | 4 5 9 | | | |
| 15,609 | 10 | 2/0 | West African Telegraph | 7½ 8½ | 7½ 8½ | | January and July | | |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 103 106 | 103 106 | 4 15 6 | March & September | | |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | | January and July | | |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 100 105 | 100 105 | 7 17 8 | June and December | | |
| 38,321 | 10 | 0/6 | West India and Panama | 1 1½ | 1 1½ | | | 1½ | 1⅜ |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11 11⅜ | 11 11⅜ | 5 4 4 | May and November | 11 1/16 | 11⅜ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | | |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 109 112 | 4 11 1 | June and December | 110⅜ | |
| 64,248 | 15 | 5/3 | Western and Brazilian | 9 9½ | 9 9½ | 4 14 10 | May and November | 9 3/16 | |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6⅞ 7½ | 6⅞ 7½ | 5 3 8 | | 7 | 6⅞ |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 3 | 2½ 3 | | | | |
| £165,300 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 104 108 | 105 109 | 5 12 2 | February & August | | |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 104 108 | 105 109 | 5 12 2 | " " | | |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 2 3 | May and November | | |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 105 | 102 105 | 5 15 11 | March & September | | |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chill Telephone (fully paid) | 3 3½ | 3 3½ | | | | |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/16 1/8 | 1/16 1/8 | | May and November | | |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | 1/8 1/4 | 1/8 1/4 | 7 5 6 | Yearly | | |
| 484,597 | 5 | 3/0 | National | 7⅞ 7⅞ | 7⅞ 8 | 3 8 9 | June and December | 7⅞ | 7 1/16 |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 18 | 16 18 | 3 6 8 | " " | 18 | |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16½ 17½ | 16½ 17½ | 3 8 7 | " " | | |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅞ 6⅞ | 6⅞ 7 | 3 11 5 | | 6⅞ | |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 4 6 | January and July | 109¼ | |
| 58,000 | 5 | 3/0 | United River Plate | 3½ 4 | 3½ 4 | | " " | | |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 100 105 | 100 105 | 4 17 1 | " " | | |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ 15½ | 14½ 15½ | 3 4 6 | | 15⅝ | 15¼ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ 17 | 16½ 17 | 3 10 7 | | 16 1/16 | 16⅛ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 138 | 134 138 | 3 13 8 | June and December | | |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | | | | |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 8¼ 8¾ | 8¼ 8¾ | | | | |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | | | | |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8½ 9½ | 8½ 9½ | | | | |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12⅞ 13½ | 12⅞ 13½ | 4 8 11 | | 13¼ | 12 1/16 |
| 8,322 | £5 | .. | House-to-House Electric | .. .. | .. .. | | | | |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. .. | .. .. | | | | |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | | January and July | | |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 8 8½ | 8 8¼ | 3 12 9 | | | |
| 111,000 | 5 | .. | London Electric Supply | .. .. | .. .. | | | | |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13½ 14½ | 13½ 14½ | 2 15 2 | | 14 | 13⅞ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 123 | 120 123 | 3 14 5 | June and December | 122 | |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9 9½ | 9 9½ | | | | |
| .. | .. | .. | Rand Electric | ⅜ ½ prem. | .. .. | | | | |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 10¾ 11½ | 10¾ 11½ | | | 11 | 10 1/16 |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 3 7 | | 11 | |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9½ 10 | 9½ 10 | 3 10 0 | | 9 1/16 | 9½ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1⅛ 1⅜ | 1⅛ 1⅜ | 5 8 8 | | | |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅜ 1⅝ | 1⅜ 1⅝ | 6 17 2 | | | |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 114 | 111 114 | 4 0 0 | March & September | | |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July | | |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1½ 1⅝ | 1½ 1⅝ | 8 10 11 | February & August | | |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 104 107 | 104 107 | 4 5 9 | January and July | | |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. .. | .. .. | .. | | | |
| 110,000 | 2 | .. | Electric Construction | 1 1½ | 1⅛ 1⅜ | .. | | | |
| 12,845 | 2 | 2/9⅜ | Do. 7 per Cent. Cumulative Pref. | 2½ 3 | 2½ 3 | 4 13 4 | September | | |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅜ ¾ | ⅜ ¾ | .. | | | |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. | | | |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23 24 | 23 24 | 4 3 4 | February & August | 23⅜ | 23⅛ |
| £200,000 | 100 | .. | * Do. 4 per Cent. Debentures | 105 107 | 105 107 | 3 14 9 | March & September | 106½ | 106⅜ |
| 15,995 | £10 | .. | International Okonite Ordinary | .. .. | .. .. | .. | | | |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. .. | .. .. | .. | December and June | | |
| 30,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ½ ¾ | 5/16 5/16 | .. | | | |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 41 | 38 41 | 4 7 10 | March and July | 40 | 39½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 104 107 | 104 107 | 4 15 3 | January and July | | |
| 37,514 | £5 | .. | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. .. | .. .. | .. | | | |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. .. | .. .. | .. | | | |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16 17 | 16 17 | 3 8 7 | March & September | 16⅝ | 16½ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 17 18 | 17 18 | 3 17 9 | | 17½ | 17 |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 114 | 109 114 | 4 0 0 | February & August | | |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 42 44 | 42 44 | 2 16 10 | January and July | 43½ | 42 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 15 15½ | 14¾ 15¼ | 3 6 5 | | | |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 135 137 | 135 137 | 2 18 5 | May and November | | |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway | 14 14½ | 13½ 14 1/16 | 2 2 10 | | | |
| 10,000 | 10 | 5% | Do. 5% Preference | 17½ 17⅝ | 17⅛ 17⅝ | 2 16 10 | | | |
| 135,000 | Stock | 4% | Do. 4% Debenture | 114½ 116½ | 114½ 116½ | 3 10 10 | January and July | | |

In calculating the yield on this security, allowance has been made for accrued interest but *not* for redemption.

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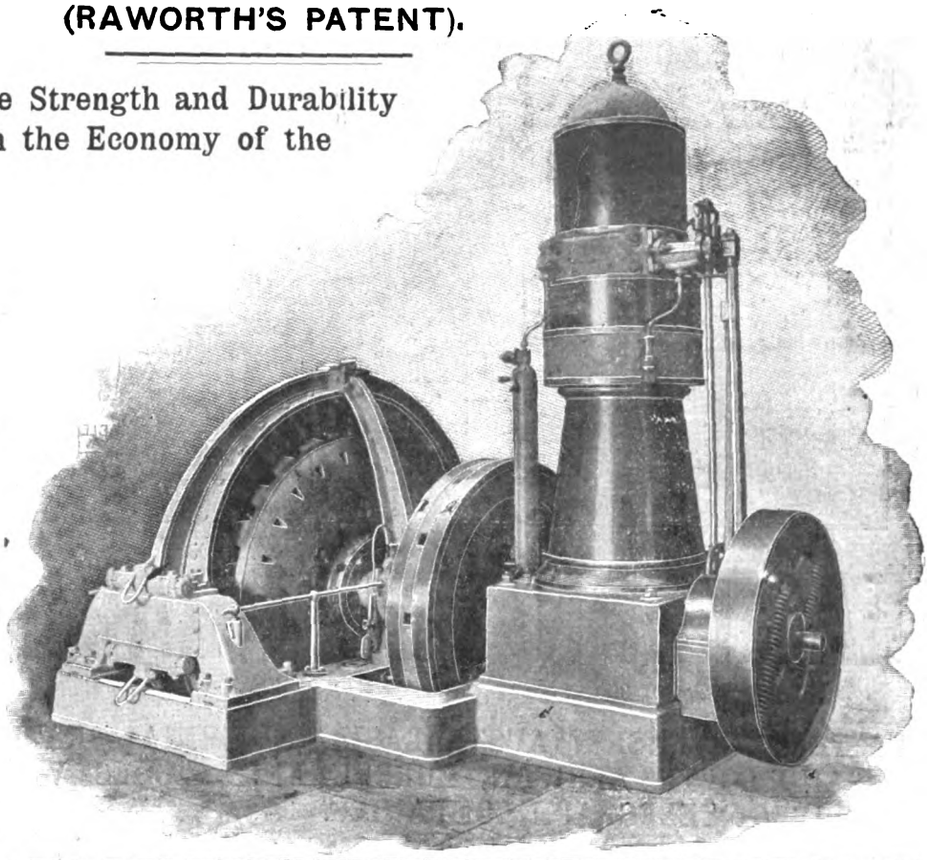

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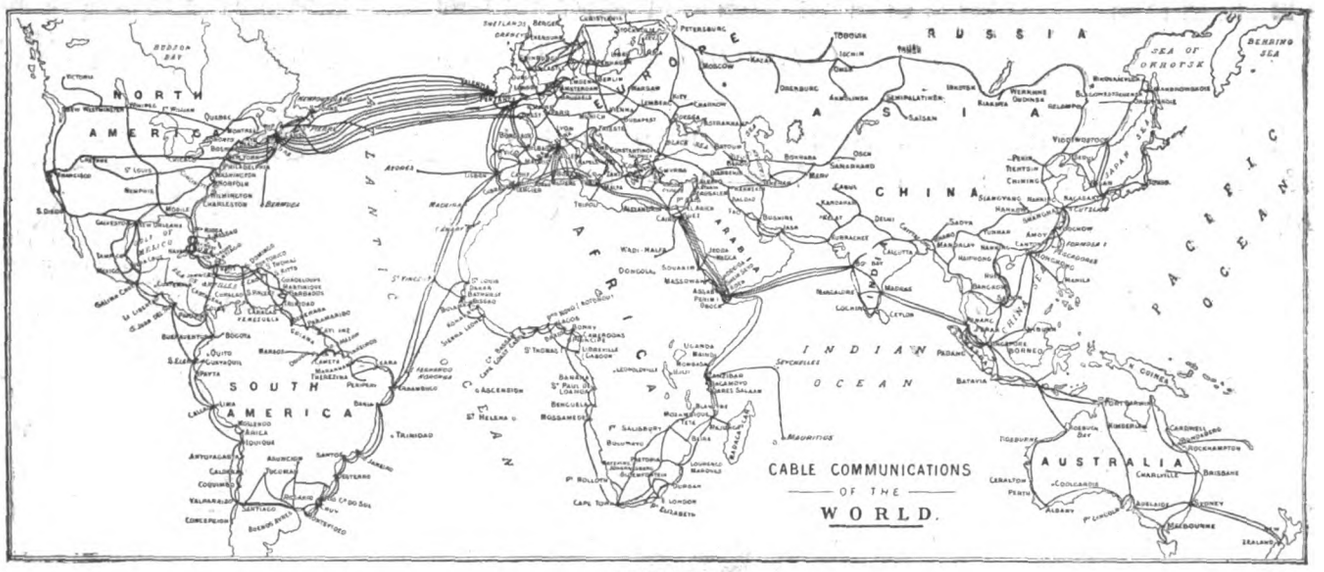
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.

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## TENDERS INVITED.

THE URBAN DISTRICT COUNCIL OF EALING are prepared to receive TENDERS for WORKS in connection with the Extension of their Electric Lighting Station at South Ealing.

Drawings and Specification can be inspected, and Bills of Quantities and Form of Tender obtained, on application at the Office of Mr. Chas. Jones, C.E., Surveyor to the Council, on and after Monday next, the 22nd day of June, between the hours of Ten and Four, and upon payment of £2. 2s., which will be returned on receipt of a bona fide Tender.

Sealed Tenders, endorsed "Tenders for Extension of Electric Station," to be delivered at my office not later than 4 p.m. on WEDNESDAY, the 1st day of July, 1896.

The Council do not bind themselves to accept the lowest or any Tender.

By order,
WM. RUSTON, Clerk.

Public Buildings, Ealing, W., 16th June, 1896.

COUNTY BOROUGH OF ROCHDALE.

The FREE LIBRARY COMMITTEE invite TENDERS for the ELECTRIC LIGHTING PLANT required at the Free Public Library, consisting of Gas Engine, Dynamo, Wiring and Fittings.

Plans may be seen and Specification and Form of Tender obtained on and after Saturday, 20th June, at the office of Mr. S. S. Platt, Assoc.M.Inst.C.E., the Borough Surveyor, on payment of a deposit of £1, which will be refunded on the return of the documents and the receipt of a bonâ-fide Tender.

Tenders, under cover, endorsed "Free Library Electric Lighting," must be delivered at my office not later than noon of Tuesday, 30th June, inst.

The Committee do not bind themselves to accept the lowest or any Tender.

JAMES LEACH, Deputy Town Clerk.

Town Hall, Rochdale, 19th June, 1896.

WATFORD URBAN DISTRICT COUNCIL.

ELECTRIC LIGHTING,

The Council invite applications from Eminent Consulting Engineers, prepared and qualified to advise them in regard to the preparation of an intended Memorial to the Board of Trade for a Provisional Order under the Electric Lighting Acts, as to the best system to be adopted, the area to be lighted, the cost of the undertaking, its probable development, and generally in relation to the subject; but not as to whether the Council should retain or dispose of the powers to be conferred by such Provisional Order.

Applications, stating particulars of experience, and fee required for such preliminary report and advice, to be sent to the Council Offices on or before 24th inst. The Council give no assurance as to subsequent employment.

H. MORTEN TURNER, Clerk.

Council Offices, Watford,
12th June, 1896.

PACIFIC AND EUROPEAN TELEGRAPH COMPANY (Limited).

NOTICE is Hereby Given that the COUPONS on this Company's FOUR PER CENT. GUARANTEED DEBENTURES, due 30th inst., will be PAID on and after that date at PARR'S BANKING COMPANY AND THE ALLIANCE BANK (Limited), Bartholomew-lane, London, E.C.

Coupons must be left at the above Bank three clear days for examination.

By order,
W. H. AXWORTHY, Secretary.

Winchester House, Old Broad-street,
London, E.C., June 18th, 1896.

AFRICAN DIRECT TELEGRAPH COMPANY (Limited).

NOTICE is Hereby Given that the COUPONS on this Company's FOUR PER CENT. MORTGAGE DEBENTURES to bearer, due July 1st next, will be PAID on and after that day at PARR'S BANK (Limited), Bartholomew-lane, London, E.C. Coupons must be left at the above Bank three clear days for examination.

Warrants in payment of the Interest on the Registered Debentures will be sent out on the 30th inst.

The DEBENTURE REGISTER will be CLOSED from WEDNESDAY, the 24th to TUESDAY, the 30th inst., both days inclusive.

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H. E. PLANK, Secretary.

Winchester House, Old Broad-street,
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Candidates must have had training in mechanical and electrical engineering and be competent draughtsmen.

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By order,
J. MOORE HAYTON, Town Clerk.

Court Buildings, South Shields, June 9, 1896.

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Municipal Buildings, Paisley, 13th June, 1896.

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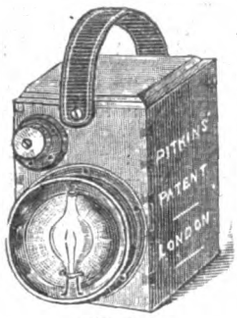


FIG. 1A.

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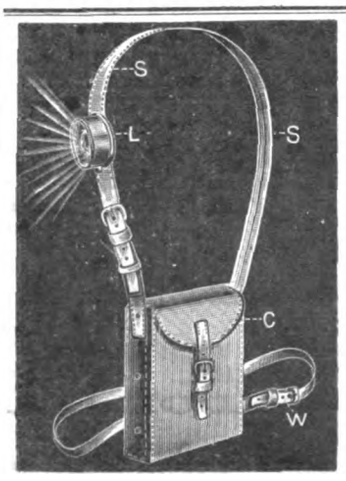


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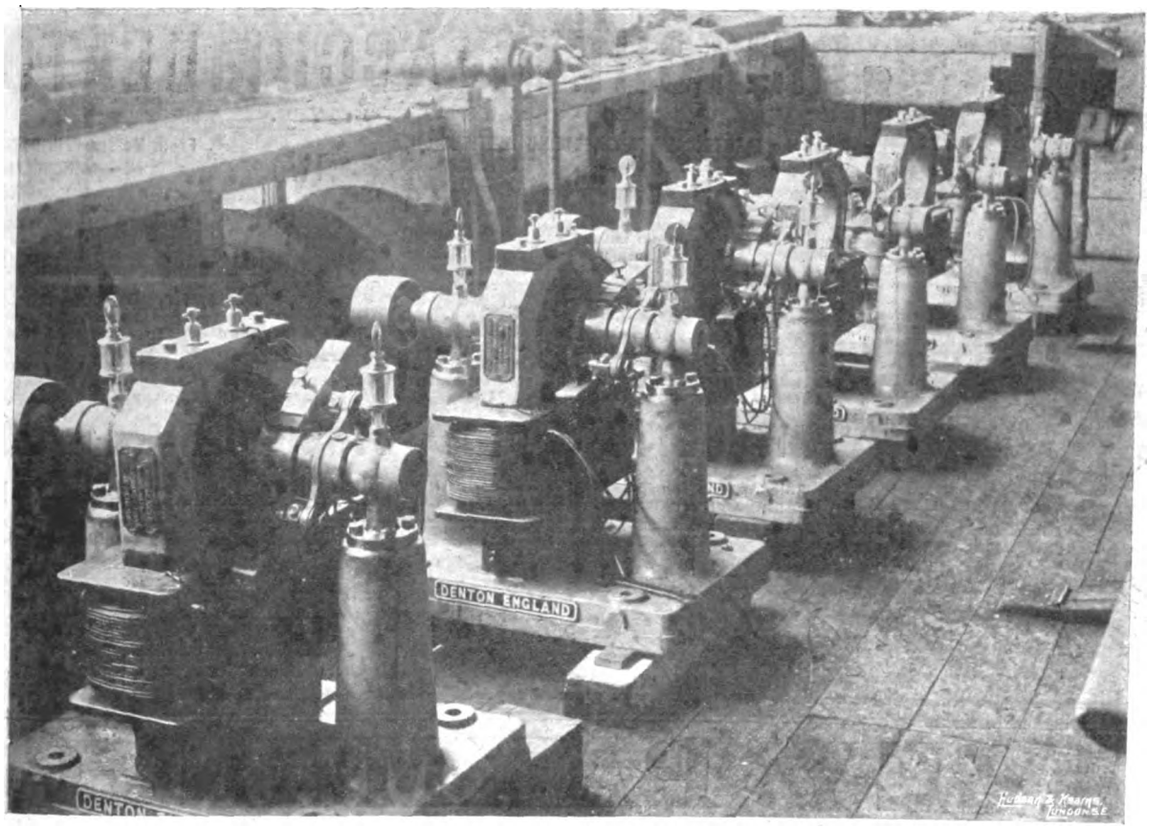


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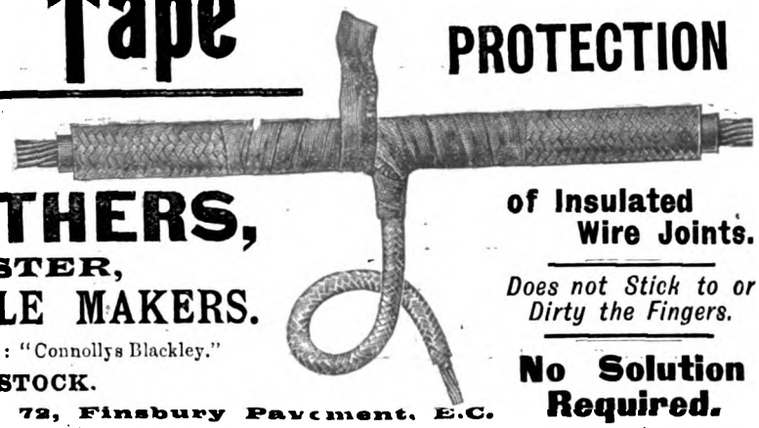

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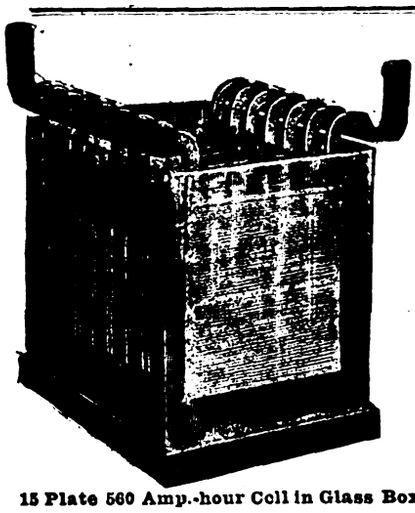

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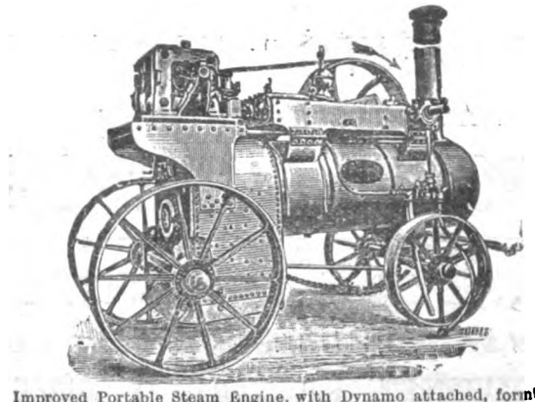

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A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 944. [Vol. No. 8. XXXVII.] FRIDAY, JUNE 19, 1896. PRICE SIXPENCE.


## NOTES.

THE Associated Chambers of Commerce did not gain much, we fancy, by their interview with the Secretary of the Post Office in reference to the cheapening of telegrams. Of all the many suggestions made with that object in view, the one for letting certain parts of the address go free is about the worst. Its obvious effect would be not to cheapen telegrams but to make them longer. Senders would simply be spared so much trouble in the practice of curtailment, which they perform with singular ingenuity at present; whilst the Department would be put to the enhanced expense of transmitting more words for the same money. Mr. SPENCER WALPOLE estimates the value of the concession demanded at £600,000 per annum. This amount may be overstated; but whatever the figure, it would be a dead loss to the Telegraph service, without in the least profiting the public, who would take their full maximum as often, and exceed it as seldom, as they do now.

FOR the other recommendation put forward by the Association, namely, the amalgamation of the Post Office and Telegraph accounts, there is certainly more to be said. The process of dividing accounts, so inextricably intermixed as these must be, cannot but entail considerable needless outlay; and the final apportionment appears to be satisfactory to neither party. This method of keeping the accounts has not led to economy of administration, but has rather tended to saddle the Telegraphs with extravagances not properly its own. It is hard to believe that the Telegraph does not pay its way, or that it could not be made to do so if it were allowed to; but as that seems to be past praying for, it would be better to leave off pretending to keep separate accounts, and then we should hear no more about the Telegraph Service being unremunerative.

A CAREFUL perusal of the full text of Mr. ARTHUR WRIGHT'S Presidential Address to the Municipal Electrical Association does not lessen the regret we felt when it was delivered in a severely compressed state that sufficient time was not afforded to discuss the many interesting points therein raised. In most engineering societies the discussions are fully as important as the Papers; in an Association such as the one which has just met at Whitehall, the discussions are even more likely to promote its objects than the Papers themselves. Mr. WRIGHT touched lightly, but not unprofitably, on a number of knotty problems; the proper period for municipal electrical loans, the vagaries of assessment authorities, the correct way to dispose of profits, the management of municipal electric light undertakings by gas committees, the most equitable and expedient method of charging for current, consulting engineers *versus* resident engineers, salaries, uniformity of accounts, and last, but not least, he brought forward a formidable array of cogent reasons justifying the separatist policy which has led to the formation of yet another independent electrical society.

WE have, on previous occasions, frequently discussed the question as to the period over which the repayment of municipal electric light loans ought to be spread. Broadly speaking, it seems to us that the only safe principle upon which the central authority can go in this matter is to lighten the terms and lengthen the period, as far as possible, in the case of loans intended to secure for a community the prime necessaries of urban life, such as good drainage, good water, suitable municipal buildings, and an adequate number of open spaces, dealing in a more commercial spirit with purely commercial undertakings, such as gas and electricity works. In the first category there is but little depreciation, and the undertakings benefit posterity even more than they benefit the existing generation. On the other hand, gas, electrical and similar enterprises are subject to all the risks that accompany ordinary commercial ventures, not the least of which is the danger of supercession by new methods, and it would be unwise in the extreme to allow local authorities to pile up huge debts upon so insecure a foundation.

AS to the disposal of profits, we quite agree with Mr. WRIGHT and Mr. Alderman HIGGINBOTTOM that before the rates are relieved by annual doles, it were better that a renewal fund or a reserve fund should be built up sufficient to provide for extensions and contingencies. The prosperity of a particular town is a precarious asset at the best, and the smaller its indebtedness when the "slump" begins, the better. It is also to be hoped that Mr. WRIGHT'S exhortation to municipal authorities to make their accounts uniform in spirit as well as in letter will not fall on dull ears. Again, it is satisfactory to find that central station engineers are becoming alive to the good policy of broadening the base upon which the financial success of their undertakings is founded; not

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so many years ago tariffs were deliberately devised so as to press heavily on the ten-light householders, "pour encourager les autres," so to speak.

THE President of the Municipal Electrical Association certainly does not lack boldness. Not content with raising the delicate question of whether Corporations would do better to employ their resident engineers and dispense with the services of consulting engineers, he proceeded to grasp yet another nettle, to wit, the inadequacy of the salaries at present paid to most municipal electrical engineers. The last is a matter which requires careful handling, especially by a municipal employé who is desirous of enlisting the benevolent support of municipalities on behalf of an Association of which he is one of the most prominent promoters. As to whether it is best to employ the resident engineer or a consulting engineer to carry out extensions, &c., this is just one of those questions about which no sensible man will lay down a general law. If a wealthy corporation of a large town has exercised proper care in selecting its electrical engineer, he certainly should be entrusted with the carrying out of all extensions; but youth, inexperience, and a small salary are not conducive to sound advice when a new departure is contemplated.

SMALL beginnings often lead to great endings. Although the two and a-half miles of electric tramway recently opened at Hartlepool do not represent a great undertaking, many a much longer line has been started less deserving of the attention of practical students of modern traction. For it is not the size of the undertaking that makes the Hartlepools electric tramway of special importance; it is the fact that it is probably the prototype and representative of the system which will be generally, and we hope extensively, adopted in the future. The Hartlepools line is the first trolley system in this country to be driven entirely by direct-coupled high-speed generating sets, the plant being composed of two Willans engines, mounted on the same bedplates with two E.C.C. compound-wound dynamos. We have already referred in a previous issue to the fact that a direct-coupled Willans-Siemens set has been put into the Stockwell power station of the City and South London Railway. With these exceptions, all the power stations for public electric traction in this country have been run by rope or belt or otherwise geared engines.

MUCH of the success which has thus far attended the use of the Willans engine in traction power-stations is due to the use of automatic cut-off gear. The particular form of valve gear employed is prompt in action and gives steam over a wide range of cut-offs. It is therefore fitted to control the sudden and heavy variations in load to which traction-power engines are subjected. The throttle governor, though it has proved itself well adapted to the needs of the electric light engine, would cut but a sorry figure, we fear, were it applied to engines doing the duty of the Hartlepool plant.

IT will be interesting to watch the effect which the extension of electric traction in this country will produce upon the design of continuous-current dynamos. In America a number of distinct types of so-called railway generators have arisen. In that country, too, although direct-coupled sets have been adopted in many places, the average speed of the generators is lower than it would be likely to be here, if any very extensive use of direct-coupled sets should be made in this country. The dynamos which the Electric Construction Company have built for Hartlepool are inverted, two-pole, compound-wound machines, with armatures wound on the Eickemeyer system. The entire equipment of the system reflects great credit on the Electric Construction Company who have carried out the work.

REASONS, which are sufficiently cogent, have induced the *Engineer* to postpone until next year the "Horseless Carriage Competition," which it has so enterprisingly set on foot. As our contemporary pertinently observes, there would be nothing gained by merely showing that horseless carriages which have run on French roads will also run on English ones, or in awarding a thousand guineas for an imperfect carriage which might be surpassed in a month or two. In the interests of so infantile an industry, everything is to be gained and nothing lost by putting off an important competition, and the extra time gained by those who are endeavouring to attain to a really successful solution of a difficult problem will be sure to tell on the results achieved. We are glad to see that our esteemed contemporary has spoken in no less uncertain terms than we ourselves did in a recent issue, regarding the present stage of development of the industry:—

> The exhibitions at the Crystal Palace and at the Imperial Institute contain, it is believed, the very best horseless carriages in the world. But a careful examination of these vehicles leads to but one conclusion, namely, that nothing nearly suitable to the demands of the English public has yet been produced. On the one hand, so far, no vehicle has been made to run using the heavy oils, without producing a very disagreeable smell. They are more or less imperfect, crude machines; full of promise, full of possibilities, but totally unfit to put into the market. On the other hand, the carriages which run with light oil, petroleum spirit, benzine, or naphtha, although even elegant in design and sumptuous in finish, do not at present comply with the law of Great Britain, and render necessary the storage of a highly inflammable liquid, in a way that would set the insurance companies up in arms. . . . We do not think it can be said that any fairly satisfactory carriage has yet been produced. A visit to the Crystal Palace or the Imperial Institute will convince the most enthusiastic that, one and all, the vehicles are noisy, and that, one and all they leave behind them most objectionable evidence that they have passed. In the matter of vibration, again, some of them are simply intolerable. Now, the general public will not buy carriages, either for pleasure or for business purposes, which are not at once safe, comfortable, odourless, and silent. . . . We know that some thoughtless folk believe that finality has been reached, and that such vehicles as those now to be seen are as good as can be produced. We are quite certain that is not the case, and that in a little time great advances will be made, and vehicles produced which will compare with those now in use much as a Great Northern locomotive does with the Rocket.

| Cable Interruptions. | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique | Dec. 19, 1895. |
| Ceara—Maranham | April 23, 1896. |
| Monte Alegre—Santarem | May 5, 1896. |
| Cadiz—Teneriffe | June 6, 1896. |
| Jamaica—Colon | June 10, 1896. |

**Lundy Island Cable.**—It is stated that the Lundy Island cable, which connects with the Bristol Channel telephonic service, and which was erected two years ago by the Government upon the recommendation of the Royal Commission, has parted.

**Personal.**—We very much regret to announce that by the explosion of apparatus containing acetylene at high pressure,

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Mr. Lennox, the chief assistant in Prof. Dewar's laboratory at the Royal Institution, met with a terrible accident last Tuesday, necessitating his removal to Guy's Hospital. Mr. Lennox, we are deeply sorry to hear, has lost one of his eyes, though the sight of the other seems not to have been impaired; he also is suffering from severe face wounds.

**Wolverhampton.**—Mr. Harman Lewis, the borough electrical engineer of Wolverhampton, has kindly notified to us that, in our description last week of the Wolverhampton electric supply system, the capacity of the plant given did not include the spare plant. As a matter of fact the total capacity, including spare plant, is 10,000 lamps. The boiler pressure should have been stated to be 130lb. per square inch.

**Damage by Lightning.**—During a heavy thunderstorm on Saturday last week a miller named Buttram, a resident of Binham, who was taking shelter under a tree near the White Horse Inn, Briningham, was struck by lightning and killed. ——An extraordinary incident of the storm happened at Drung, near Moville (Ireland) on Saturday last. When the thunderstorm came on, a woman was engaged in a shed milking a cow. There was also in the shed at the time a calf, a dog, and a cat. The lightning struck the shed, and killed the four animals, the woman escaping.

**Institution of Electrical Engineers.**—At the special general meeting held on Monday afternoon last, the proposed resolutions altering the regulations contained in the Articles of Association of the Institution of Electrical Engineers were passed unanimously. Sir David Salomons occupied the chair, and there were in all eight persons present. It was resolved that the special general meeting for confirming these resolutions shall be held on Monday, July 6th, at 4.15 p.m.; and that the meeting of Members and Associates for receiving the amended accounts shall be held on the same date, at 4.30 p.m. Both meetings are to be held at the offices of the Institution.

**Verband Deutscher Elektrotechniker.**—The fourth annual meeting of this well-known German electrical society is being held in Berlin from the 17th to the 20th inst. The programme just published announces among other items the reading of the following Papers:—"The Transmission of Power Plant at Rheinfelden," by Herr Rathenau; "The Electrical Plant at the Berlin Industrial Exhibition," by Herr Sarasin; "On the Magnetic Researches of the Second Department of the Reichsanstalt," by Dr. Ebeling; "The Phenomena in the Armature of Three-phase Motors," by Herr Bauch; "On Electrical Overhead and Underground Railways in large Cities," by Herr Schwieger; "On a Steady Ballistic Galvanometer," by Dr. Heim; "The Interests of Municipalities in pending Electrical Engineering Questions," by Dr. Kallmann; "On Three-phase Motors with Reduced Speed," by Herr Görges.

**International Telegraphic Conference.**—The Conference at Buda-Pesth was opened on Monday by a speech from the Minister of Commerce, His Excellency Ernst Dániel, who presided. Representatives from Chili, San Salvador, and Venezuela, which countries have hitherto stood outside the International Convention, were present, in addition to the accredited representatives of the States subscribing to the Convention, and the principal cable and telegraph companies. The *Standard's* correspondent says:—"The Eastern Telegraph Company was represented by the Marquess of Tweeddale, Lord Sackville, and Mr. Hiberdine; the United States Direct Cable Company by Mr. Andrews; the South Australian Telegraph Company by the Hon. I. Playford; and the New South Wales Telegraph Company by Sir Saul Samuel." It would be very difficult to crowd many more errors into so few lines.

**Arctic Thunderstorms.**—At the last meeting of the Royal Meteorological Society for the present session Mr. H. Harries read a Paper on "Arctic Hail and Thunderstorms," in which he showed that the commonly-accepted opinion that hail and thunderstorms are almost, if not quite, unknown in the Arctic regions is incorrect. He had examined 100 logs of vessels which had visited the Arctic regions, and found that out of that number no fewer than 73 showed that hail was experienced at some time or other. Thunderstorms were not so frequent as hail, but they have been observed in seven months out of the twelve, the month of greatest frequency being August. Mr. Harries is of opinion that the breeding place of thunderstorms in these high latitudes is in the neighbourhood of Barent's Sea.

**Indian Telegraph Rates.**—It is, the *Pioneer* understands, likely that the first step will shortly be taken towards the cheapening of telegraphic communication in India. No actual reduction on the present tariff will be made, but deferred telegrams will be delivered by hand instead of being sent by post from the receiving office. The ultimate effect it is thought will be to eliminate "ordinary" messages to a great extent so far as the general public is concerned. The charge of eight annas (16 annas = 1 rupee) for eight words, with a free address which averages about another eight words, is a very low one—half an anna per word, which compares favourably with the sixpenny telegram in England. In time, no doubt, says the *Pioneer*, we shall have a four-anna telegram; but a great increase in the number of wires, signalling instruments, and signallers will have to be provided before this final change can be made. At home the average distance to which a message is signalled is between 60 and 70 miles; in India it is between 700 and 800.

**Electricity on War Ships.**—At the recent meeting of the Institution of Naval Architects in Berlin, Herr Dietrich, Constructor-in-Chief of the Imperial German Navy, read a Paper on the development in design and construction of German men-of-war. He thought England might with advantage copy Germany in employing electricity as much as possible instead of steam. The German Admiralty found that the only way to get rid of the heat from numerous steam pipes was to do away with them. By the use of electricity the conducting wire took the place of the steam pipe, and the ships were rendered more healthy as well as safer in action. All new German warships have electricity as the motive power for ventilating fans, turning gear of gun turrets, ammunition hoists, coaling winches, and such purposes. In the discussion which followed it was noticeable that Herr Dietrich's Paper had made a great impression on the English part of his audience, and there was a desire felt that his remarks on the further employment of electricity should be recommended to the notice of the English Admiralty.

**Municipal Electrical Association.**—At the business meeting of the Municipal Electrical Association, held on Friday last, it was decided to hold the meeting next year at Manchester. The following officers were elected: President, Mr. C. H. Wordingham, of Manchester; Vice-Presidents, Messrs. V. A. H. McCowen, of Belfast, and F. Newington, of Edinburgh; Committee, Messrs. Arthur Wright, of Brighton, W. Arnot, of Glasgow, A. H. Gibbings, of Bradford, A. B. Mountain, of Huddersfield, J. H. Rider, of Plymouth, and T. P. Wilmshurst, of Halifax; Hon. Treasurer, Mr. G. H. Cottam, of Hampstead; Hon. Secretary, Mr. A. B. Mountain, of Huddersfield. It was unanimously resolved to present to Mr. Wm. L. Madgen, who has been acting as hon. secretary during the period of organisation and the first Convention, the best thanks of the members for the invaluable help he has rendered in the formation and organisation of the Association, and as a record of their appreciation, the resolution is to be suitably engrossed and presented to him with a bronze to be selected by himself.

**Lighting of the Manchester Ship Canal.**—A new electric light installation has been established by the Ship Canal Company at Trafford Bridge. The installation which has been displaced was of merely a temporary character, power being supplied by no less than three different generating stations. The engines used were old "portables" that formed part of the plant employed in making the canal, and from the point of view of coal consumption were very extravagant. Constant difficulties were experienced, and naturally the working expenses were considerable. The new plant consists of two sets of compound inverted cylinder engines of 100 H.P., made by Mr. Goodfellow, of Hyde, two sets of 30 H.P. engines by Messrs. Browett and Lindley, of Patricroft, and two 60-kilowatt alternators and exciters, by Messrs. Baxendale and Co., of Manchester. The lighting area includes the Manchester and Salford Docks and the locks at Mode Wheel, together with the road to the locks. There are 66 continuous-current arc

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lamps, 28 alternating arc lamps of 2,000 c.p. each, 360 incandescent lamps of 50 c.p. each, 100 of 32 c.p., and 28 of 16 c.p. Inside the sheds incandescent lamps alone are used.

**The Costliness of Cheap Engineering.**—Under this title *Engineering News* of New York publishes a communication making some excellent points against the unwise and injurious methods which have been too often adopted in the management of public works of an engineering character. Perhaps the strongest point made is the exposition of "the wrong which cities do to their own interests and to contractors by altering the plans and specifications of competent engineers to suit the funds which they have available for the work." The writer has just come from "looking at a large sewerage system which is worse than worthless. It was planned by a good engineer, but the plans were changed by one who was unworthy to unlatch his shoe strings, and the taxpayers have to suffer." His conclusion regarding the matter is thus summed up: "Our cities do need thoroughly competent and conscientious engineers and advisers—men who cannot be bought and sold. There are plenty of such men to be had. If our cities will rely on such engineers to prepare plans for their work, and allow no changes except such as these engineers may make, we should then have good public work, and tricksters would not bid on it." But such men, we may add, are not to be had for the mere pittance considered by many English cities to be sufficient remuneration for the services of their engineers.

**The Otto Ozonisers.**—M. Otto, of Paris, has recently brought out an apparatus for the production of ozone, which is formed of a number of elements, each consisting of a conducting sheet, which can be plain, or in the shape of a grating, but the corners of which must be rounded off. Each sheet is placed between two plates of glass or other dielectric, and the elements so formed are enclosed in a casing, and separated from each other so as to allow the gases to be treated to pass between them. The alternate elements are connected together, and to the opposite terminals of a high-tension transformer. So far, the apparatus differs little in its construction from those already in the market, but M. Otto has found that an oscillatory discharge gives the highest yield of ozone, and greatly diminishes the heating which takes place. This oscillatory discharge can be obtained by so choosing the dimensions of the constituent elements that the apparatus acts as a resonator, and this condition is satisfied when the ratio between the co-efficient of self-induction L of the apparatus and its electrical capacity C is such that the resistance of the system is less than $\sqrt{\frac{4L}{C}}$. With an apparatus having glass sheets 40cm. long, 16cm. wide, and 1mm. thick, with sheets of conducting metal 27cm. long, 5cm. wide and 0·1mm. thick, the elements being arranged 1·5mm. apart, and the apparatus being supplied with a current having a periodicity of 80 ∿ and a pressure of 5,700 volts, the power consumed in full operation is 10 watts.

**"Wanted, the Reason Why."**—Under this title, which bears an appropriateness unguessed by our contemporary, *The Engineer* thus comments on Prof. Fleming's recent lecture at the Royal Institution:—

"As information is acquired concerning natural phenomena, it becomes more and more evident that many of our most treasured theories and explanations will have to be thrown on the scrap-heap of scientific hypotheses. The researches of Lord Rayleigh in argon and helium have already demonstrated that there is much in the received molecular theory of gases that have will to be rejected as untrue. The Röntgen rays have done the same for light, and now Prof. Dewar has shown that as yet nothing like a satisfactory theory of electricity and magnetism has been framed. The Friday evening discourse last week at the Royal Institution was delivered by Prof. Fleming, and was mainly a statement of the very remarkable results obtained in the course of a series of experiments carried out by himself and Prof. Dewar on electrical conduction at low temperatures. It is not too much to say that these results go far to upset all our preconceived notions, and tempt us to ask if the phrase 'conservation of energy' conveys any adequate idea whatever of any natural processes. Thus, for example, Profs. Dewar and Fleming seem to have established that a pure metal at absolute zero would have no electrical resistance, so that the smallest filament could carry the most enormous conceivable current without being heated. Some time since we stated that it was quite conceivable that a magnetic screen might be produced, and that if it was produced we should be within measurable distance of perpetual motion; in other words, of a machine which could work itself. Prof. Fleming stated on Friday night that a pure metal at the absolute zero would form an absolutely opaque screen to electro-magnetic radiation. But the whole lecture bristled with statements going to show that there is no apparent connection between causes and effects, and that the expenditure or not of energy in the performing of processes is brought about in ways of which we know nothing. For instance, it is impossible to send a current of electricity along a pure metal at normal temperatures without loss of energy. We have only to bring down the temperature to zero, and the loss of energy ceases. What is the connection between heat in the wire cone and the expenditure of energy? As the years roll on science seems to drift closer and closer to the rocks of agnosticism: and the man who studies and experiments most will in the end be he who knows least." Why the conception of a perfect conductor should upset science, any more than the conception of frictionless surfaces in machinery has done, is more than we can tell. Students of modern science very naturally will ask for "the reason why."

**Conversazione at the Central Technical College.**—On Friday last a very successful *conversazione* took place at this Institution. The college was tastefully decorated for the occasion, and during the evening the Chairman of Council and Lady Halsbury, accompanied by the officers of the Institute, held a reception in the library. In addition to the collections of apparatus and instruments usually shown at such gatherings, a concert by students of the college and their friends was given in one of the large lecture theatres, and the National Hungarian Band played a selection of music at intervals throughout the evening. Interesting exhibits were arranged in the laboratories of all the departments, and demonstrations were given by the staff and students of the college. The Department of Mechanics and Mathematics showed students apparatus for finding the various mechanical laws by quantitative experiment, and a large collection of mathematical models, calculating machines, integraphs, &c., including the original and the newest forms of harmonic analyser invented by Prof. Henrici for determining several coefficients of Fourier's series by one operation. In the Engineering Department very complete arrangements for boiler and engine trials were shown—a 5 H.P. De Laval steam turbine running at 32,000 revolutions per minute, a Tower spherical engine of 8 H.P., and a 40 H.P. engine specially arranged for experimental purposes. The actual engine used by the late Mr. Willans in his important researches on steam consumption, and subsequently presented to the college by Messrs. Willans and Robinson, was on view in the adjoining laboratory, the cylinders, &c., being cut through to show the internal arrangements. Demonstrations of testing strength of materials were given on the 100-ton and other testing machines with which the laboratory is equipped, each machine being fitted with autographic apparatus for drawing the stress strain diagrams. Amongst a collection of instruments used for engineering purposes were the latest forms of extensometers invented by Prof. Unwin and by Prof. Ewing. The junior laboratories of the physical and electrical engineering department contained numerous pieces of apparatus arranged for quantitative experiments in heat, light, sound, and electricity and magnetism, amongst which may be mentioned the "Simple Apparatus for Determining the Mechanical Equivalent of Heat," described before the Physical Society about 18 months ago, and another for proving Ohm's law. In the dynamo and motor laboratories various forms of continuous and alternating-current machines were shown running, and demonstrations were given in testing the "regulation" of transformers by the differential method. The "injector" for producing any desired alternating wave-shape used by Messrs. Barr, Beeton and Taylor in their investigations on "The Influence of the Shape of the Applied Potential-Difference Wave on the Iron Losses in Transformers," was shown in operation. An exhibit which attracted considerable notice was a valuable Lorenz apparatus for determining the ohm, made by Messrs. Nalder Bros. and Co. for the McGill University, Montreal, and sent to the Central Technical College to be tested. Prof. Ayrton also showed a historical collection of electrical measuring instruments developed at the college. In addition to experiments with Röntgen rays, the Chemical Department (under Prof. Armstrong) exhibited apparatus used and specimens obtained in researches carried out by the staff and students of the department, apparatus for the use of elementary teachers, as recommended by the B.A. report, and a variety of instruments employed in crystallography.

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## LORD KELVIN'S RESEARCHES.

How different life is at the end of the nineteenth century from what it was at the beginning! Then communication was by stage coach and sailing vessel. The only telegraph a semaphore. All means of distribution of wealth slow and uncertain. Yet what an advance on previous centuries! We can hardly conceive how people lived when hand-spinning and weaving had to provide clothes for everybody. The laws of mechanics discovered in the seventeenth century were rapidly applied in the eighteenth. The experimental discoveries of Boyle and others about gases produced the steam engines of the succeeding years. The seventeenth century may be described as that of the discoveries of dynamics. The eighteenth as that of the discoveries of steam. The nineteenth as that of the discoveries of electricity.

How has all this come about? By patient plodders working on the lines of inductive science. By learning from Nature in the school of experience. All who work on these lines are truly scientific. They may be making experiments on the magnificent scale of laying ocean telegraphs, or on the diminutive scale of measuring the minute change of temperature of melting of ice under pressure; they may be applying mathematics to calculate the oceanic tides, or to determine the size of an atom; but whether they are engaged on the large or the small, on matters immediately applicable to the service of man, or on investigations that are of no more immediately obvious use than a baby, still they are truly scientific if they learn from Nature in the school of experience. It is the continually learning that is the essence of the truly scientific spirit. Very few have either the ability or opportunity of working in all these lines—of advancing human activity and human knowledge. If one were asked to point out a typical example from those who have applied scientific methods to the advantage of mankind, an example of the kind of intellect that has changed the face of society so that our whole industrial system has been utterly revolutionised and with it the conditions of life of the majority in all civilised nations, the first name that would occur would be that of Lord Kelvin.

He has worked in the most diverse lines. With the whole gamut of applied mathematics at his finger ends he has applied it to the laying of telegraph cables and to calculate how best to signal through them, how best to compensate for the action of the iron in ships on their compasses and how to predict the tides, how to measure temperature and electricity, how to calculate the age of the earth and the size of an atom. In each of these lines and in many others he has made important contributions to the sum of human knowledge and has improved the opportunities of human activity.

Lord Kelvin was born in Belfast in 1824, and when only 22 years of age was appointed in 1846 to the post he still holds. His contributions to the service and information of mankind have been recognised by learned bodies all over the civilised world. An enumeration of the honours conferred upon him by learned bodies would serve no useful purpose here. That he has been so universally honoured confirms our faith that the honour we give him is not an insular prejudice but is founded on true greatness. Even the Crown has been compelled to recognise his valuable services, and has conferred on him first knighthood and then a peerage.

Lord Kelvin's work may be roughly summarised under the following heads:—

(1) Mathematical papers which are mainly concerned with problems that arose in connection with special physical questions.

(2) Elasticity and optical theory.

(3) Hydrodynamics and vortex theory, tides and navigation.

(4) Thermodynamics, heat, and the age of the earth.

(5) Electromagnetic work, including the laying of cables.

Lord Kelvin's mathematics is of the specially powerful type that distinguishes such giants as Laplace and Green. He is determined at all costs to solve the question, and does not give up because it leads to laborious approximations and complicated series. He rejoices no doubt in elegant methods, as, for example, in the theory of electrical images; but what some would consider inelegant and sledgehammer methods are at hand to obtain the result. His mathematics is for the sake of the result, and not for the sake of the mathematics. He has especially developed the methods of physical investigation depending on the principles of the conservation of energy, and the popularity of these methods owes a great deal to his powerful example.

The theory of elastic solids owes a great deal to him. Continental authorities had investigated the question largely from the point of view that solids were collections of points which acted upon one another independently, and, neglecting the pretty obvious fact that their structure and properties could not be explained by any such simple hypothesis, had deduced that the rigidity was necessarily three-fifths of the compressibility in all simple solids. It really came to be a definition of a simple solid; for when it was conclusively shown that plenty of recognised solids had quite other numerical relations between the rigidity and compressibility, all that could be answered was that jelly and cork and india-rubber, and indeed most solids, were not simple solids. Lord Kelvin has always advocated the much more scientific course of first showing inductively from experiment that the knowledge of the properties of elastic solids can be reduced to a knowledge of the two qualities rigidity and compressibility, and thence deducing the behaviour of solid bodies from this. The method is the only satisfactory one open to us in our existing intense ignorance of the structure of solids, and has led in his hands to very valuable results. In Karl Pearson's "History of the Theory of Elasticity" more than a hundred pages are devoted to Lord Kelvin's contributions to the theory of elasticity. The most characteristic peculiarity of these pages is the way in which they bristle with suggestions as to all sorts and kinds of elastic bodies. It is there stated of his work on elasticity: "There is that fertility of idea and that mark of genius which has made Sir William Thomson the leader and characteristic representative of physical science in our own country to-day." The two most generally interesting of his investigations on elasticity are concerned with the elastic solid theory of the ether and with the question as to the rigidity of the earth. The mere enumeration of these investigations shows how Lord Kelvin has devoted himself to hurling his attacking battalions at the most important and impenetrable of the outworks of our enemy, Ignorance. In each case he has advanced most important trenches against these outworks. In his study of the elastic-solid theory of the ether he has shown, apparently conclusively, that no simple elastic-solid theory is competent to explain the properties of the ether. In his study of the rigidity of the earth he has shown reasons to believe that the earth is extremely rigid, reasons which must be taken account of by all future investigators and which overthrow such suggestions as that the present surface of the earth is a thin shell floating on a liquid nucleus.

These investigations as to the rigidity of the earth arose out of investigations as to the tides. From his connection with submarine cable-laying he has long had an intense interest in navigation, and the theory of the tides and tidal prediction have gained much from him. That the Indian Government have spent large sums of money in providing tide-calculating machines based on Lord Kelvin's inventions is pretty conclusive proof that his investigations in this direction have borne useful fruit. Without the assistance of these machines the calculation of tide tables is an extremely laborious process, so much so that it has been seldom undertaken so as to give accurate results in the case of any except the most important ports. With these machines accurate results can be obtained with comparatively little labour.

In other directions Lord Kelvin has assisted navigation. By his inventions in connection with the method of sounding by observing the compression of air by the pressure at a depth in the sea he has notably aided ships in determining their position in thick weather. With the old method of throwing the lead the ship had to be brought almost to a standstill in order to get any result, and this method was entirely inapplicable in deep water unless the ship was quite at rest. With the method introduced by Lord Kelvin the ship may be

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proceeding rapidly and valuable results obtained in very deep water. The value of the method to all rapid ocean-going steamers is incalculable, and the possibility of safe rapid passages in thick weather is, at least partly, due to the introduction of Lord Kelvin's sounding apparatus on board all large ocean-going steamships. This has been effected notwithstanding the notorious conservatism of sailors, of whom, almost more than of any other class, it may be said, "People working in established ways have their own work to do and have no time to waste upon 'fads.' So much is this the case that it often happens that they have very little knowledge of how things would work out if they departed from the ruts they are accustomed to run along. That is to say, the spirit of scientific research, which was to some extent present in the industry in its early stages, has nearly all evaporated, leaving behind regular rules and a hatred of fads."

Another important aid to navigation provided by the spirit of scientific research which certainly never evaporated out of Lord Kelvin was his compass, with its delicate suspension, slow period, facility for compensation, and freedom from vibration. Though it has been criticised as a scientific toy and as gimcracky, these criticisms only show the prejudice of the critic, as is proved by the almost universal adoption of these gimcracky scientific toys by those who have had practical experience of them and of others.

Hydrodynamics has benefited in many ways by Lord Kelvin's activity. He has developed important general theorems and applied them to solve many complicated problems. He has studied the waves produced by ships, and advocated bulb keels on a large scale before yacht builders discovered them. He has largely advanced our knowledge of vortex motion and has proposed the intensely suggestive vortex atom theory of matter. All through his work he has been harping on the possibility of explaining elasticity by motion. The stiffness of a gyroscope, the elasticity of a vortex ring, in which movement confers elasticity on inelastic material, have been continually underlying his views of Nature. Our knowledge of how far such things can and how far they have not yet explained the phenomena of matter and of the ether is largely due to his initiative. In 1847 he showed how Faraday's ether forces could be illustrated by the possible displacements of an elastic solid; and though the connection was a mere analogy, because it made electric and magnetic actions depend upon identical properties of the medium, nevertheless it was the germ from which Maxwell's mathematical representations of Faraday's views may have sprung, and with them all modern developments of electro-magnetism.

A generation that has been reared on the law of the conservation of energy, who have imbibed with their earliest scientific milk the equivalence of heat and energy, can hardly understand the position of science when Lord Kelvin began his professoriate. The domain of mathematical physics was then almost entirely in the hands of persons with a taste and training in pure mathematics. The true physical basis of mechanics was passed over as unimportant and the analysis that solved problems was all important. A generation that called the acceleration of gravity a force, and bewildered the unfortunate student with it, was by that very fact convicted of carelessness about physical conceptions. A confused nomenclature is an almost certain sign of confused or careless conceptions. Thomson and Tait, by their "Natural Philosophy" and by the influence they have exerted by their teaching, have succeeded in rousing British science from this disastrous position. They called special attention to the law of the conservation of energy and to the physical basis of mechanics at every point. They emphasised the experimental basis of natural philosophy, and took as their text a quotation from Fourier, which clearly points out that our knowledge of the ultimate principles upon which Nature depends is far too imperfect for us to proceed any distance without continual reference to experiment for verification and enlightenment. It is very remarkable how quickly the doctrine of the equivalence of heat and energy spread after Joule's measurements. The old caloric theory had really been disproved absolutely by Rumford and Sir Humphrey Davy in the beginning of the century, and yet it survived until after 1850. It took more than a hundred years to break through the authority of Newton in physical optics, but within ten years after Joule's experiments the equivalence of heat and energy was practically universally acknowledged. In Britain this was certainly largely due to the immense influence exerted by the genius of Lord Kelvin. He seized the great idea, worked out its ramifications into all the corners of physical investigations, and forced it on the scientific world. In a similar way he expounded and amplified the Second Law of Thermodynamics. Even before he saw clearly how to reconcile Carnot's conclusions with Joule's experiments he extended Carnot's work by founding on it an absolute scale of temperature. He saw clearly that there must be a reconciliation possible, and worked away at the truth on both sides nothing doubting. When the reconciliation was discovered he redoubled his energy and refounded all his former work on the new foundation, while he leaped onwards and propounded the general theorem of the ultimate degradation of energy, and began his great battle with the uniformatarians of the time who were proclaiming everywhere that there was no evidence in Nature of any beginning or ending of our system. On the one side Lord Kelvin investigated the heat of the earth and the variations of its temperature downwards, and deduced therefrom a quite moderate antiquity for this globe, while on the other he showed that the sun himself must die and our whole system perish in night.

The rapid acceptance of the two laws of thermodynamics is unquestionably due largely to Lord Kelvin's genius and energy in extending them to the whole range of thermodynamics, to elasticity, electricity, magnetism, &c., and this is made doubly evident by considering what happened in an isolated district to which his influence hardly extended. Down to the year 1875, in Dublin the acceleration of gravity was called a force, and the Second Law of Thermodynamics was unknown. Only for Lord Kelvin this might almost have been the case all over Britain. When Sir Humphrey Davy was unable to break through the caloric theory notwithstanding his extraordinary reputation, the rapidity with which it was broken by Joule and Thomson is doubly remarkable and is an eternal tribute to their power.

Of all Lord Kelvin's work, that for which he is probably best known is his electromagnetic work. His methods of treating electricity and magnetism have permeated all modern investigations. His instruments are used in innumerable departments of modern research. In two special directions his influence has been specially felt—in the development of the practical measurement of electric and magnetic magnitudes and in the development of submarine telegraphy.

When Lord Kelvin began working, his intense desire for concrete realisation of everything he dealt with led him to require a numerical measure of electric and magnetic quantities. Weber had shown how this was possible, but still it was not attained by workers in electromagnetics. Each observer quoted his own galvanometer or his own battery or his own copper or iron or platinum wire. Such and such an action "produced 5 scale divisions on my galvanometer." "My electromagnet was wound with 200 turns of fine wire and excited by 20 cells of Callan's battery." Such are the only hints obtainable of what quantities were being dealt with. There was no real attempt to reduce the observations to any common numerical scale. The distinction even between such essentially diverse quantities as current and voltage was very hazy indeed; much the same sort of haziness existed with reference to them as at present puzzles unfortunate students of magnetism in reference to magnetic force and magnetic induction, which are spoken of as if they were quantities of the same kind—an indigestible muddle that the practical electrician has fortunately thrown up, and framed for himself a solid digestible theory of the magnetic circuit. Authorities spoke of quantity-currents and intensity-currents as if they were two utterly distinct kinds of current, one of which produced heat and the other shocks. No accurate ideas were current as to the relations between energy and electromagnetic quantities. All this muddle was intolerable to Lord Kelvin. If there was one thing more than another he objected to it was to indistinct physical conception and to the consequent impossibility of numerical measure. To him and to others,

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but in a very large degree to him, is due the international system of electromagnetic measures that exists as one system in all civilised nations. It is almost impossible to overestimate the value of such a system, coupled as it has been with accurate and easy methods of making the measurements. All who have studied the history of the steam engine know the rapid strides with which improvement progressed after Watt introduced his method of measuring the power of an engine. The rapid advances and improvements that have been made in the applications of electromagnetic energy are largely due to the great ease of electromagnetic measurements, and this great ease is largely due to Lord Kelvin's influence in providing a scientific system of units and to his inventive genius in providing accurate and convenient measuring instruments and methods of measurement. One characteristic of his instruments may be worth noting as an evidence of his power, and will be appreciated by all who have experience of scientific instrument makers. It is that he has been able to impress his own ideas on these makers and has forced them to depart from their beloved methods of fixing everything as in a vice and of destroying all certainty of adjustment by wrenching everything with gripping screws. To Lord Kelvin is certainly due the merit of introducing rational constraints in scientific instrument making, and it requires as much determination and ability to force a British workman out of his grooves as to get the Admiralty to accept a new form of compass.

Between 1840 and 1850 telegraphy advanced very rapidly. One expression of those days shows how entirely electric telegraphy has superseded all other methods of communicating by distant signals. Newspaper paragraphs were then headed "By Electric Telegraph." Nobody nowadays talks of *Electric* Telegraphs. There is no need of the "Electric." There are no other telegraphs now. After 1850, submarine telegraphs became of importance and were rapidly extended from the narrower to the wider channels. Attention was early directed to the impossibility of reading signals succeeding one another rapidly through these submarine cables. A good deal of confusion arose as to the nature of this delay in signalling. It was mixed up with the question as to the time taken by the signal to reach the far end of the cable. A mere delay in time would not have been of serious importance; even though a signal took an hour to reach America, it would have been quite unimportant if it had been legible when it did reach its destination. Lord Kelvin quite early in the discussion clearly pointed out the conditions that determined the possible rapidity of signalling. He showed that under ordinary circumstances of signalling the resistance and capacity of the cable were of primary importance, and that self-induction was of a very secondary importance, unless when the cable was coiled up on board ship; and he propounded the law of squares, as it got named, expressing the speed of signalling in cables of different lengths. This question of speed of signalling was of vital importance in respect of long cables, and was hotly discussed in reference to the then being proposed Atlantic cable. In 1855 Lardner writes of this project, "The sanguine consider the project practicable, and its speedy realisation probable; the phlegmatic notice it only with ridicule; men of science generally admit the possibility of the enterprise; while men of finance more than doubt the possibility of a remunerative result." As these latter really controlled the situation, and as the remunerative result entirely depended on how many messages could be sent through the cable per day, the whole possibility of the Atlantic cable centred round this question. Mr. Whitehouse, who was intensely enthusiastic in his belief in the success of the enterprise, fought manfully against the law of squares, believing that if this law were true Atlantic telegraphy was practically impossible. He published most interesting results of experiments on cables made with an apparatus in which iron was magnetised by sudden discharges from an induction coil. An interesting revival of this method has been recently employed in Cambridge for studying the still more rapid Hertzian radiations. These results seemed quite inconsistent with the law of squares, and although he was unable to find any flaw in Lord Kelvin's reasoning, he stated that he did not believe in the law of squares, and said that, if it were true, submarine telegraphy across the Atlantic would be impossible. "I can only regard it as a fiction of the schools, a forced and violent adaptation of a principle in physics, good and true under the circumstances, but misapplied here." To this Lord Kelvin replied by reiterating the validity of the law of squares, and by showing that the experiments quoted confirmed the law they appeared at first sight to disprove. In the midst of this controversy the Atlantic cables of 1857 and 1858 were laid. The failure in laying the first and of the insulation of the second after being laid, gave rise to immense controversy, but the possibility of laying a cable and of telegraphing through it was conclusively proved. Notwithstanding Mr. Whitehouse's remarks about the law of squares Lord Kelvin had all along maintained that the law was true and that Atlantic telegraphy was possible. His investigation of the speed of signalling had convinced him that the methods employed were going in the wrong direction. In the 1858 cable large induction coils producing an electromotive pressure of perhaps 2,000 volts had been employed, and the failure of the cable had been attributed largely to this excessive pressure. Recent experience of high-pressure transformed oscillating currents would confirm this. Lord Kelvin advocated an entire revolution in all this. He introduced the reflecting galvanometer, with its tiny magnet suspended by a single fibre of silk, and with its beam of light to record its movements. He showed that the conditions for rapid signalling consisted in being able to observe the first beginnings of the current at the far end, and devised the reflecting galvanometer and subsequently the siphon recorder for this purpose. As has been stated by a recognised authority, "the siphon recorder, with its shifting zero, was supremely indifferent to the vagaries of the current which were so destructive of intelligible marks in a dot and dash instrument." As a consequence of these drastic innovations subsequent long cables were worked with electric pressures of a few volts and the rapidity of signalling enormously increased. Thus it was that long-distance submarine telegraphy became financially successful and consequently possible. Continental authorities on submarine telegraphy agree with British authorities in the belief that Lord Kelvin's instruments have rendered long-distance submarine telegraphy practicable. These instruments, which rapidly revolutionised submarine telegraph practice, were the result of Lord Kelvin's study of the theory of signalling in cables, and are a notable example of an invention founded on abstruse theoretical investigations. Of the actions that take place in cables an acknowledged authority writes, "Some of these effects have been known and understood from the earliest times, or more correctly since the time when William Thomson taught telegraph cable engineers the principles of their business (in its electrical aspects) and to a great extent the practice too."

Of the living it is hard to write as to their personal characteristics. Everybody who has directly or indirectly been brought into contact with Lord Kelvin has felt the influence of his single-minded enthusiasm for truth, his intense sincerity and sympathetic encouragement. Can a higher tribute be paid to character than to describe it as truthful, sincere, and sympathetic?

Are we not then right in celebrating enthusiastically the jubilee of such a one? He has provided us with noble and magnificent ideas as to the past and as to the future, as to the indefinitely great and the indefinitely small. He has advanced civilisation by making the all-pervading ether available for our use, by enabling us to measure its properties, and by teaching us how to lay the nerves of civilisation in the depths of the oceans. He has helped to unify humanity, to modify competition by co-operation, to push forward the federation of the world.

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**Röntgen Rays and the Nile Expedition.**—So thoroughly practical are Röntgen rays considered by the Medical Department of the War Office that two sets of Röntgen ray apparatus, it is reported, have been sent up the Nile to be used by the army surgeons in locating bullets and in determining the extent of bone fractures.

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## LORD KELVIN AND SUBMARINE TELEGRAPHY.

No branch of applied science is more indebted to Lord Kelvin than submarine telegraphy. Those interested and intimately connected with the subject in the "fifties" were able men, but the great assistance given to them by Lord Kelvin is freely and frankly acknowledged by them all. Mr. Oliver Heaviside says, "Sir W. Thomson taught telegraph engineers the principles of their business (in its electrical aspects), and to a great extent the practice too." To the truth of this statement the history of the rise and progress of submarine telegraphy bears witness.

No sooner was Lord Kelvin's attention directed to the subject in 1855 than, in a Paper read before the Royal Society, he outlined the theoretical laws governing the speed of transmission of telegraphic signals in cables and their connection with Fourier's laws for the linear propagation of heat.

To Lord Kelvin's early Papers (1855 and 1856) we are indebted for the "law of squares," the law for the calculation of the "curve of arrival," and for the formula by which the capacity of any core of given material may be found when the respective diameters of the conductor bare and covered are known; or, in fact, for the first information on the subject of "the influence of the lateral dimensions of wire and insulating coating on the rapidity of signals by a submarine cable of stated length." To-day these laws and formulæ are matters of "common knowledge" with all cable engineers and electricians. But in 1856 all was chaos; and, thanks to the clear light thrown upon the subject of cable design by the publication of these fundamental laws, "practicians" were saved an immense amount of time, work and money.

In the year 1856 cable men were engaged in discussing the practicability of enclosing two or more cores in the same iron sheathing; but Lord Kelvin's quaintly entitled Paper, "The Peristaltic Induction of Electric Current," published in the *Proceedings* of the Royal Society in May, gave engineers warning of the danger that would arise in so constructing a cable, and the idea was wisely abandoned as far as regards long cables. For shorter cables, the system of multiple cores in one iron sheathing has been frequently adopted; the length of these lines, however, rarely exceeds 150 knots, and even under such conditions, high-speed working brings out the disturbing effects of mutual induction anticipated by Lord Kelvin. In November, 1856, in the *Athenæum*, he published a Table derived solely from theory, which showed the delay occurring upon cables of given lateral dimensions and of varying length from 150 to 2,400 miles. The value and accuracy of the deductions given have since then been abundantly proved; at the time, however, the experiments of Dr. Whitehouse (on the first Atlantic cable) were not in accord with the figures given by Lord Kelvin.

Amongst the numerous other Papers read before various Societies, we may mention that on "Practical Methods for Rapid Signalling by the Electrical Telegraph" (*Proceedings*, Royal Society, December, 1856), in which the method of working cables by the "mirror" was foreshadowed. This system was afterwards modified and developed into the well-known mirror system. A second Paper, on the "Electric Conductivity of Commercial Copper of Various Kinds," points out the importance of constructing a submarine telegraph cable with copper wire of high conductivity. The following Table quoted from this communication shows the necessity that then existed for an investigation of the subject.

*Table of Relative Conducting Qualities of Single No. 22 Copper Wire Supplied from Manufactories A, B, C, D.*

| — | Resistance of equal lengths. | Weight of seven feet. | Resistances reduced to equal conducting masses and lengths. | Conducting power reciprocals of resistance of equal and similar masses. |
|---|---|---|---|---|
| A | 100 | 121·2 | 100 | 100 |
| B | 100·2 | 125·8 | 104 | 95·05 |
| C | 111·6 | 120·0 | 110·5 | 90·5 |
| D | 197·6 | 111·7 | 182·0 | 54·9 |

The practical result of these experiments was that since 1857 a clause requiring high conductivity copper has found a place in all specifications for the manufacture of cable.

In the *Philosophical Magazine* (1861) Prof. Thomson, associated with Mr. Fleeming Jenkin, illustrated the relation between the true and false discharge from a coiled cable, attributing the phenomena to the electromagnetic induction from coil to coil. Before the publication of this Paper Mr. F. C. Webb, who had independently noticed the same effect, published in the *Engineer* (1859) the experimental data on the point, and substantially the same explanation. Before the Royal Society in 1865 an important Paper was presented "On the Forces Concerned in the Laying and Lifting of Deep Sea Cables."

In conclusion, to show the extent and range of Lord Kelvin's influence on the working, testing, and laying of submarine cables, we cannot do better than briefly enumerate

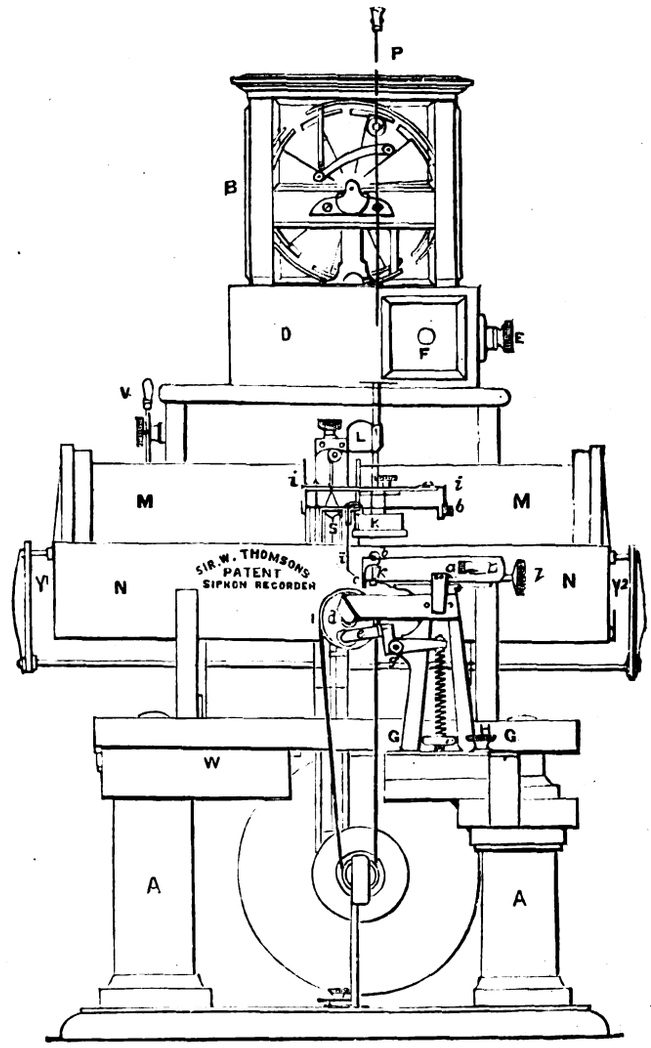


FIG. 1.—Early Form of Siphon Recorder.

the apparatus devised by the Professor of Natural Philosophy in the University of Glasgow to lighten the labours of the submarine telegraph engineer.

*Mirror Speaker.*—With the introduction of this instrument for signalling upon long cables, the first great step forwards was made and the subsequent development of the submarine telegraph system was assured. The speed of working on Atlantic cables was raised at a bound from a possible 2 or 3 words per minute to the high rate of 22 or 25 words. The secret of its advantage as a receiving instrument over all other then existing forms was the extreme lightness of the moving parts (a mirror with tiny magnets attached). This mirror, upon which a ray of light was thrown, was suspended in the centre of some thousands of turns of copper wire, through which each impulse transmitted to the cable passed before going to earth. The deflection of the mirror and the

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consequent movement of the reflected ray of light was made in conjunction with the telegraph code to represent the letters forming the words of the message.

*Astatic Mirror.*—The astatic mirror, as a means of testing the perfection or otherwise of cables and insulated conductors, was as great an advance upon the appliances for this purpose then in the hands of telegraph engineers as was the mirror speaker to the operator. It is even now the most sensitive instrument of the kind that we have, and by its employment,

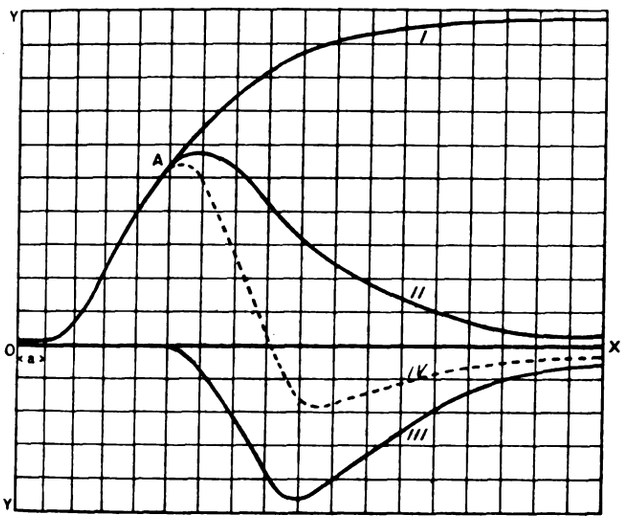


FIG. 2.—"Arrival" Curves.

Distances along O X represent intervals of time.
Distances along O Y represent strengths of currents.
Curve I. shows the gradual increase in strength of the received current at one end of a cable when the battery is applied to and kept in contact with the other end.
Curve II. shows the effect of applying the battery during a length of time equal to $4a$, and then putting the cable to earth.
Curve III. represents the "arrival curve" if the opposite pole of the battery is applied to the cable for an interval of time equal to $3a$.
Curve IV. represents the curve of arrival given by a signal current of duration $4a$, followed by an opposite or curb current of duration $3a$. (Single curb method.)
A. Point where applied current attains about half its maximum strength, a period of $5a$ after the first application of the battery.

faults in insulation and want of uniformity in the manufacture of core which would have escaped notice in the days when the sluggish horizontal galvanometers were used, are represented as glaring defects.

*Quadrant Electrometer.*—This instrument afforded electricians a very delicate and accurate means of measuring potential differences; for cable testing on lines where strong earth currents prevail, it has been particularly useful. The writer has also had practical experience with the multicellular type, and when testing Atlantic cables he has found it both efficient and accurate.

*Marine Galvanometer.*—This well-known galvanometer was specially designed for and is solely used for testing on board cable-laying and repairing ships. The same principle is involved in its construction as in that of the astatic instrument, which, by reason of its extreme sensitiveness to vibration and magnetic influences, is quite unsuitable for work on board ship. This marine galvanometer is so constructed that the motion of the ship or its change of direction will not produce sensible deflections. This highly desirable result is attained by adopting a different method of suspending the mirror and magnet to that which obtains in an ordinary mirror galvanometer; the suspension fibres passing through the centre of gravity of the mirror and magnets. By enclosing the whole instrument with a thick soft iron core, the magnet system is further almost completely shielded from outside magnetic influences, the residue of the directive force of the earth's magnetism being finally counteracted by a strong horseshoe magnet. This instrument has been in constant use for many years, and has proved invaluable to those engaged in the laying and maintenance of cables. Its sensitiveness when properly balanced and adjusted is approximately $\frac{1}{10}$th to $\frac{1}{15}$th that of the astatic mirror.

*Siphon Recorder.*—This to-day almost universally used signalling instrument, an early form of which is shown in Fig. 1, was first patented by Lord Kelvin in 1870. Its sensitiveness, though sufficient, is perhaps inferior to that of the mirror; but, as it affords a permanent record of the received signal, its range of speed is no longer limited by the capabilities of the receiving clerk. The working speed of this instrument, even on Atlantic cables, has reached 250 letters per minute, whilst a mirror clerk would be doing excellent work when receiving under similar conditions at 125 letters per minute. These very obvious advantages were soon recognised by the various cable companies, with the result that to-day fully nine tenths of the submarine cable work of the world is carried out by means of the siphon recorder.

*Automatic Curb Sender.*—Lord Kelvin's actual apparatus has not, it is true, come into general use in the working of cable lines, but as developments of it are likely in the near future to play a prominent part in telegraph work, a short notice will not be out of place. The instrument was fully explained in Prof. J. A. Ewing's Paper communicated to the Society of Telegraph Engineers in 1876, and the "arrival curves," with their explanation, given in that Paper are so instructive that they are reproduced here, Fig. 2. These curves represent the theoretical reasons why "curb sending," suggested by Lord Kelvin, promises to be of such value. This instrument, like many other inventions, was in advance of the existing requirements. Slightly different adjustments of the same transmitter provided three distinct methods of "curbing." The first and most important was the "single curb," the result of which is shown by Curve IV.; the second one gave the "preparatory curb," and the third adjustment gave the "double curb."

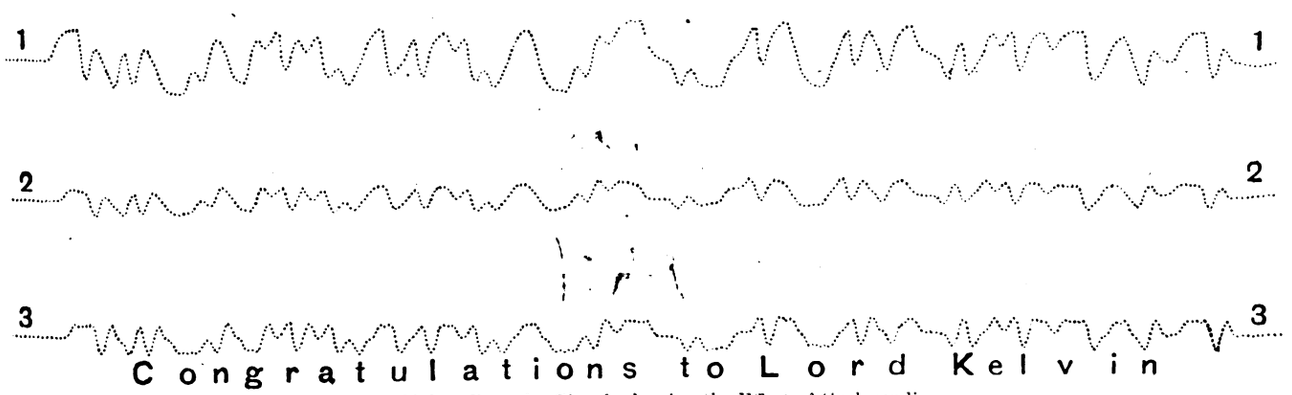


FIG. 3.—Siphon Recorder Signals showing the Effect of Curb sending.
(1) Condensers receiving only. (2) Condensers receiving and sending. (3) Automatic Curb, sending and receiving on Condensers.

The broad principle of "curb sending" is the immediate transmission, after each effective impulse of current sent into the line, of an impulse of opposite polarity and of a shorter duration, effecting on cable circuits what is known among land line telegraphs as a wipe-out. By this means the dragging-out or tailing of the signals is prevented, and greatly improved definition at a given speed is secured. An example of the improvement obtained is shown in slip 3, Fig. 3, where the signals when curb sending may be compared

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with those obtained under the usual working conditions. Unfortunately the definition of the original slip 3 is wanting in the reproduction.

If we were to write fully upon the numerous fundamental inventions due to Lord Kelvin we should be writing a history of submarine telegraph engineering. But enough has been said to make it evident that the establishment, maintenance, and commercial success of submarine telegraphy, are due in a great measure solely to the employment of the instruments and methods described, which, as the working tools of the ocean telegraphist, have done and are still doing sp'endid service. The earliest forms of some of the apparatus mentioned may not have been perfect in design, nevertheless with the exception of the introduction of the condenser and duplex methods of working cables, telegraph cable engineers and electricians have had to be practically content to act as "improvers" upon the ideas and inventions originated by Lord Kelvin.

ARTHUR DEARLOVE.

## THE ELECTRICAL MEASURING INSTRUMENTS OF LORD KELVIN.

Half a century of effort induces, nay, rather compels retrospect. Not otherwise is it possible to place in their true relation and perspective, the events or incidents which may be under review. Similarly, if we would acquire and place on record a fuller and more critical knowledge of a man or of a movement, our point of view must be one which is removed as far as possible from the stress and conflict of everyday existence. Claims to distinction press so closely and so insistently on every hand, and the attempt to select or appoint is so beset with extraneous considerations, that the necessary selection for the guidance of opinion or for the determination of procedure is a matter of great difficulty. Further, all such matters are liable to change as time progresses, with its inevitable sifting of the real from the unreal. When the scope of such an inquiry is the 50 years—1846-1896—a half-century of our history fraught with the most momentous changes—the task appears in no degree lighter, and when that inquiry is to be directed upon Lord Kelvin a feeling of despair is apt to arise. The winning personality of the man so enshrouds us that it seems an impertinence to dissect and analyse one whom we have been constrained to regard with feelings of reverence and affection. And yet he himself—his whole life-work—is a splendid example of the true attitude: deepest reverence and affection for the genius and personality of the men who have striven, with the keenest criticism of their methods and results.

During the fifty years which have elapsed since William Thomson, a young man of 22, took upon himself the duties of Professor of Natural Philosophy in Glasgow University, the domain of physics has been the scene of developments that must have appeared to contemporaries more in the character of revolutions than evolutions. Entering upon that domain with a training and mental equipment that were alike unique, the young Glasgow professor speedily took his place in the very forefront of investigators, and again, as often before, the eyes of the scientific world were turned towards the University of Glasgow for "light and leading."

For the present article the purview is limited to the practical side of Lord Kelvin's work—to his investigations as they took bodily form in methods suited for the practical needs of the workman or of the investigator, and instruments by which these methods could be readily and conveniently applied. Now it is not enough for the purpose in view that we catalogue the various forms and characters of the instruments and apparatus now familiar, or which have, in the past, borne the name of Thomson. The source of the influence and example which we seek to elucidate lies deeper, we believe, than this, and is not to be revealed in its entirety by such a list. His opportunities as a teacher have to be taken account of, and it is there that the most lasting effect of his influence in this respect is to be found. What this influence has been on the lives and work of the generations of students who have passed through his hands it would not be easy to estimate. It is impossible, however, to doubt that the intensely practical character of Lord Kelvin's academic teaching, and the example of his laboratory work and method has been a compelling influence towards the experimental treatment of physical problems now so universal.

It is not easy, under existing circumstances, to realise how comparatively recent is the whole structure of exact measurement in physics generally, and in a still less degree does one realise this phenomenal growth from qualitative to quantitative knowledge when the phenomena of electricity are considered. It may not, therefore, be amiss to note here a few of the names and dates that are intimately connected with the foundation of electrical measurement.

Cavendish and Coulomb laid the foundations of electrostatics, the former about 1750, and the latter about 1785.

Oersted carried out his investigations on the action of currents on magnets about 1820; whilst the corresponding investigation of the electro-dynamical action between currents and currents, due to Ampère, is of date 1846.

Faraday's work on induction and electrolysis was prior to 1840.

Joule's classical investigation of the unit of work falls between the dates 1843 and 1867.

Gauss and Weber's researches, which formed the basis of that system of units which is now practically of universal application, were made prior to 1840.

These beginnings of electrical measurement were eagerly taken up by Prof. W. Thomson, and throughout this 50 years of work measurement has been his guiding principle. In the class room and on the platform, in the proceedings of scientific societies, and in scientific periodicals, he has continually urged the importance of measurement as an indication of the quality of our knowledge. The perfection and reliability of the methods and instruments of measurement, furnish a precise and accurate indication of the reality of our knowledge regarding the phenomena with which they are concerned. The strong grip of this truth, which Prof. Thomson retained in all his work, was undoubtedly one of the strongest impulses towards the desire for precise and convenient units which had its result in the appointment of a Committee on Electrical Units at the British Association appointed at the meeting of 1861. After eight years of wisely ordered and careful work that Committee presented a final report establishing the C.G.S. system of units, and presenting in concrete form the first of the three fundamental electrical units, the ohm. It is unnecessary here to follow the vicissitudes of the British Association ohm through the 27 years of its existence. Enough has been said to show that amongst the small band of philosophers to whom we owe such a deep debt of gratitude, the name of William Thomson must ever be reckoned amongst the first.

Meanwhile, Prof. Thomson had been working out a series of instruments on the electrostatic principle, for the measurement of electrical pressure. As early as 1855 an absolute electrometer had been exhibited to the British Association at the Glasgow meeting of that year, and in 1856 the divided-ring electrometer was first described in a foreign periodical. If it were possible to reproduce in all its detail the evolution of the Thomson electrometers that followed throughout the next ten years, most interesting and instructive would be the result. We should see an instrument, just completed and resplendent in all the beauty of the instrument maker's art, begin to change almost at the instant of its appearance on the laboratory testing table. Additions and changes, each it might be minute and apparently of no great consequence, would so accumulate as to fairly obscure the original design, and point to the necessity of some radical change in form, dimensions, shape, arrangement, or other feature. Then a new instrument would appear to be in its turn changed, altered and finally to give place to an improved successor. Year after year this process went on until 1867; and in that year an important communication laid before the British Association describes and illustrates two instruments — the absolute electrometer and the quadrant electrometer—which (as will be seen later) form practically the standard types of instruments now in use for the measurement of pressure.

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The course to be followed towards the attainment of precise measurements in electricity had now been made clear. The methods and apparatus devised by Sir W. Thomson and his co-workers on the Units Committee of the British Association had given a definitive value to the unit of resistance. Methods and instruments for the precise measurement of electrical pressure had been given by Sir W. Thomson, along with a first attempt at a definitive value of the volt. And, lastly, for the measurement of current there were then in existence sine and tangent galvanometers, evident developments of the "multiplier" of Schweigger and Nobili; and the electro-dynamometer due to Weber, and constituting a most important practical result of his classical researches.

For the next ten or twelve years there is comparatively little to record in the development of electrical measuring apparatus. Almost the only purpose for which electrical energy was employed being telegraphy, accurate measurement was not directly a necessity of the operations carried on, although indirectly it was a most important adjunct in showing the direction along which improvements in speed and accuracy were to be sought. Further, the quantities dealt with were small and quite within the range of the types and patterns of the early instruments. Hence, comparatively speaking, few measuring instruments were required, and no inducement was offered, either to manufacturers or designers, to promote an industry of electrical measuring instruments.

With the introduction of the incandescent lamp, however, in the early eighties, measurement in electrical phenomena entered upon a new phase. Economy now became an important factor in the production and distribution of electrical energy, and hence accurate, reliable and convenient measurement formed an essential feature of the process. Again, the quantities to be measured had increased, especially current, in which, instead of tenths of amperes, hundreds and tens of hundreds had to be provided for. Heretofore it had been possible to select or control the positions in which instruments were to be used so as to prevent external influences from vitiating their accuracy. Under the new conditions no such selection was possible, and measurements were required under the most adverse circumstances. The influence of moving iron, stray magnetic fields, and electrodynamic action from very large currents, all must be taken account of, and discounted as far as was possible.

The problem of adapting the means of measurement to fulfil the new conditions was at once attacked by Sir William Thomson; and the instruments issued under his name from time to time mark the lines along which the development proceeded, and indicate the success from time to time achieved. At first the Oersted arrangement, with a rotating magnetic system, was adhered to. The suspension for such an arrangement presented no great difficulty in a laboratory instrument, but for an instrument to be used in a factory, and to be placed in the hands of a workman who would probably have no more respect for it than he had for his foot-rule or level, the matter was one of some difficulty. It was advisable to retain, if possible, the silk fibre suspension for the needle, and to render this capable of fulfilling the conditions of practical convenience and hardiness various plans of guard rings and collars were tried. The most promising, however, was that in which the upper end of the silk fibre was fixed to a spring, since the instrument was by this means protected from injury by sudden jars. A screw adjustment for the spring provided a means of lowering the suspended magnetic system on to a fixed support, and thereby making the instrument perfectly portable. This arrangement, of course, required in the design minute parts and somewhat fine workmanship, and was objectionable in instruments to be produced on a commercial scale. These instruments were protected against the influence of external magnetic forces by a heavy iron shield surrounding the coils and the suspended magnets. This magnetic shield added weight, which was inconvenient, and it was with the greatest difficulty that a uniform result could be obtained. In another type of instrument a similar indicating arrangement was used; but the opposing magnetic field was greatly strengthened, as compared with the earth's field, and in this way external influences on the magnetic system sufficiently neutralised to enable the iron shield to be dispensed with. Two instruments of this class deserve mention—the graded voltmeter and the graded ampere-meter. In these the magnetic system, which was controlled by a separate magnet of known strength, was supported by a jewelled cap resting on a fine point, and carried in a suitable case, which could be placed near or far from the electro-magnetic coil. This case (magnetometer) was constructed to traverse a graduated path on a platform, at one or both ends of which there was fixed an electrodynamic coil. The magnetometer could thus be placed at points near or far from the acting coil. It was, therefore, possible to give these instruments a very wide range, and in the hands of trained observers, when used with proper care and discrimination, they were capable of very accurate and reliable work, and even yet have not entirely given place to newer types.

A type of instrument which has been singularly persistent, especially for commercial purposes, is that which acts by reason of the principle that a piece of magnetic matter placed in a non-uniform magnetic field tends to move from places of weaker to places of stronger force. The great advantage and convenience of these instruments consist in the fact that they are not nearly so liable to interference from external electric action as the preceding types. Unless special arrangements are devised, the gradient of magnetic field required to injuriously affect their indications is not readily obtainable; hence they are peculiarly useful for switchboard purposes. Both voltmeters and ampere-meters are constructed on this principle, the magnetic body being a small spheroid or ellipsoid of soft iron, suspended in a magnetic field produced by a coil so wound as to cause a variation of the magnetic force along the vertical axis of the coil. Amongst the instruments at present on Lord Kelvin's lists the well-known ampere gauge is the representative of this class. A coil, in the ordinary sense of the word, is not a *sine qua non* for the production of a magnetic field, and where large currents are to be measured a coil of *one* turn might be more than sufficient. To meet this case Sir W. Thomson has designed an ampere-gauge of a most interesting form. The conductor is of such a shape in the portions adjacent to the path along which the soft iron ellipsoid moves that the cross-section, in planes perpendicular to that path, diminish to a minimum, forming what might be termed an electric rapid, and the required gradient of magnetic field.

Those who had taken up the new profession of electrical engineering speedily found that they were advantageously placed with regard to measurement in the operations they were required to carry out, and in dealing with the new phenomena which met them on every hand. A greatly extended demand for instruments was the natural consequence, and the problems presented for solution in supplying the varied requirements, attracted the mechanical skill and electrical knowledge of many designers with the happiest results. Speaking generally, the two principles to which reference has already been made were adhered to, the second being, perhaps, specially favoured, since it lent itself more readily to the production of "gravity" instruments—those in which gravitational attraction on a ferro magnetic mass is opposed to the electrodynamic action. An exception must be referred to, on account of its interest and importance—the "hot-wire" instruments, after the Cardew voltmeter. These, while no doubt open to objection from the amount of energy they consume, have yet, we believe, great possibilities in them with respect to the measurement of alternating currents.

Sir W. Thomson, however, became impressed with the opinion that the measure of success achieved by the instruments of other designers, and by those of his own design, suggested a radical change in the principle or principles employed. For pressure instruments he therefore turned to electrostatics and to his own divided-ring electrometer of 1855; and for current measurement to Ampère's researches and the electro-dynamometer.

The divided-ring electrometer of 1855 had become the quadrant electrometer of 1867; and this last, after 20 years, furnished the design for the Kelvin multicellular voltmeter of the present day. Beginning its existence as an instrument with "commercial" sensibility, it has given a new meaning

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to these terms, in making it possible for the measurements of the workshop and factory, and electric light or power station, having an accuracy and reliability, which, not many years ago, were barely possible in the laboratory. Sir W. Thomson describes the development of the divided ring electrometer into the quadrant electrometer in the following terms:—"I have made great improvements in the instrument—first, by applying a light mirror to indicate deflections of the moving body; next, by two half-rings four quadrants, and, consequently, for an electrified body projecting on one side only of the axis, an electrified body projecting symmetrically on the two sides and movable round an axis; and lastly, . . . by a . . . gauge and . . . replenisher." This instrument acted heterostatically, and it was obvious that an instrument to meet the practical conditions of electrical engineers must be idiostatic. To obtain the required sensibility it was, therefore, necessary to produce the increased force by increasing the condenser area. Sir W. Thomson effected this by superposing the quadrants of cells and building up the corresponding needles in a light aluminium stem. One pair only of quadrants is used, and the number of pairs superposed may be anything from 3 to 15. The later forms of this instrument have been specially designed for switchboard purposes, and has proved itself a most valuable instrument. Instruments of this type have been made reading up to 2,500 volts. The introduction of alternating currents, which had given a difficult problem to the older instruments, brought no difficulty for the newer type. These measured with equal accuracy (taking account of a small possible correction for contact-effect) pressures either alternating or continuous. They were not subject to interference from external magnetic action, nor from electromagnetic or electro-dynamic forces, and could be readily and effectively screened from electrostatic interference. In a word, they constitute a large step towards the ideal voltmeter.

The problem of adapting the Weber electro-dynamometer to the measurement of current had become increasingly difficult as the amounts to be measured increased. Sir William Siemens attempted the solution, and attained a certain measure of success, his electro-dynamometer being still a well-known instrument. The crux of the problem clearly consisted in providing a means for conveying the current to be measured to the movable portion of the electric circuit constituting the dynamometer, the conditions being sufficient electrical conductivity and minimum mechanical resistance to the motion of the movable part of the circuit. To meet these conditions Sir William Thomson made the movable part of his dynamometer circuit to consist of one or more turns of conductor placed at each end of a balanced beam, to which the coils were attached, or of which they formed part. This beam is supported by a "ligament suspension" to each of two trunnions; the ligament consisting of a number of fine copper wires laid closely side by side to form a ribbon, one end of which is soldered to the fixed support, and the other to one of the trunnions of the beam. The electro-dynamic action on the movable circuit, in the operation of measurement, is counterpoised by weights, and as the instrument is "zero reading" the ligament is under no bending moment at the instant of observation. The current-measuring instrument thus produced, and which has a world-wide reputation as the Thomson (or later, Kelvin) electric balance, comes very near to absolute fulfilment of the conditions imposed on the ideal electro-dynamometer.

In the foregoing paragraphs no attempt has been made to indicate with any degree of fulness all that Sir William Thomson has done on behalf of electrical measurement. The outstanding and essential features only of that work have been referred to; no notice whatever could be taken of many ingenious and interesting mechanical details which he introduced from time to time; of the new phenomena brought into view by his instruments; of his valuable work in the difficult region of recording instruments. Space, and not inclination or opportunity, forbids. Enough, however, has been said to show that however high his place may be in the illustrious roll of scientific men, whether of our empire or of the world, his achievements as a designer and constructor of electric measuring instruments make a sensible addition to his fame. And, to our mind, if it be said that the addition so made is small, it has this deep and far-reaching significance for men of science of all time—that there is no degradation to Science when it takes up and fulfils the wants of practical humanity, and that the genius of a Thomson finds a no less worthy object in providing an ampere gauge and voltmeter for the engine room and factory; than when it spends itself on the more abstruse problems of cosmic physics.

J. Rennie.

## MR. ARTHUR WRIGHT'S PRESIDENTIAL ADDRESS TO THE MUNICIPAL ELECTRICAL ASSOCIATION.

You have done me the great honour of asking me to preside at this our first annual Convention, and I feel I cannot take up a portion of your time to better purpose than by proving the pressing want of some such Association as we are now inaugurating to further and protect the interests of the municipal electricity undertakings, which in the very near future will probably exceed eighty in number, and represent a capital outlay amounting to £4,000,000 sterling. I therefore propose to show how exceedingly numerous are the questions that are being constantly met with in our special branch of electrical engineering, and why, in my opinion, none of the existing societies can really supply our want. I think you will share my regret that the very nature of our problems, and the particular standpoint from which we municipal men have to look at them, prevents us from deriving the great benefit of having among our regular members the numerous experienced managers and engineers of companies supplying electricity. Although the objects of this Association are generally and very tersely stated in the constitution, I may be allowed to amplify the wording there by stating that, in promoting the special interests of municipal electricity undertakings by bringing together, for the purpose of comparing experiences, the men responsible for their management, we hope to succeed in getting the representatives of the ratepayers to participate in our discussions, and to obtain their valuable co-operation and municipal experience in trying to solve our difficulties, so that our recorded conclusions may receive the greater consideration from the head governing bodies.

For the purpose of classification I will divide some of the problems that have already confronted the management of municipal electrical undertakings into three distinct groups—those relating to policy, to commercial and to technical questions. Although it could be truly said that some of the questions of policy come within the sphere of one, if not more, of the older societies, and that many of our commercial and technical problems could be advantageously discussed from a *general* point of view before some of them, yet it must surely be to the advantage of the community to have the *particular interests* of our industry safeguarded and properly represented by an Association comprising among its members the representatives of the ratepayers and the technical officers in charge.

The group of "Questions of policy" must obviously include those relating to what should be the proper period allowed for the repayment of loans. That some decision ought soon to be arrived at is evident when we remember that in London the Vestries can get permission from the County Council to repay their capital in periods exceeding 40 years, whereas, in many of the provincial towns, 25 years is the period fixed by the Local Government Board. There is obviously no reason why posterity outside the metropolis should be so much more generously dealt with, at the expense of the present generation, or why folks in the provinces, *who have to pay all the expenses and suffer from the inevitable troubles incidental to the starting of a new industry*, should also have to behave so much more handsomely to people who it must be remembered will have an advantage over us in being born 25 years later in the world's progress.

Take, again, the question of assessment of electricity works and mains. The interpretation of the law on this point is so uncertain among experts that it is actually possible, in the case of two municipal electrical undertakings in the South of England, for the relative assessments to be nearly as ten is to one, although the capital invested is about equal. At first sight, to anyone not directly interested in the success of municipal electricity works, this variation of assessment would probably not be considered very serious, as apparently it is only a question of taking money out of one municipal pocket and putting it into the other; but to the men responsible for the success of this one special department, the question of assessment affects the vital results of the electricity undertaking paying or the reverse, and increases or diminishes the near possibility of a reduction in the tariff for supply, which they realise is necessary to ensure the general use of electricity among all classes of ratepayers.

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The decision arrived at, as to what policy should be pursued in relation to the profits obtained, has a similar effect on the rapid growth of municipal electricity undertakings. The practice of insisting on maintaining high tariffs, so as to be able to hand over large profits to the general body of ratepayers, on the ground that they should be handsomely repaid for their risk in mortgaging their rates, is very naturally resented by those ratepayers who make use of their own municipal supply. They contend that by this policy they are being severely taxed, in the shape of having to pay heavy electricity bills, for the benefit of a number of people who we now know ran practically no risk at all, and as non-users do not help their own municipal enterprise. Again, when we remember how prone some municipalities are to pride themselves on the large profits made in their undertakings, and when we remember the policies advocated by some of our friends, who would lead us to imagine that the object is simply to supply electricity to those who can afford to pay the necessarily high initial price, it is evident that good must come from our discussing this point, and bringing home to the governing bodies the truth that the criterion of success of a municipal electricity undertaking, trading in what cannot be called a necessity, is not so much the profits made out of the undertaking as the more or less general use the ratepayers make of the supply offered. Those who advocate putting aside a large proportion of the annual profits to building up a reserve fund for use in case of unlooked-for contingencies are often charged with want of consideration for the general ratepayers who backed the necessary cheque in starting the undertaking; these critics, however, forget that in this matter it is the duty of a Corporation not only to start, but to continue to supply a cheap and satisfactory service, and to insure against any possible mishaps that may arise in the future.

Again, the question of creating a mutual electricity works insurance fund seems a fitting subject for discussion, considering how all our works are now being tarred with the same brush by the fire offices, and classed by them among the same hazardous risks as factories, &c.

Again, the practice of the various municipalities differs considerably in deciding whether one or separate committees should manage the gas and the electricity departments. The former practice frequently prevails, and what seems to many of us the inevitably slow progress that results from such a policy is not at present fully realised. In some towns human nature seems to be so overrated that their Corporations have made one manager responsible for these two competitive departments.

Another point in connection with the general policy that is to be followed in carrying out municipal electricity undertakings is one on which electricity works managers are not by any means all agreed among themselves—namely, whether a Corporation should make all ratepayers pay a uniform profit on the cost of production of the electricity they individually consume, or charge a uniform price to everybody. I scarcely need add that the two systems cannot both be adopted. The former has the advantage of justice on its side, while the latter has that of greater simplicity; unfortunately, however, it involves the commercially unsound principle of charging the same price for commodities which may individually require capital outlays differing as much as tenfold or more.

Again, owing doubtless to the youth of our industry, no definite rule has yet been established among municipalities as to how they should charge for electricity consumed in their street lighting and public buildings; whether, for instance, this should be done on the sound principle of having only one universal tariff, or should special tariffs be arranged for their own municipal consumption. The latter course, in view of the charges that are constantly being made of some Corporations making their electricity profits out of their own pockets, seems difficult to justify.

The wisdom, or the contrary, of municipalities taking joint action in threatened patent litigation, or in view of new Parliamentary regulations or restrictions, wants discussion and settlement.

The questions whether municipalities should carry out the wiring of private premises in competition with local tradesmen; whether they should have powers to hire out motors, arc lamps and fittings; the advisability of establishing municipal telephone systems, electric fire alarms and electric fire engines; the possible benefits of combining the water and electricity works; the use of the plant in periods of light load for the production of such by-products as disinfecting fluids, acetylene and carborundum, &c., are all interesting problems of policy which I trust will be ventilated and argued at our Conventions.

Another municipal variation of practice is shown by some believing that it is to the interest of the ratepayers to employ a sufficiently strong resident engineer to carry out both the design and the running of their undertaking, on the ground that no one but a resident can properly grasp and retain the local bearings of the problems involved in a distribution scheme of the nature of electricity supply; while others consider that a consulting engineer, owing to his having the opportunity of gaining much more varied experiences from all sorts and conditions of towns, should serve them in better stead. On the answer to the above delicate question, of course, depends what should be considered the proper remuneration of the resident engineers who have the virtual control, whether their Councils fully realise it or not, of property amounting in many cases to hundreds of thousands of pounds. The touring experiences of many of our best electrical engineers is advantageous to the men themselves in gaining fresh experiences, but it is a loss to the Corporations when the engineers are snapped up for better appointments elsewhere. The existence of this constant system of changing proves beyond all doubt that many Corporations have not yet realised the value of the immense experience these men take away with them, and how impossible it is to replace their experience by even better men until some considerable time has elapsed. Again, some Corporations fully see the advisability of getting their engineers to visit other electricity works for the purpose of keeping up to date. The great extent to which the ratepayers benefit by this policy is not, I am sorry to say, apparent to all the governing bodies. Although many of our senior brother municipal officers will be prone to think that some of the above questions do not come at all within our province for discussion, I feel that if we obtain the valuable assistance of the Chairmen of our Committees in discussing and solving them there will be little difficulty in getting the correct principles accepted and adopted by our councillors.

All the above, and a host besides, are questions of policy that press for solution, and I feel sure many will agree with me in thinking that if we leave them to the other societies to fight out we may as well adopt the equally slow course of leaving each Corporation to worry for themselves when they are individually confronted with them. The founders of this Association saw that co-operation in arriving at conclusions upon these problems would save a great deal of time, and would avoid the repetition of a vast amount of work by the different Councils. They also saw the importance of putting in black and white the results of careful consideration, by competent men, of the different policies advocated, so as to afford help to those among their *confrères* who may be in need of it.

With the second class of problems connected with our work, viz, those requiring consideration from a commercial point of view, it seems to many of us quite impossible to get this class of question satisfactorily and adequately discussed before societies, however influential and well organised, which comprise among their members men representing absolutely conflicting interests; and it appears equally futile to discuss these questions before institutions including among the members the managers of electricity supply companies, whose object in developing their business, viz., to get the biggest return on the capital expended, is so entirely different to ours in trying to supply the greatest number of ratepayers at the smallest possible cost. Moreover, it can hardly be fair or interesting to the majority of the members of existing engineering institutions for us to take up their time discussing problems which can only properly be thrashed out before a special body representative of our particular subject of municipal electricity supply.

Under the heading of "Commercial problems" must come the important question of the proper organisation of the electrical staff; that is to say, how to so organise a staff, and divide the undertaking into separate departments, as to be able to define the duties and responsibilities of each member of it, and to ensure against any discontinuity in the business in case of illness or resignation of the chief officers. Whether the principle of giving the staff a bonus depending on the results of the year's working is likely to be to the benefit of the ratepayers or not is a question on which much can be said on either side; and it ought not now to be difficult to decide what should be considered the proper scale of remuneration to the different members of the staff in accordance with their term of service, so as to avoid, as much as possible, the inconvenience and loss of experience to a Corporation of having their officers merely use their undertaking as a sort of training school.

I think a very useful purpose will be fulfilled by our Association if we could all agree on some proper method of keeping electricity accounts, or perhaps, I ought to say, of properly filling in the Board of Trade Regulation form of accounts. Everyone will now admit the great value electric lighting statistics, financial as well as technical, would be, providing they were made on an absolutely uniform basis, and I trust some of our members will early suggest some form which we can all approve and adhere to.

The question as to the right method of determining the cost of electricity supply has yet to be thrashed out, as it seems to some of us that the usual method of taking the average cost of all the units delivered is as useless for the purpose of calculating the cost of supplying any one class of consumer as if a land agent were to calculate the cost of a particular plot of ground in a town by dividing the total land value of the town by its total area. On this matter of costs depends the very important question of the actual cost of electrically lighting streets; also whether there is any justification, commercial or otherwise, for the plan adopted in many towns of charging a lower rate for electricity consumed in motors than in lamps.

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Another most interesting and still unsettled point is what should be the basis on which to calculate the cost of energy wasted in feeders, transformers, &c., for the purpose of determining the relative cost of different systems of distribution. I have not yet succeeded in meeting two men agreed as to how this should be done.

Again, it has not yet been generally recognised, as some think it ought to be, that it pays a Corporation to cater in our industry for the same class of people that prove so remunerative to the railway companies, viz., those who choose to travel third class; and that it would probably be very much more advisable for Corporations to run mains into their districts, than only into the districts occupied by the houses of the rich and often absent residents, or the early-closing shopkeepers. To put it shortly, many of us have still to realise and prove to our governing bodies that it may be far better to get electricity used in a poor man's kitchen and one dwelling room than it does to get it into many of the drawing rooms of the wealthy.

Again, you will all agree, I feel sure, that it is very important, in order to inspire confidence among the ratepayers, to show as early as possible after the starting of a municipal electricity undertaking that it can be made self-supporting, and, therefore, independent of the rates. With this object in view, it is an interesting problem in electricity supply to find whether capital is better employed in the early days of an undertaking in extending its sphere of operations into all parts of a borough, or in spending money on coal-saving refinements. To point out a danger confronting many of us, I may add that sound business men often express a belief that electricity undertakings would progress much faster if their managers took as much interest in understanding the commercial problems as they do in the over-absorbing engineering details and the fascinating scientific points connected with the industry.

The subject of wiring regulations and fire risks is one that has already received a great deal of attention, and I submit that it is still an unsettled question whether we are not weakening our position by enacting pages and pages of regulations which we have no very practical means of enforcing, and cannot afford to keep a sufficient number of inspectors to see carried out. Although I believe a certain amount of regulation writing is necessary in the early days of any industry, yet, in view of the utter absence of observed regulations concerning the use of paraffin lamps and compo gas pipes, one may be forgiven for thinking that it is better to realise at once the futility of electricity supply authorities formulating regulations, that the proper people to do this and see them carried out are the fire offices, and that the more thoroughly this is recognised the more likely these offices will be to fall into line and organise their staffs so as to ensure strict and general inspections. This seems to me to be the only way to improve the character of the interior wiring work, which at present varies so much in quality.

With regard to the last group of questions, those of technical interest, which to most of us are infinitely more attractive than those of commercial expediency, it is hardly necessary for me to do more than enumerate many of the most pressing problems.

Foremost among these, in my opinion, must surely stand the question of what should be considered the best system of distribution of electricity to any particular town or district. That the present state of things cannot be finality is obvious, when we bear in mind how numerous are the different methods at present advocated and in use for towns of comparatively the same class. Owing to the absence of some such association as ours, this vital question has not yet been thrashed out by men who are unconnected financially with particular systems, but I hope we shall not be so very much longer now in settling upon some method of selecting the plant and means of distribution which should be put down by a municipality, so as to ensure an absolute continuity of cheap electricity supply, and at the same time bear the severe practical test of enabling the manager and the rest of the officers who have to work during the day to go home comfortably to their five o'clock tea without expecting every moment to be rung up on account of some mishap or other. In connection with this battle of the systems must be decided the proper voltage of supply to be adopted by works to be erected in the future, also whether it is advisable, and, if so, in what stage of their progress, for works in actual operation to raise their voltage of supply, and the best method of effecting the change.

I only wish I could see a chance of our discussing within the next year or so such specially interesting technical problems as the advisability of earthing the neutral conductor of a low-tension system of supply, the most suitable class of mains to adopt, the proper size of feeders and generating units, the advisability of adopting for commercial, if not technical reasons, one uniform periodicity for alternating-current plant, the wisdom of interconnecting all the low-tension network of a town, &c. Although the question of the best design for an electricity works depends so much on local circumstances, yet the main considerations affecting this ought now to be determined.

The question of locating faults on a system of distribution is another point on which we must all derive benefit by comparing our different methods and difficulties. Up to the present busy men in practice have been apt to keep their various methods too much to themselves, forgetting that probably the combination of other methods with their own would be of great value.

As it has now been recognised that the present system of wood casing for interior wiring cannot be considered finality either from an electrical or æsthetic point of view, a Paper on this subject up-to-date would be most interesting and useful to all of us. Again, the best means for lighting streets, wide and narrow, can now, with the experience of many of our members, be advantageously discussed.

Our constitution has been framed in my opinion on a very liberal basis, and I trust we shall escape the internal troubles which some of the older societies have had. On Friday we proceed to elect from among our members a President, two Vice-Presidents, three members of committee, a treasurer, and a secretary for the ensuing year.

In conclusion, I feel sure that if we can only persuade ourselves to be mutually communicative and ready to exchange our views and experiences, the result will be so beneficial to the community at large, that they will be as thankful to the members who first took up the idea of forming this Association as we ourselves ought to be to Mr. Magden, our first very energetic honorary secretary, who by his ability in organisation has done so much towards making this Association promise to be a permanent and useful success.

## DISCUSSION.

Mr. Alderman HIGGINBOTTOM (Manchester) said that, among other points, the Address had raised a very important one with regard to the supply of electricity from a ratepayers' point of view, and the whole of the points mentioned were of the greatest importance to municipal undertakings, and he ventured to think that if such an Association as had now been formed had been in existence at the time of the Board of Trade Conference last year, they would have seen a very much better result. Many points that ought to have been settled were left open, and were now in abeyance. He hoped the result of this meeting and future meetings would be that they would be able to approach the Board of Trade and get these matters settled. At present they had not touched street lighting in Manchester; but they had made large profits, and it was a very successful undertaking. The President had mentioned the question of profits; that, of course, was a question that affected all very deeply. As to whether they were right in building up a large reserve fund and a large contingency fund, and making large profits to the detriment of the ratepayers, he did not know. With regard to their undertaking their Act was very clear. They were allowed to place a certain amount of money to a renewals account. The next question was the heaping up of large profits. Under their Act they were not allowed to do it. Immediately they had made 5 per cent. profit on their lighting, they were obliged to reduce the price. They made 5 per cent. last year, and had to reduce the price; they made over 5 per cent. this year, and they had to reduce it again. With regard to a contingency fund, he said they were allowed the use of their contingency fund until they had got 10 per cent. of their capital. The President had raised another point which deeply affected nearly every Authority, though he (the speaker) did not think it affected them so much, because they had gone upon the straightforward basis. Should municipal buildings, &c., be charged at a special rate? They took the view in Manchester that it was not right to charge municipal undertakings differently to what they charged the ordinary ratepayers. Another point was the question of income tax. It was a very wrong thing, he thought, that they should have to pay income tax upon the profits made for the benefit of the ratepayer. He thought the Association itself might bring forward the question as to whether they were not exempt from income tax in matters which were purely municipal and for the benefit of the city. There was another point raised with regard to making municipal undertakings the training schools for young engineers. They had several young engineers in their service in Manchester, and he, for one, felt that some arrangement should be made whereby committees looking further ahead than they did now should give adequate remuneration, not only to their head officials, but to their second and third engineers. He thought that some kind of a bonus should be given in order to keep their own men, instead of letting them go elsewhere with all the experience that they had gained with them.

Mr. Alderman RICHARDS (Chairman of the Bedford Electric Lighting Committee) said that, although Bedford was only a small Corporation, they had had very great difficulties to contend with in the introduction of the electric light. They were told that it would be impossible for them to make it pay, that their place would be shut up, and that gas would be resorted to within twelve months. Their first balance-sheet came out at the end of last year, and they had made a profit of £90, with the exception of paying back the instalment of the loan and the interest. With regard to the question of Corporations and representatives of the ratepayers being connected with this Association, he said at once, when this matter was brought before his Committee by the circular, that it was what was wanted.

**Royal Society.**—A Paper on "A Magnetic Detector of Electrical Waves, and some of its Applications," by E. Rutherford, was down for reading at the meeting of the Royal Society yesterday.

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## DISTURBANCE OF TELEGRAPH AND TELEPHONE CIRCUITS BY LIGHT AND POWER CURRENTS.

Some interesting statistics with regard to disturbances of telegraph and telephone circuits by lighting and power currents have been compiled by the German Imperial Post Office, and were communicated to the Elektrotechnischer Verein of Berlin by Dr. Strecker a little time ago. The statistics cover the period 1891—1896, and give 76 cases of damage to circuits and apparatus. In 1891 there were five cases, in 1892 four cases, in 1893 two cases, in 1894 15 cases, in 1895 31 cases, and in 1896, for the first four months, 19 cases. The increase in the number of disturbances is explained by the increase of electric tramways. In almost all cases it was telephone circuits that suffered, and only two cases of damage to telegraph lines are reported. In 61 cases electric tramways caused the disturbance, and in 15 cases electric lighting plants. In 59 cases the safety devices, such as wooden strips, guard wires, &c., failed to act. In 40 of the 76 cases the telephone or telegraph wire broke, and had been in contact with the live circuit. Many disturbances were caused during the fixing of the telegraph or telephone wire, and also by broken guard wires themselves. The damage caused, however, was mostly small, on an average about 14s. There were, however, two fires in 1894 at Dortmund and Barmen, and the damage amounted to £270 and £1,550. To protect instruments from currents of too high pressure the German Post Office puts fuses into the circuits. These fuses consist of a wire 0·07mm. in diameter, and made of a non-oxidisable alloy. They are enclosed in glass tubes 5cm. to 6cm. long, sealed up at both ends, and fitted with metal contact pieces. In this way the formation of an arc at 500 volts pressure is avoided. The fusing current of the wire is 0·8 ampere. The whole fuse is kept in position between contact springs, and is easily interchangeable. Another type of fuse used by the Imperial Post Office consists of a porcelain block, about 5cm. high, the fuse wire running through a hole across the block. Both types have given great satisfaction.

## ENGINEERING EDUCATION.*

BY EDWARD H. WILLIAMS.

Granted that life is short, and that it is of first importance that a course should end in time to allow a man to do a little practising before he dies, and granted, further, that the length of the course must be limited by the money a man can invest in it, it is required to plan an "engineering" course—not a course for an artisan. To be an engineer one must have a thorough working knowledge of the higher mathematics. Unless the entrance requirements are at the top notch, this means that parts of two years will be necessary for its perfect acquisition. Then come the applied mathematics, experimental physics, mechanics, strength of materials, some knowledge of chemistry, and a facility in handling drawing-instruments that can come only from time, and an accuracy in their use to be obtained only from experience. Is the man to be a mechanical engineer? He must have a thorough knowledge of thermodynamics, kinematics, fuels, iron, metallurgy, and measurement of power. He possibly can get along without a knowledge of the modern languages; but he must rely then on translations, and, unfortunately, the best text-books in the science are in German and French—preferably the former. To read these he must put in the continuous work of parts of three years, as technical German is no joke. In the time that is left he must learn all that he can about machinery—not machines—and here is where the ways diverge. If he is to know about machinery, he goes in one direction; if about machines, he will never become an engineer, but he may know all about chipping, filing, &c. Let me now tremblingly, a missionary to the heathen, and with, perhaps, a similar fate before me, preach my brief preachment.

Let me start with the axiom that the engineer works with his head, while the artisan uses his hands. The former knows by careful study of work, as well as by comparison of good, indifferent, slovenly, and bad work, how work should be performed, what conditions govern its inception, what economic questions must be settled before its undertaking; the latter knows how to do certain kinds of work well on certain tools, and by experience becomes a "skilled workman"—and nothing more. The one looks beyond the work to the tools, their arrangement, the building in which they are housed, the motors which run them, the economy of the service and the ultimate profit; the other moves in his little circle, knows his little stint well—and nothing more. The "engineering" school teaches the student humility, as it opens to his vision the wonderful works of the past, and shows him how small and insignificant he is in this great world, which is so old and so critical. The "shop" teaches the man the shop traditions, lets him see all that the walls contain. The man soon "knows it all;" becomes cocky and self-opinionated; comes down from his little draughting room, in the shop of the logging road he serves, to "inspect" the work the Baldwin people, for instance, are doing for them. He cuts a wide swath for a day or two, gets all the rope needful, and hangs himself. During the rest of his life he boots himself all over that shop because he did not know enough to keep his mouth shut. The "engineering" school teaches the student that each instance brought to his attention is simply an instance; that each novel instance must be solved by comparison; that the future has myriads of such instances, no two alike, and that only by abundant practice in their solution can he hope to become expert; that he must begin at the bottom of the stair with a low salary; that he can learn something from the navvy on the spoil-bank and the wiper in the stalls. It does not waste time in giving a man a smattering of how to file square, to swing a pick, to tighten bolts on a bridge, or pound his mate's hands in an effort to hit the drill-head. The truly egotistical man is the self-made man who has worked in his little circle till the grass is worn off; the man who thinks he has invented what the nearest library would show to have been common property since the creation. This man wishes the embryo engineer to fritter away his time in learning how to perform manual labour which he will under no circumstances put in practice in after life; which will seriously cut into the time allotted to his education; which can be at best but superficial and valueless; and which will make him narrow and self-opinionated.

Let me further preach that the professor in charge of a course knows better the needs of the course than either the artisan or the expert. The first is constantly asked for men to do certain things; is told of new departures; is freely consulted, because his position makes him the father-confessor, from whom all think they can get advice *gratis*. What the artisan sees over the sideboards of his treadmill is not the world. The expert, to be truly one, must specialise, and thus leave broad for narrow grounds. He may be lord-paramount in his little sphere; but he must stay therein, if he is to dogmatise. It is always an unfortunate day for him when he flops laboriously to the top of the fence and crows defiance to the world, as it shows him that security of position is nearer the ground. In the future let the critic and comparer lay down the rule followed by every engineer: study the results before going ahead. It is far easier to criticise and destroy than to build.

* Abstract from the *Engineering Magazine*.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, June 19th.**

ROYAL INSTITUTION.

*9 p.m.* Friday Evening Discourse: "The Utilisation of Niagara," by Thomas C. Martin.

**THURSDAY, June 25th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*9 p.m.* Conversazione at the Royal Institute of Painters in Water Colours, 191, Piccadilly, W.

**FRIDAY, June 26th.**

PHYSICAL SOCIETY.

*5 p.m.* Meeting at Burlington House. Papers to be read: (1) "Admittance and Impedance," by F. Bedell; (2) "On the Properties of a Body of Negative Resistance," by Prof. S. P. Thompson; (3) "On Bare Wire Resistances," by H. F. Burstall.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

**The Institution of Civil Engineers.**—At the recent annual general meeting of this Institution, the report of the Council for the session 1895-96 was read and adopted. The tabular statement of transfers, elections, deaths and resignations during the year show an effective increase of 109 on the previous total of 5,921, while the number of students was, 847 as against 816 at the corresponding period of last year. The gross numbers on the books on March 31st in 1895 and 1896 were 6,737 and 6,907 respectively. The income during the twelve months ending March 31st was £21,779, the expenditure amounted to £53,334, including £35,936, capital mainly absorbed directly by the new building. In recognition of the merits of some of the Papers awards out of the funds appropriated to that purpose have been made amongst others to Capt. H. Riall Sankey, Prof. J. A. Ewing and Mr. H. F. Parshall.



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## HERO-WORSHIP.

Elsewhere in the present issue will be found reviews, from various standpoints, of the life's work of the Professor of Natural Philosophy in the University of Glasgow, and also a brief chronicle of the events which have marked the celebration of his professorial jubilee. Here, therefore, we need only put forward one or two reflections inspired by the incidents of Monday and Tuesday last. The distinguishing note of the two days' congratulatory chorus just concluded was deep and genuine affection. It was no mere formal tribute that was paid to Lord KELVIN. Admiration of a life devoted, with unsurpassed success, to physical science and its practical applications; pride in the world-famed achievements of a fellow townsman, a fellow countryman, a fellow investigator, were mingled with and often well-nigh obscured by the deeper sentiments generated by the personal magnetism of the man, generated by his force of character, by his unconquerable humility, by his unaffected simplicity of mind. "Moral qualities rule the world," as EMERSON has finely said. How many of the six hundred who were assembled on Tuesday evening in St. Andrew's Hall were capable of appraising at their proper worth the multitudinous contributions to pure and applied science which had been made during those fifty long years from 1846 to 1896 by the guest of the evening? And, even had everyone present been equal to the task, and fully conscious of how much poorer the civilised world of to-day would have been had a WILLIAM THOMSON never existed, we doubt if the gain in accurate appreciation thus accruing would have compensated for the absence of that affectionate regard which was inspired by considerations of a totally different order. But if science is to gain that firm hold upon the hearts and imaginations of the people, such as was rightfully

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the reward of the Church in its heroic days, it must do so mainly in virtue of the lovable personality of its leaders. Of one thing we may now be assured; the material triumphs of science, magnificent, beneficent as they are, will not suffice; indeed, there is such a complaint as a surfeit of marvels coupled with an uneasy sense of irritation arising from frequent vainglorious boasting of the many victories gained over the obscurantists. The mass of mankind, Board Schools, Voluntary Schools, Secondary Education, and University Extension notwithstanding, is hopelessly dull of mind; prone to believe that the cleansing vivifying stream of scientific conquest will continue to flow, even though the Republic guillotines its chemists; unable to apprehend that the world of the middle ages was not exactly a replica of the world of to-day or to comprehend that there is a systole-diastole action ever going on in the affairs of men which may, unless carefully regulated, lead to retrogression as easily as to progression.

Hence science has need of its heroes, and does well to honour them, and especially so to-day when innumerable little ripples of reaction threaten to coalesce into a single sweeping wave. The cold dry light of scientific truth is found inadequate for the needs of humanity, and in place thereof we have now much pseudo-scientific mystical imagining, and a plentiful crop of plausible arguments based on deceptive and irrelevant analogies. "Doth any man doubt," says Bacon, "that if there were taken out of men's minds vain opinions, flattering hopes, false valuations, imaginations as one would, and the like, but it would leave the minds of a number of men, poor shrunken things, full of melancholy and indisposition and unpleasing to themselves?" This, it would appear, is somewhat the state of affairs brought about by the implications of modern science, affording a very pretty opportunity for those antipathetic to the present search after the foundations of physical truth and knowledge to "just hint a fault and hesitate dislike," to depreciate the value of science and to throw doubts upon the desirability of its early inculcation, before the youthful mind has been rendered immune by time-honoured, oft tried, methods. In its bracing, never-ending struggle against forces of this peculiar kind science will derive more strength from the simple lives, single minded aims and lofty characters of its representative men than from the greatest victories won in fields remote from human sympathy and appreciation.

## THE KELVIN JUBILEE CELEBRATION.

Of the many happy results that flow from the vigorous well-ordered municipal life of a moderately-sized city, not the least is the enthusiasm with which its inhabitants do honour to its local gods. Had Lord Kelvin lived and laboured for half a century in London, his professorial Jubilee would no doubt have been duly honoured, and, in the upholsterer's sense of the word, in a more splendid style. But in London the celebration would have lacked the great feature which distinguished the festivities that have just taken place in Glasgow. All functions and ceremonies require the play of a little thought, of a little imagination, to render up their full meaning and significance; brilliant gatherings, long ceremonies, monster banquets are in themselves but symbols, and disappointing symbols sometimes. Now in the capital of the Empire, except on the most rare occasions, the atmosphere is not conducive to idealisation. By no stretch of the liveliest imagination can one figure to oneself the denizens of the "great wen" participating as a whole even in the spirit much less in the body, in a mere University, a mere scientific celebration. But in Glasgow the prominent part taken by the Corporation, the long articles in the papers—some most ably written, others in a light but kindly vein—the stir in and about and far from the ceremonial centres, all contributed to foster the idea that Glasgow as a whole was energetically bestirring itself to do honour to the world-famed, world-beloved Professor of Natural Philosophy, and was proud that others sought also to do likewise.

*Monday, June 15th.*

The first public event laid down in the programme jointly drawn up by the University and the Corporation was a *conversazione* in the Bute Hall on Monday evening. Glasgow University is fortunate in many things, and perhaps most of all in its magnificent site and building. Squalid, scattered buildings, hidden away as if the public were ashamed of them, and the objects to which they are devoted, are not calculated to foster that feeling of loyalty to one's *alma mater* without which so much is naught. But the Glasgow University buildings are outward and visible manifestations of the honour in which learning and research are held, and of the commanding position occupied by them in the minds of the dwellers by the Clyde. A *conversazione* is not, as a rule, an altogether satisfactory species of social function; indeed, the term would seem to be justifiable only on the *lucus a non lucendo* principle. The gathering at the University, however, was exceptional. No fewer than 2,500 persons filed slowly into the Bute Hall between half-past eight and 10 o'clock, being received at the entrance by the members of the Senate, and by the Lord Provost and magistrates, whilst, seated on a dais just inside the Hall, Lord and Lady Kelvin greeted those personally known to them. The chief attraction of the evening was in the library, where a fine array of Kelvin instruments was to be found, and where the officials of the Anglo-American Telegraph Company, the Commercial Cable Company and the Eastern Telegraph Company were busy sending and receiving congratulatory messages from all parts of the globe. The Anglo-American Company had arranged with the Post Office for special land-lines and, working automatic, sent messages direct to Heart's Content over their 1894 cable at the rate of about 110 letters a minute. One of the telegraphic feats of the evening was the despatch of a message of some 25 words from the Jubilee Committee to Lord Kelvin over a circuit more than 19,000 miles in length. This message, emanating from Glasgow, went direct to Heart's Content, thence to New York, Chicago, San Francisco, Los Angeles, New Orleans, Jacksonville (Florida), New York, Heart's Content, and thence home again. The time occupied in sending the original despatch was 7½min., Lord Kelvin's reply taking 4min. The Anglo-American Company also made a feature of the famous 1858 first message, which was repeated again and again from Valentia; they also exhibited the original mirror instrument and key used on the 1865 and 1866 cables. The Eastern Telegraph Company's show performance was a 108-word message despatch from Santiago (Chili) at 4:37 p.m. and received in the Bute Hall at 9:36 p.m., the actual time of transit being 16 minutes. This despatch passed over the lines of no less than five different companies—the West Coast of America Telegraph Company, the Pacific and European Telegraph Company, the Western and Brazilian Telegraph Company, the Brazilian Submarine Telegraph Company, the Eastern Telegraph Company. The Commercial Cable Company established practically a direct line between the Bute Hall and their New York office, thus placing Lord Kelvin in touch with a number of scientific Americans gathered there at the invitation of Mr. J. W. Mackay. Lord Kelvin's newest recorder was used at the Glasgow end for the occasion with conspicuous success. Lord Kelvin spent the greater part of the evening in the vicinity of the telegraph instruments gleefully sending and receiving despatches. The scene in the picturesque Bute Hall and in the Quadrangle was one likely to remain long in the minds of those who witnessed it, the profusion of quaint academic costumes giving the gathering a colour and a variety not often seen in these prosaic days.

*Tuesday, June 16th.*

On Tuesday morning the presentation of addresses by the delegates from English and foreign universities and scientific societies took place in the Bute Hall. The doors were opened at

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half-past nine, and a little before ten the long procession of delegates filed in, their robes presenting a wealth of colour which effectually lightened up the somewhat sombre interior of the hall. Exactly at ten o'clock the Senate, headed by Lord Kelvin, entered; the whole audience rising and cheering vociferously. Then began the great function of this historic Jubilee celebration. First of all a letter of congratulation from the Prince of Wales was read out, and then for more than one hour the delegates advanced in succession and presented their messages of goodwill. The majority of the delegates merely advanced to the dais, more or less gracefully bowed, handed Lord Kelvin the documents entrusted to them and precipitately retired. Here and there, however, a delegate was found sufficiently courageous to depart from this self-denying ordinance, and the impressive ceremony was thus redeemed from the slight suspicion of monotony which might otherwise have existed. Undoubtedly the most marked departure from uniformity was that made by Dr. John Hopkinson, who, as representing the Institution of Electrical Engineers, delivered a well-worded address in a most happy manner, prefacing it by a few well-chosen phrases. "The Institution of Electrical Engineers," said Dr. Hopkinson, "acknowledged Lord Kelvin in a very literal sence as the father of their profession. Lord Kelvin had done more, much more, than any other man in this or any land to place that profession in the honourable position it now occupied. The Institution had deputed him to present their address as a token of hearty love and esteem from his children" :—

We, the President, Council and members of the Institution of Electrical Engineers, desire hereby to offer to your Lordship our sincere and hearty congratulations on the occasion of the jubilee of your Professorship of Natural Science in the University of Glasgow. It will ever be a source of pride and satisfaction to this Institution that one who occupies so pre-eminent a position in the scientific world should have been its first President in 1889, besides having been an original member and President in 1874 of the same Association when it existed under the name of the Society of Telegraph Engineers. Not only have you contributed more than any other living man to our knowledge of the laws of Nature, but you have found time to perfect practical applications of science wherefrom every branch of the electrical engineering profession has derived special benefit. We desire, in conclusion, to express our fervent wish that you may continue for many years to enjoy the blessings of good health, and that science may still further benefit by your labours.—JOHN HOPKINSON (President), F. H WEBB (Secretary).

How well the assembled delegates represented the science of the world would be best gauged by a perusal of the illustrious names which figured in the long list of representatives; a brief enumeration of some of the names known more particularly to readers of *The Electrician* will, however, suffice :—

M. Lippmann (University of France), M. Henri Moissan (University of France), M. Picard (University of France), M. Mascart (College de France), who presented the Arago Medal of the Académie des Sciences to Lord Kelvin, M. Violle (École Normale Supérieure), Prof. Heinrich du Bois (University of Berlin), Prof. Quincke (University of Heidelberg), Prof. Woldemar Voigt (Royal Society of Science, Göttingen), Mr. T. C. Martin (National Electric Light Association, U.S.A.), Sir George G. Stokes and Prof. J. J. Thomson (Cambridge), Prof. Carey Foster and Sir Henry E. Roscoe (London), Prof. Oliver J. Lodge (Victoria University), Prof. Burdon Sanderson (Oxford), Prof. Andrew Gray and Principal J Viriamu Jones (University of Wales), Prof. Stroud (Yorkshire College), Prof. W. G. Adams (King's College), Prof. Ramsay (University College), Prof. Osborne Reynolds (Owens College), Sir Frederick Abel (Society of Arts), Mr. A. A. Common (Royal Astronomical Society), Prof. A. W. Rücker (British Association), Prof. John M. Thomson (Chemical Society), Sir Benjamin Baker (Institution of Civil Engineers), Dr. John Hopkinson (Institution of Electrical Engineers), Major P. A. MacMahon (Mathematical Society), Captain W. de W. Abney (Physical Society), Sir Joseph Lister (Royal Society), Prof. Schuster (Manchester Literary and Philosophical Society), Prof. Silvanus Thompson (Finsbury Technical College) and Mr. H. A. C. Saunders (Eastern, Brazilian Submarine, and allied cable companies). Amongst those who were present, and assisted in the Jubilee proceedings, we may mention Prof. Cleveland Abbe (Weather Bureau, Washington), Prof. Roberts-Austen, Prof. Ayrton, Prof. G. H. Darwin, Prof. James Dewar, Prof. J. A. Ewing, Lord Rayleigh, Prof. G. F. Fitzgerald, Dr. Gladstone, Prof. Alex. B. W. Kennedy, Prof. Perry, Mr. W. H. Preece, and Prof. W. A. Tilden.

The presentation of the addresses having been brought to a close, Prof. Moody Stuart next, amid prolonged applause, presented Lord Kelvin for the degree of Doctor of Laws. The ceremony of capping was performed by Prof. Gairdner, amidst a renewed outburst of cheering. Lord Kelvin then took the chair as senior professor in the University, and proceeded to confer honorary degrees on Prof. Cleveland Abbe, Prof. Christian Christiansen (Copenhagen), Prof. Per Theodor Cleve (of Upsala), His Excellency Gen. Annibale Ferrero, Ambassador to this country from His Majesty the King of Italy, Prof. Izidor Fröhlich (of the University of Buda Pesth), M. Lippmann (of the Sorbonne), Prof. Archibald Liversidge (of the University of Sydney, New South Wales), M. Mascart, M. Henri Moissan, Prof. Simon Newcomb (of Johns Hopkins University, Baltimore), Prof. Nikolai Aleksejevich Oumou, M. Picard, Prof. Georg Quincke, and Prof. Woldemar Voigt.

The long ceremony was then concluded by an affecting address from Lord Kelvin, listened to with breathless attention by the immense audience :—

The University of Glasgow is honoured by the presence to-day of many distinguished visitors from foreign countries, from America, from India, from Australia, and from all parts of the United Kingdom. Names of men renowned for their scientific work in distant countries have been added to our list of honorary graduates. That I have had the honour of conferring these degrees in the name of the University is a subject of keenest regret to all here present, because it is due to the absence of Principal Caird on account of illness. We hope that the beginning of next session will see him at home in the University with thoroughly recovered health. In his absence the duty of conferring degrees has fallen, according to university law, on me as senior professor present. I am also one of the recipients of the degree, and, in the name of all who have to-day been created Doctors of Laws of the University of Glasgow, I thank the Senate for the honour which we have thus received on the occasion of the jubilee of my professorship. For myself, I can find no words to express my feelings on this occasion. My 50 happy years of life and work as Professor of Natural Philosophy here, among my students and my colleagues of the University and my many kind friends in the great city of Glasgow, call for gratitude: I cannot think of them without heartfelt gratitude. But now you heap coals of fire on my head. You reward me for having enjoyed for 50 years the privilege of spending my time on the work most congenial to me and in the happiest of surroundings. You could not do more for me if I had spent my life in hardships and dangers, fighting for my country, or struggling to do good among the masses of our population, or working for the benefit of the *people* in public duty voluntarily accepted. I have had the honour to receive here to day a gracious message from His Royal Highness the Prince of Wales and addresses from sister universities in all parts of the world; from learned societies, academies, associations, and institutions for the advancement of pure and applied science: from municipal corporations and other public bodies: from submarine telegraph companies, and from their officers, my old comrades in their work; from students, professors, and scientific workers of England, Scotland, and Ireland and other countries, including my revered and loved St. Peter's College, Cambridge, and my twenty Baltimore coefficients of 1884. The term coefficients is abused by mathematicians. They use it for one of the two factors of the result. To me the professor and his class of students are coefficients, fellow-workers, each contributing to whatever can possibly be done by their daily meetings together. I dislike the term lecturer applied here. I prefer the French expression—"*conference*." I feel that every meeting of a professor with his students is rather a conference than a pumping in of doctrine from the professor, perhaps ill understood and not well received by his students. The Scottish universities have enabled us to carry out this French idea of conference. I think in every one of his classes the professor is accustomed to speak to his student sometimes in the form of *viva voce* examination, and oftener, I hope, in the manner of interchange of thoughts, the professor discovering whether or not the student is following his lecture, and the student pointing out his own view on the subject, and helping the professor through his treatment of the subject. I have had addresses also from my old Japanese students of Glasgow University, now professors in the University of Tokyo, or occupying posts in the Civil Service and Engineering Service of Japan. I wish particularly to thank my Baltimore coefficients for their address. They have been useful to myself in my own keen endeavour—unsuccessful, I must say—nevertheless keen—to find out something about—to know something about—light and ether and crystals. The addresses which I have received to-day contain liberal and friendly appreciation of all my published mathematical and physical Papers, beginning in 1840, and ending—not yet, I hope. The small proportion of that long series of writings which has led to some definite advancement of science is amply credited for its results. The larger part, for which so much cannot be said, is treated with unfailing and sympathetic kindness as a record of persevering endeavour to see below the surface of matter. It has been carried on in the faith that the time is to come when much that is now dark in physical science shall be seen bright and clear, if not by ourselves, by our successors in the work. I am much gratified by the generous manner in which these addresses have referred to the practical applications of science in my work for submarine telegraphy: my contributions to the advancement of theoretical and practical knowledge of the tides; my improvements in the oldest and next oldest of scientific aids to navigation, the sounding plummet and the mariner's compass, and my electric measuring instruments for scientific laboratories, for the observation of atmospheric electricity and for electrical engineering. I now ask the distinguished men who have honoured me by presenting to me these addresses to accept for themselves personally, and for the societies represented by them, my warmest thanks for the great treasure which I have thus received—good-will, kindness, friendship, sympathy, encouragement for more work—a treasure of which no words can adequately describe the value. I thank all present in this great assembly for their kindness, which touches me deeply, and I thank the city and University of Glasgow for the crowning honour of my life which they have conferred on me by holding a commemoration of the jubilee of my professorship.

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On Tuesday evening the jubilee festivities terminated with a banquet in the St. Andrew's Hall. Some 600 were present, the Lord Provost presided, and the entertainment was marked, as indeed were all the functions connected with this memorable celebration, by the excellence of the arrangements. Before commencing the toast list the Lord Provost read a thoughtful telegram from the Queen, which was received with enthusiastic applause. Of the many speeches to which the audience were treated we will content ourselves with one only, *the* speech of the evening in every sense of the term; every word was heard all over the huge hall, and every allusion, pathetic or humorous, was instantly appreciated. When the Lord Provost proposed the toast of Lord Kelvin the whole gathering rose to their feet, cheering as only Englishmen know how, waving their handkerchiefs and clapping their hands, almost drowning the loud strains of the organ; a demonstration of love, veneration and enthusiasm which was repeated when Lord Kelvin brought his much too brief reply to a close:—

My Lord Provost, your Excellency, my Lords, and gentlemen,—First of all, I desire to express the deep and heartfelt gratitude with which I have heard the most kind and gracious message from Her Majesty the Queen, which has been read to us by the Lord Provost. But I cannot find words for thanks. I can only, on the part of Lady Kelvin and myself, tender an expression of our loving loyalty to the Queen. My Lord Provost, my Lords, and gentlemen, I thank you with my whole heart for your kindness to me this evening. You have come here to commemorate the jubilee of my University Professorship, and I am deeply sensible of the warm sympathy with which you have received the kind expressions of the Lord Provost regarding myself in his review of my 50 years' service, and his most friendly appreciation of the practical results which have come from my scientific work. I might perhaps rightly feel pride in knowing that the University and City of Glasgow have joined in conferring on me the great honour of holding this jubilee, and that so many friends and so many distinguished men, friends and comrades — day-labourers in science,—have come from near and far to assist in its celebration, and that congratulations and good wishes have poured in on me by letter and telegram from all parts of the world. I do feel profoundly grateful. But when I think how infinitely little is all that I have done I cannot feel pride; I only see the great kindness of my scientific comrades, and of all my friends, in crediting me for so much. One word characterises the most strenuous of the efforts for the advancement of science that I have made perseveringly during 55 years; that word is failure. I know no more of electric and magnetic force or of the relation between ether, electricity, and ponderable matter, or of chemical affinity, than I knew and tried to teach to my students of natural philosophy 50 years ago in my first session as professor. Something of sadness must come of failure; but in the pursuit of science, inborn necessity to make the effort brings with it much of the *certaminis gaudia*, and saves the naturalist from being wholly miserable, perhaps even allows him to be fairly happy, in his daily work. And what splendid compensations for philosophical failures we have had in the admirable discoveries by observation and experiment on the properties of matter, and in the exquisitely beneficent applications of science to the use of mankind with which these 50 years have so abounded! You, my Lord Provost, have remarked that I have had the good fortune to remain for 50 years in one post. I cordially reply that for me they have been happy years. I cannot forget that the happiness of Glasgow University, both for students and professors, is largely due to the friendly and genial city of Glasgow in the midst of which it lives. To live among friends is the primary essential of happiness; and that, my memory tells me, we inhabitants of the University have enjoyed since I first came to live in it in 1832, 64 years ago! And when friendly neighbours confer material benefits, such as the citizens of Glasgow have conferred on their University in so largely helping to give it its present beautiful site and buildings, the debt of happiness due to them is notably increased. I do not forget the charms of the old college in the High Street and Vennel, not very far from the comforts of the Saltmarket. Indeed, I remember well when, in 1839, the old Natural Philosophy class-room and apparatus-room (no physical laboratory then) was almost an earthly paradise to my youthful mind. And the old College Green, with the ideal memories of Osbaldiston and Rashleigh, and their duel, created for it by Sir Walter Scott, was attractive and refreshing to the end. But density of smoke and of crowded population in the adjoining lanes increased, and pleasantness, healthiness, and convenience of the old college, both for students and professor, diminished year by year. If, my Lord Provost, your predecessors of the Town Council, and the citizens of Glasgow, and well wishers to the city and its University all over the world, and the Government, and the great railway company that has taken the old college, had left us undisturbed on our ancient site, and had not given us our new college in return for a passenger and goods station, I do not believe that attractions elsewhere would have taken me away from the old college; but I do say that the 50 years of professorship which I have enjoyed would have been less bright and happy, and I believe also less effective in respect to scientific work, than they have been with the great advantages with which the University of Glasgow has been endowed since its migration from the High Street. My Lord Provost, I ask you to communicate to your colleagues of the Town Council my warmest thanks for their great kindness to me in joining to celebrate this jubilee. Your Excellency, my Lords, and gentlemen, I thank you all for the kind manner in which you have received the toast of my health proposed by the Lord Provost, and for your presence this evening to express your good wishes for myself.

And with these words this inadequate chronicle must end. It was a jubilee unique in character, and worthy of one who has not been content to spend his life "beholding the bright countenance of truth in the quiet and still air of delightful studies," but has come down boldly into the dusty arena where in these days can the "immortal garland" alone be fairly won.

## THE LANGDON DAVIES ALTERNATE-CURRENT MOTOR.

The importance of a self-starting single-phase alternate-current motor has been appreciated far and wide, and many have been the attempts to design a successful machine. Hitherto, however, the efficiency has been low even at full load, the power factor small, causing an excessive idle current, and the starting torque insignificant. Also the means of obtaining the split current have not always been very practical.

Mr. Langdon Davies has materially advanced the design of this class of motor, although he does not appear to have overcome the difficulty of a low-power factor, *vide* Prof. Silvanus P. Thompson's tests, which are appended. The improvements, however, are sufficiently marked in respect of starting torque and efficiency to make the motor eminently suitable for many purposes in which the idle current is not a serious objection.

The improvements invented and patented by Mr. Langdon Davies are covered by patents No. 19,364, 1894, and No. 18,870, 1895. The first refers chiefly to a method by which

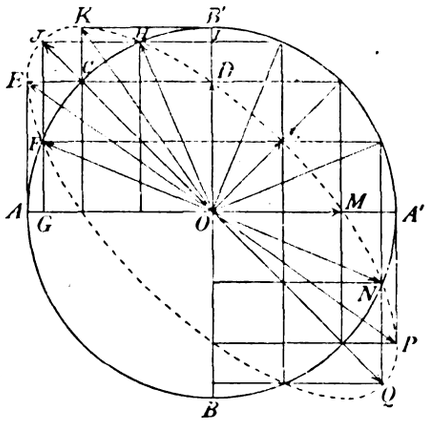


FIG. 1A.

a single-phase alternate current may be made to produce a rotary field suitable for a self-starting alternate-current motor and also suitable for a transformer the function of which is to transform a single-phase current into two approximately equal currents differing from one another in phase. In the second specification means are detailed by which the greatest possible starting moment may be attained in a motor and the greatest possible efficiency in a transformer by maintaining the rotating magnetic field at constant strength and causing it to revolve as nearly as possible uniformly.

The improvements embodied consist mainly in the following modifications of existing designs. In the first place, Mr. Langdon Davies has demonstrated the general law that when the axes of two simple harmonic fields are inclined to one another at an angle which is the supplement of the phase angle between the two respective fields, they produce a constant and uniformly rotating resultant field. In a two-phase motor, for example, the two sets of coils are placed at right angles to each, and the two currents are in quadrature, *i.e.*, at 180deg. – 90deg. It is well known that under these conditions the resulting magnetic field is practically uniform, both as regards intensity and rate of rotation. It is not practicable at present to split a single-phase alternate current into two branches with a phase difference of 90deg., although it is comparatively easy to accomplish a phase difference of 45deg. Now if such a split current be supplied to two sets of coils wound at right angles to each other, the resultant rotating field will not be uniform.

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This is shown in Fig. 1A, in which AA′ and BB′ are the two axes of the coils, and the lines OF, OE, OJ, OK, OH, OD, &c., show the magnitude and direction of the resultant field at intervals of $\frac{1}{16}$th of a period. Examining the ellipse which bounds the line representing the intensity of the resultant field, it is seen that the strength varies, and that the angular advance is not uniform.

In Fig 1B is shown the improved method of arranging the coils in the Langdon Davies motor. The two axes of the field windings are inclined to each other at an angle of 180deg. – 45deg, that is, the supplement of the phase angle between the component fields (taken as before at 45deg.). Following out the construction it will be seen that the curve joining the lines OE, OJ, OK, &c., is a circle. The resultant magnetic field is therefore of constant magnitude, and moreover it has a constant angular advance.

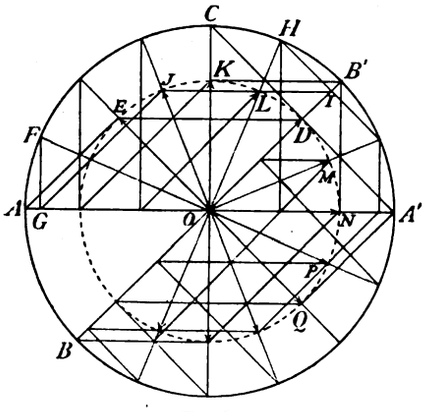


FIG. 1B.

In the second place, Mr. Langdon Davies has found that it is impossible to distribute the magnetic field in an alternate-current motor as usually constructed with squirrel-cage armature and small air-gap. This is shown in Fig. 1. which indicates the results obtained from tests made with iron filings. In fact, without going into figures, it is clear that, with a single coil of wire wound across a diameter, there will be a constant magnetomotive force acting in the central space, and the reluctance will be greatest in the centre and least at the edges. It follows, therefore, that the magnetic field will be densest at the edges, *i.e.*, near to the winding

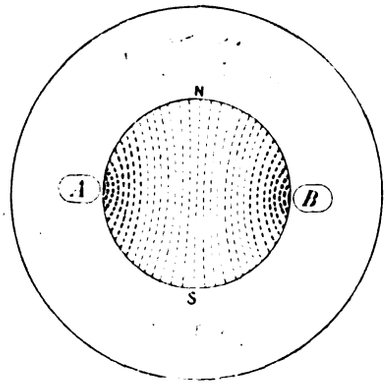


FIG. 1.

holes in the iron cores. Also, when two such fields are combined, as in Fig. 2, the resultant field cannot be uniform, no matter how the two coils be set or how the phases be arranged. In the improved motor the windings are distributed so as to compensate for the varying reluctances of the central space. For example, in Fig. 3, which shows the method of winding for a two-pole machine, a portion only of the winding is threaded through the holes A B, whilst another portion is threaded through C D, another through E F, &c. The several windings vary the magnetomotive force in proportion to the reluctance. The dotted lines show the directions taken by the windings in passing from hole to hole.

The number of the sections into which the winding is divided varies in accordance with the size of the motor. Three divisions are sufficient for the smallest class of two-pole motors, four or more sections for larger two-pole motors. The split current with a phase difference of 45deg. between the two branches is obtained in the smaller motors by placing a non-inductive resistance in series with one of them and making the ampere-turns in each the same.

The method by which the windings are designed for various phase differences depends upon the following conditions, which have been determined by Mr. Langdon Davies. They find that when a set of coils are wound upon the same or similar cores, so as to have equal ampere-turns at the same impressed volts, that—

1. The turns in the several coils are equal to the sine of the angle through which the current in each coil lags, multiplied by a constant; thus, if T = the number of turns in a coil,

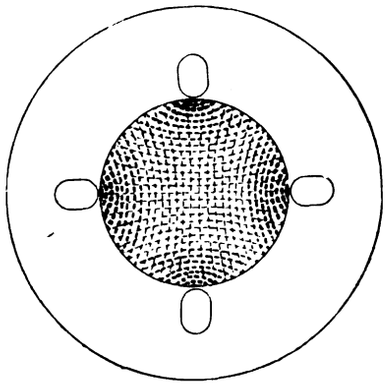

FIG. 2.

the current in which lags through any angle $\phi$, then $T = a \sin \phi$, where $a$ is a figure which remains constant for all the coils.

2. The resistance of each coil is equal to the sine of the angle of lag, multiplied by the cosine of the same angle, multiplied by E, multiplied by the constant $a$, and divided by the ampere turns, that is to say—

$$R = \frac{E\, a \sin \phi \cos \phi}{z},$$

where E = the volts, and $z$ = the ampere-turns.

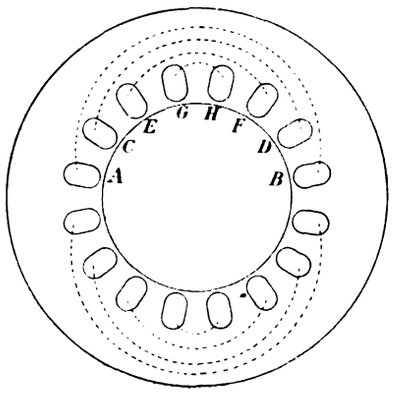


FIG. 3.

3. The current which will flow in the coils is equal to the ampere-turns divided by the sine of the angle of lag, multiplied by the constant, that is to say—

$$C = \frac{z}{a \sin \phi},$$

where C = current in amperes.

The rule by which the turns in the several sections are proportioned is the following:—

Draw a figure, such as Fig. 3A, in which the points A, B, C, D, E, F, G, H, on the circumference of a circle, correspond to the equally-spaced holes similarly lettered in Fig. 3.

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Bisect the intervals between the holes in points 1, 2, 3, 4, and 5, marked on the circle.

From the neutral point 1 draw a radius, and from the point 5 at the centre of the polar surface draw another radius; they meet at the centre O in a right angle.

Draw a line 2, 6, so that the angles at 6 are right angles.

Draw right angles 6, 2, 7—2, 7, 3—7, 3, 8—3, 8, 4—and 8, 4, 9.

Then the lengths of the lines 2, 6—3, 7—4, 8, and 5, 9 represent and are proportional to the numbers of turns which should be wound through the holes A B, C D, E F, and G H respectively.

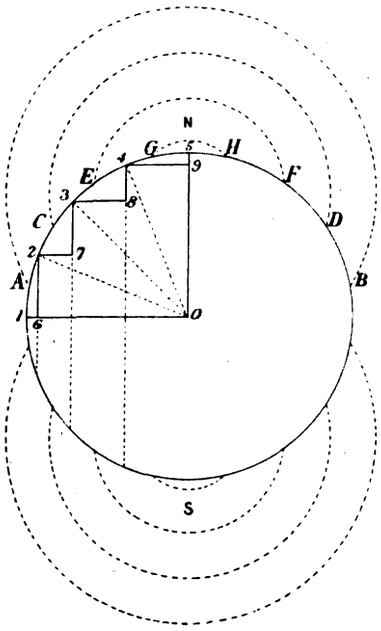


FIG. 3A

Thus, for example, if the winding through A B is 19 turns, then the winding through C D will be 16 turns, through E F will be 10 turns, and through G H will be 5 turns, these being the nearest whole numbers. The advantages of fractional parts are given to the winding G H.

The calculation is similar when the number of sections is less or greater than four.

The rule given above is readily deduced from the fact that the reluctance of two paths represented in Fig. 5 by lines $y$ and $z$ varies approximately as the sines of the angles Y and

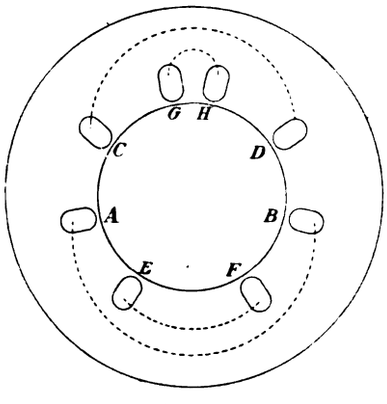


FIG. 4.

Z. It is therefore necessary to apply a proportionately greater magnetomotive force about $z$ than about $y$.

It will be observed that neutral intervals occur between the upper and the lower windings; it is expedient to provide in this manner for neutral areas between the polar surfaces.

When the total number of turns to be wound on is but small, sufficient accuracy cannot be obtained with equally-spaced holes, and it is then preferable to wind an equal number of turns in each section, and to vary the distances between the holes.

Such a field magnet may be set out in the manner shown in Fig. 6, the diameter of the armature space coinciding with

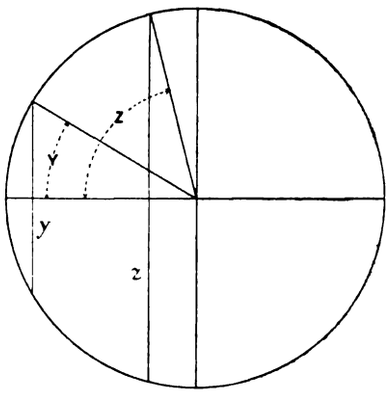


FIG. 5.

the axis of the field is divided into twice as many parts as there are coils to be wound (in this case 16). At right angles to the axis of the field are drawn parallel lines through the points 2, 4—6, 8, 10, 12, 14, 16, cutting the diameter of the armature space. Through the points where these lines cut the

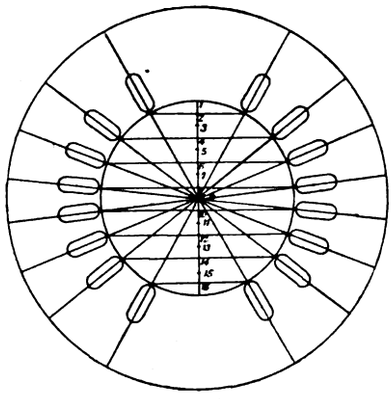

FIG. 6.

diameter are drawn radii, and the holes for winding are punched upon these radii; as shown, these holes are bisected by the radii.

In a similar manner a cylindrical magnet core can be wound so as to obtain four or more poles. Fig. 7 shows a cylinder prepared to receive a four-pole winding.

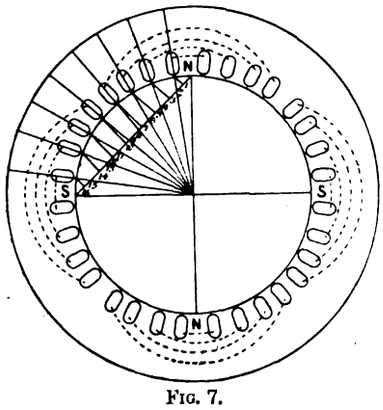


FIG. 7.

In the case of a four-pole magnet, when the holes are equally spaced and the number of turns on the coils differs from one another as in Fig. 3, a diagram such as Fig. 7A has to be drawn to determine the proportions to be given to the several sections of the windings.

It is very similar to Fig. 3A, but the radii 5—0 and 0—1, meet in an angle of 45deg.; in other respects the description of Fig. 3A applies.



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So far the particulars apply to windings for obtaining one uniform field. To yield a uniform rotating field a second

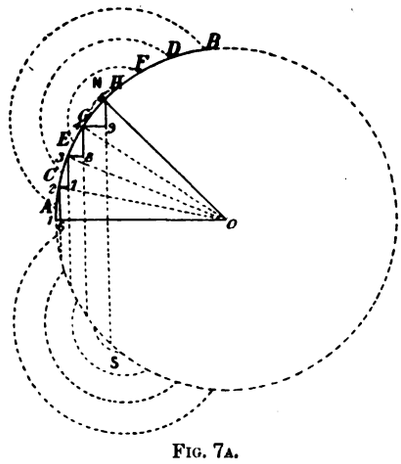


Fig. 7a.

winding is required separated from the first winding by an angular distance dependent on the difference of phase in the two windings, as already explained. The second winding can

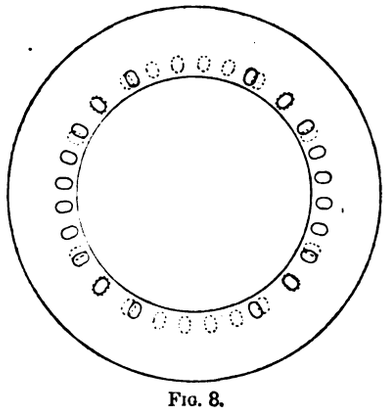

Fig. 8.

be applied over the first, using the same holes or some of them to accommodate both the windings. Thus in Fig. 8 the full lines show a cylinder set out with holes for winding, as in Fig. 6, except that in this case the windings are to be each in five sections.

The dotted lines show where the holes repeat at 90deg. distance from the holes represented by the full lines. The phase difference between the currents in the coils is in this case assumed to be 90deg. It is obviously impracticable

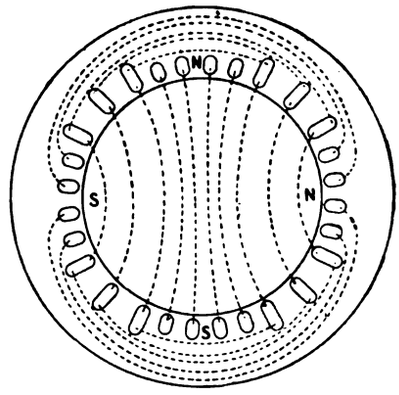


Fig. 9.

to punch the double set of holes as they occur in this diagram. Fig. 9 shows the arrangement of holes suitable to receive two windings, the one over the other and at right angles.

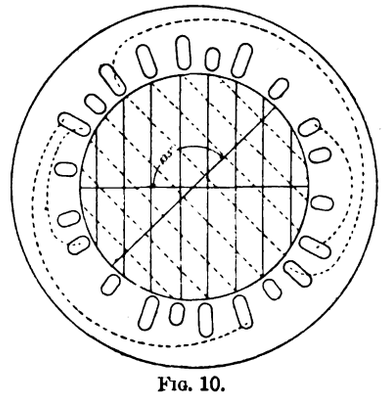

Fig. 10.

The dotted lines crossing the central space represent diagrammatically one pair of windings, and the dotted lines outside the central space represent the other pair of windings.

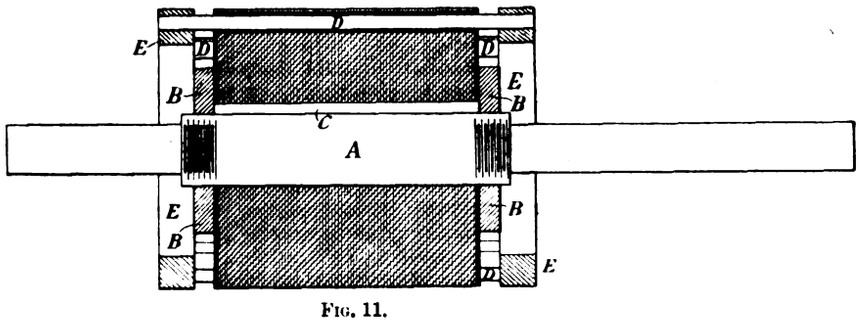


Fig. 11.

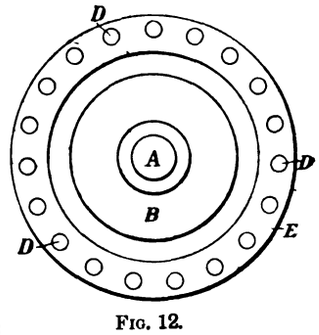


Fig. 12.

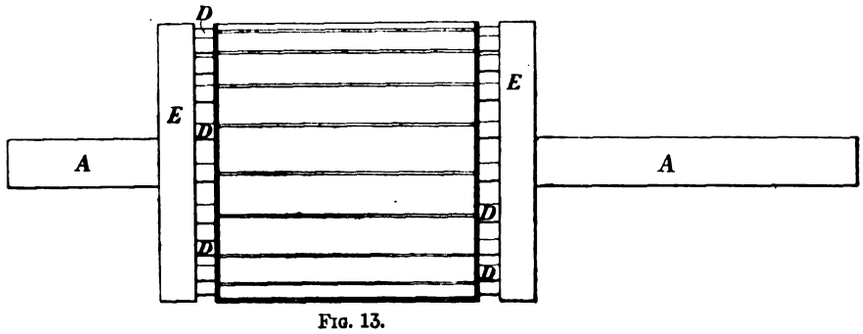


Fig. 13.

Fig. 10 shows the arrangement which is suitable for a motor in which the difference of phase in the two component fields is 45deg., and in which the current in the two coils is

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derived from the same source, the coils being adjusted to equal ampere-turns in the manner already described.

Figs. 11, 12 and 13 show the squirrel-cage rotor which is suitable for use with field magnets such as herein described; it consists of a series of iron discs threaded upon a shaft, A, and clamped fast between screw nuts, B. A feather, C, prevents the discs from turning on the shaft. A series of copper rods, D, are passed through the discs, and at their ends are fixed into massive copper rings, E. Saw cuts are made in the edges of the discs parallel to the axis, and penetrating into the holes which receive the copper rods. These slits are seen in Fig. 13. The thick black lines in Fig. 11 indicate insulating material.

Fig. 14, which is taken from a photo, shows the general appearance and construction of the Langdon Davies motor.

The power given out by the motor was measured by a Raffard brake adapted to absorb several horse-power. The friction at the bearings of this brake was found to be rather unduly large owing to the worn state of the bushes; and a preliminary trial showed that no less than 148 watts, or about one-fifth horse-power, was absorbed thereby when the motor was running idle at a speed of 2,365 revolutions per minute. The power measurements made on the brake had therefore to be increased by crediting to them a corresponding allowance in lieu of any more direct measurements of the total output of power.

It will be seen that the slip of the field when the motor was running light was only 16 revolutions out of 2,568, and at two-thirds load it was only 5½ per cent. The efficiency was excellent, better indeed than that obtainable with a

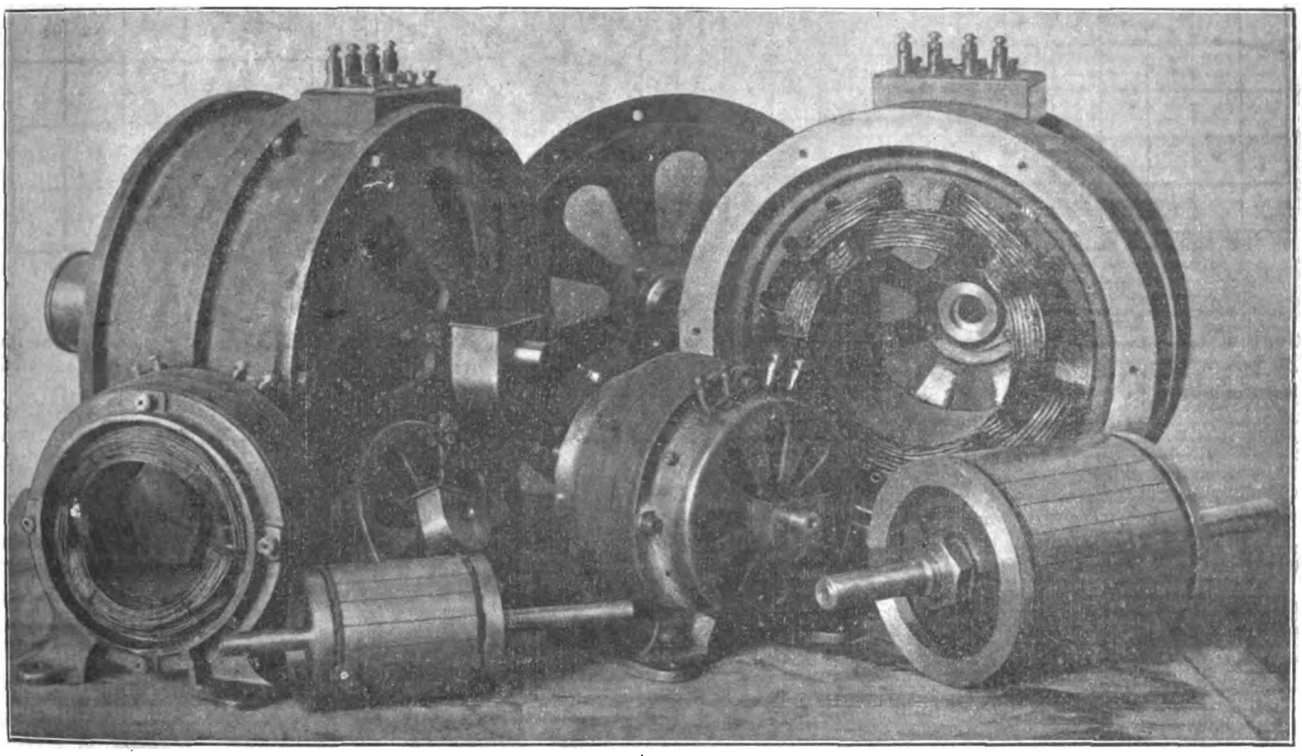

FIG. 14.

Prof. Silvanus P. Thompson has reported favourably on these motors. He says, "They attain advantages hitherto only fully realised by the two-phase and three-phase systems of currents." Two motors were tested by the Professor, a four-pole machine weighing 125lbs. and giving ¾ B.H.P. at from 2,550 to 2,250 revolutions per minute, and a smaller two-pole machine giving 1/16 B.H.P. at about 4,500 revolutions per minute. The tabulated figures of the first test are as follows:—

continuous-current motor of the same dimensions. The starting torque, although not so large as that obtainable with continuous currents, was sufficient for most purposes. A test made on a motor of the same size and type as that tested by Prof. Thompson gave results shown in the curve in Fig. 15.

The power factor, which has already been mentioned as the weak point of this otherwise excellent motor, varied from 0·19

| Brake load. | Speed | B. Power H.P. | B. Power + correction. H.P. | T'rque (pound feet.) | Volts. | Amp. | Amp. reading. | Appar'nt power. (Watts.) | Watt meter r'ading | True power Watts | True power E.H.P. | Power factor. | Efficiency % | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brake unconnected ..... | 2,552 | ... | ... | ... | 99·5 | 8·4 | 6·5 | 819·0 | 4·0 | 161·0 | 0·21 | 0·19 | ... | Speed of field, 2568. |
| Friction of brake bearing and coupling only ..... | 2,369 | ... | ... | ... | 100·3 | 9·2 | 8·0 | 924·5 | 6·75 | 271·7 | 0·36 | 0·29 | ... | ∴ Slip at zero load 1½ per cent. |
| | 2,361 | .. | ... | ... | 100·1 | 9·5 | 8·5 | 951·3 | 6·75 | 271·7 | 0·36 | 0·28 | .. | |
| Two pounds ..... | 2,540 | 0·246 | 0·394 | 0·508 | 99·75 | 9·5 | 8·5 | 948·0 | 10·0 | 402·5 | 0·54 | 0·42 | 73·0 | ... |
| | 2,500 | 0·241 | 0·389 | ... | 98·75 | 9·2 | 8·0 | 910·0 | 9·5 | 382·4 | 0·51 | 8·42 | 76·3 | ... |
| Three pounds ..... | 2,450 | 0·355 | 0·503 | 0·762 | 100·0 | 10·3 | 10·0 | 1,030·0 | 10·0 | 402·5 | 0·54 | 0·39 | 93·1 | ... |
| | 2,330 | 0·338 | 0·486 | ... | 100·5 | 9·8 | 9·0 | 982·6 | 9·5 | 382·4 | 0·512 | 0·38 | 91·5 | ... |
| | 2,330 | 0·338 | 0·486 | ... | 100·0 | 10·3 | 10·0 | 1,030·0 | 9·5 | 382·4 | 0·512 | 0·37 | 91·5 | ... |
| Four pounds..... | 2,270 | 0·439 | 0·587 | 1·016 | 99·75 | 11·5 | 12·5 | 1,149·0 | 12·5 | 503·1 | 0·674 | 0·44 | 94·2 | Speed of field 2,409 slip at ⅔ load ∴ about 5½% |
| | 2,280 | 0·441 | 0·589 | ... | 99·0 | 11·75 | 13·0 | 1,163·0 | 12·5 | 503·1 | 0·674 | 0·43 | 94·3 | |
| Five pounds ..... ..... | 2,310 | 0·558 | 0·706 | 1·270 | 99·5 | 11·9 | 13·5 | 1,191·0 | 13·5 | 543·4 | 0·728 | 0·45 | 96·9 | Considerable vibration of brake. |
| | 2,315 | 0·559 | 0·707 | ... | 99·0 | 12·2 | 14·0 | 1,207·0 | 14·0 | 563·5 | 0·755 | 0·46 | 93·6 | |
| Six pounds ..... | 2,287 | 0·663 | 0·811 | 1·524 | 99·5 | 14·2 | 19·0 | 1,414·0 | 15·5 | 623·8 | 0·836 | 0·44 | 95·9 | ... |
| | 2,280 | 0·662 | 0·810 | ... | 99·25 | 14·2 | 19·0 | 1,410·0 | 15·5 | 623·8 | 0·836 | 0·44 | 95·9 | ... |
| Six and a-half pounds..... | 2,258 | 0·709 | 0·857 | 1·651 | 99·5 | 15·6 | 23·0 | 1,555·0 | 17·0 | 684·2 | 0·917 | 0·44 | 93·4 | ... |
| | 2,240 | 0·704 | 0·852 | .. | 99·25 | 15·8 | 23·5 | 1,568·0 | 17·0 | 684·2 | 0·917 | 0·43 | 92·9 | ... |
| | 2,258 | 0·709 | 0·857 | ... | 99 5 | 15·5 | 22·5 | 1,538·0 | 18·0 | 724·5 | 0·971 | 0·47 | 88·2 | ... |
| Seven pounds ..... | 2,252 | 0·707 | 0·855 | ... | 99·75 | 15·3 | 22·0 | 1,525·0 | 17·5 | 704·4 | 0·944 | 0·46 | 90·5 | ... |
| | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | Motor pulled up. |



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to 0·47 at about full load. We are sorry to find no comment on this in the report.

Mr. Langdon Davies informs us that the power factor is affected considerably by apparently small details. For example, the width of the slots in the stators and rotors, and the width of the air gap require to be made exactly to the calculated dimensions. This is illustrated in Fig. 16, the curves in which show the variations of power factors in machines of the same size and made to the same drawings without paying sufficient

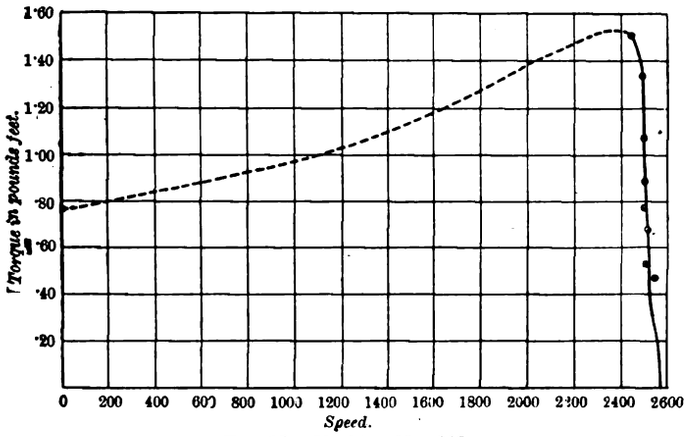



Fig. 15.—Machine No. 118.

attention to the exact dimensions of the slots and gaps. The power factor is also affected by the number of bars in the rotor and by the number of sections per pole in the stator windings. These facts being duly appreciated it is evident that much better results are possible. In a recent motor, designed to test this point, Mr. Davies has obtained a power factor of 0·715 for an output of 0·623 B.H.P. The idle currents would not be serious in such a small motor.

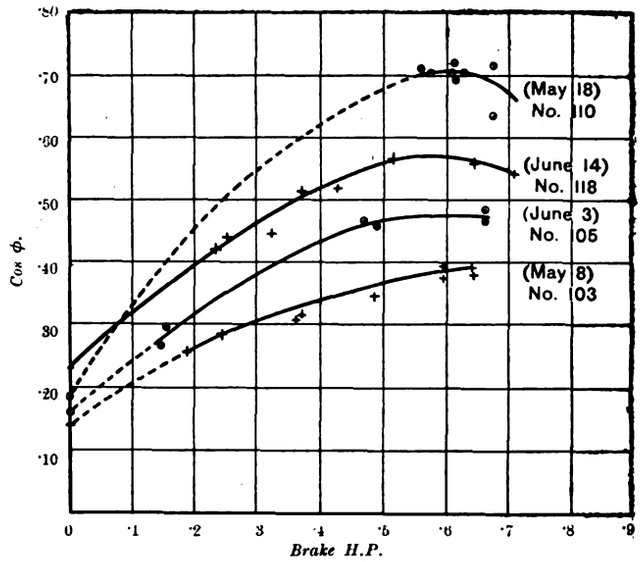
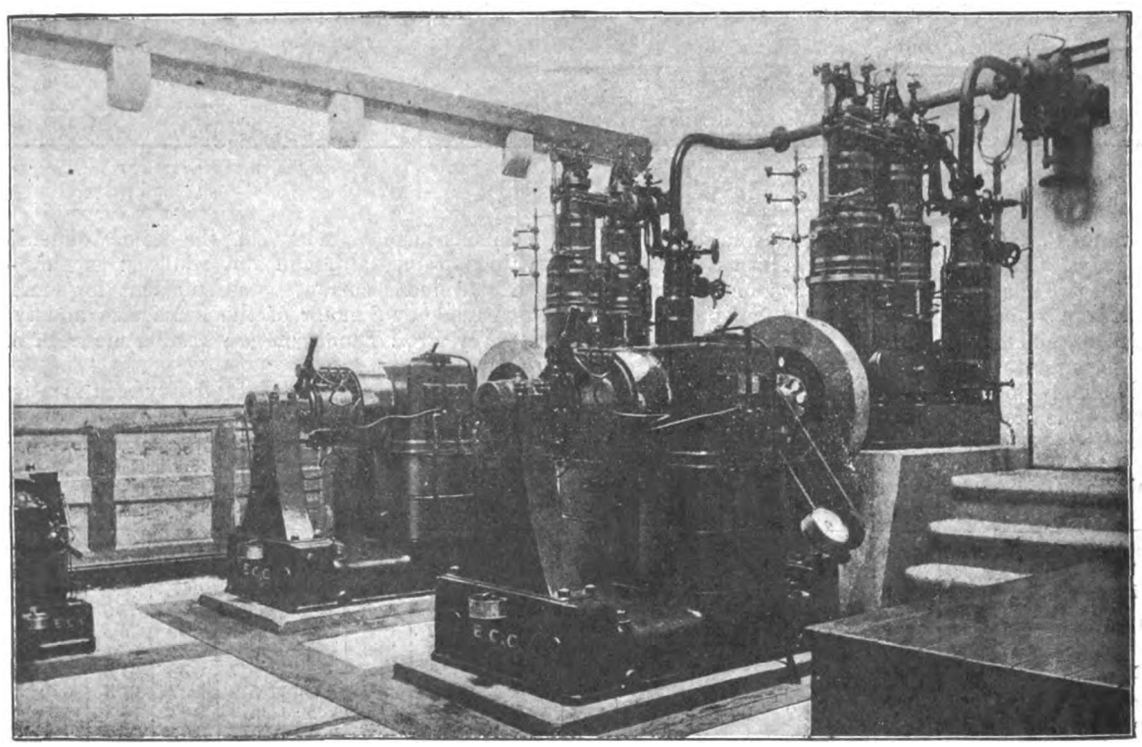



Fig. 16.

It is clear that before alternate-current motors can be used largely on central-station supply mains, the power factor will have to be improved.

## HARTLEPOOLS ELECTRIC TRAMWAYS.

The electrical equipment of this line has been carried out by the Electric Construction Company, on behalf of the General Electric Tramways Company. The inspection on behalf of the Board of Trade was made by Major Cardew and Colonel Yorke on May 14th, when the general arrangements were approved, and the line was opened for public service on May 19th. The original line was laid in 1884, and was worked by steam until 1891, when, falling into a derelict condition, it was closed. The rights were acquired early in 1895 by the General Electric Tramways Company for the purpose of equipment on the overhead system.



View of Generating Station.

The total length of the line which joins the two Hartlepools is 2½ miles. The entire roadway has been repaired by lifting the rails, rebedding them on concrete, and relaying the pave-

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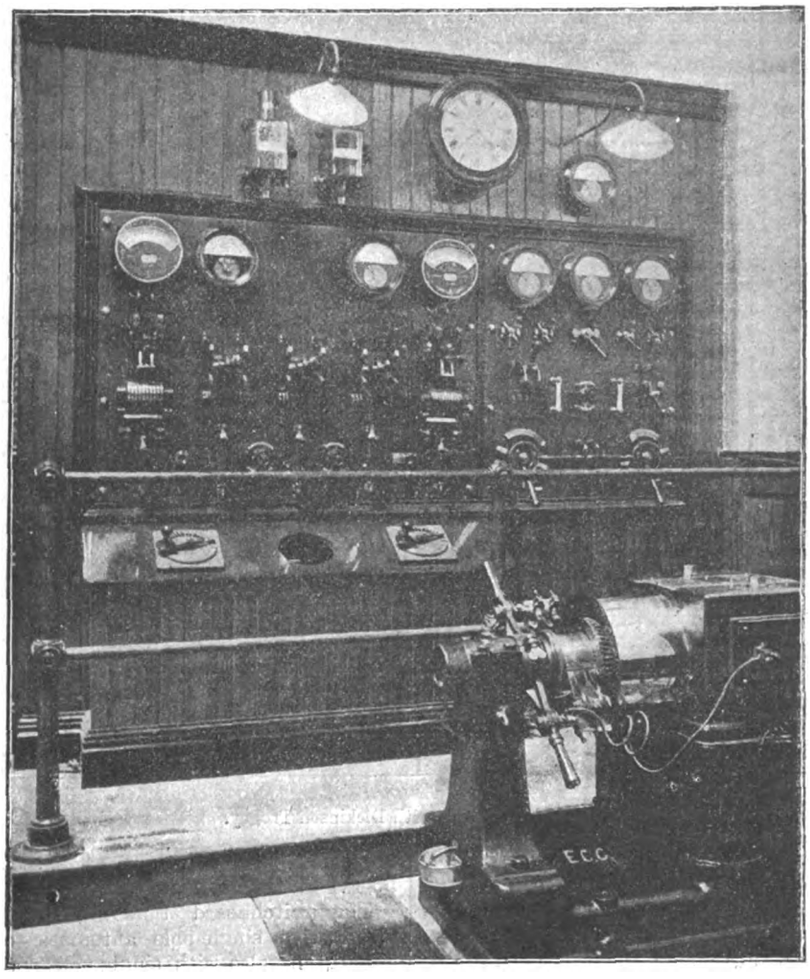
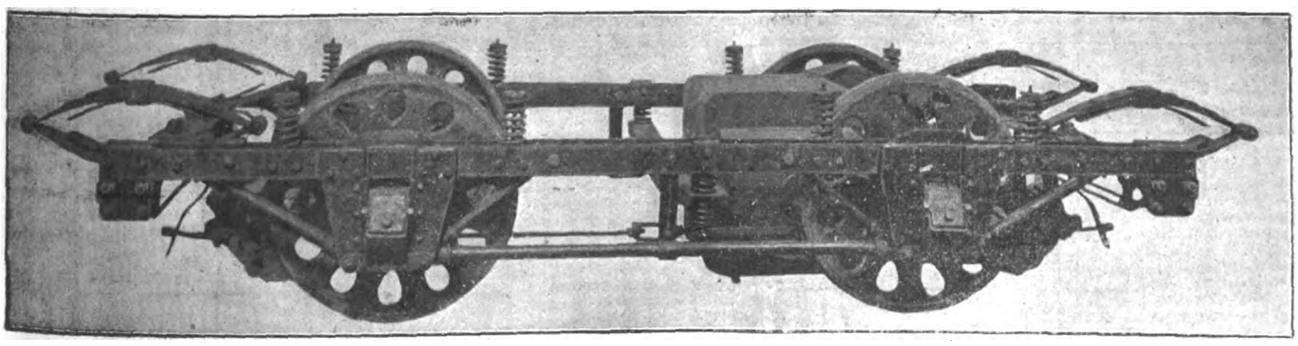
ment. There is a single track with 16 turnouts. It follows the centre of the roadway, and is laid with 65lb. girder rails. The gauge is 3ft. 6in., and the maximum gradient is 1 in 40, the minimum radius of curve being 40ft. The generating station is almost equidistant from the ends.



View of Switchboard.

The boilers are in duplicate, of the Galloway type, manufactured by Messrs. Galloway, of Manchester. They are 20ft. long and 6ft. in diameter, are capable of evaporating 3,400lb. of water per hour, and work at 140lb. pressure. The boiler mountings are of the usual Galloway pattern. The boilers are fed by an electrically driven three-throw feed pump, 6in. stroke, 2in. diameter, which, at 65 revolutions per minute, is capable of delivering 700 gallons of water per hour. The feed water is heated by a Berryman feed heater. The motive power consists of two GGS non-condensing Willans engines of 100 indicated horse-power, running at 450 revolutions per minute and provided with an automatic cut-off. The dynamos—of which there are two—are directly coupled to the engines. Their normal output is 120 amperes, at 500 volts, but they are designed to carry 50 per cent. momentary excess current, and are therefore capable of checking the speed of the engine. They have independent bed-plates and two bearings, and the shafts are coupled by bolts bushed with hard india-rubber enclosed in brass tubes to deaden concussions transmitted from the engine. The dynamos being of the over type, the engines have been considerably elevated in order to bring the bearings into line, and for this purpose the floor at the end of the room where the engines stand is raised 3ft. 3in. above the ground level. The armatures are wound on the Eickemeyer system, and the magnets are compounded. Copper brushes are used. The commercial efficiency of the dynamos is 93 per cent., and the efficiency of the combined set about 84 per cent. One engine and dynamo suffice for the service of four cars, the second set being in reserve. Provision is made for a third set



Motor Truck.

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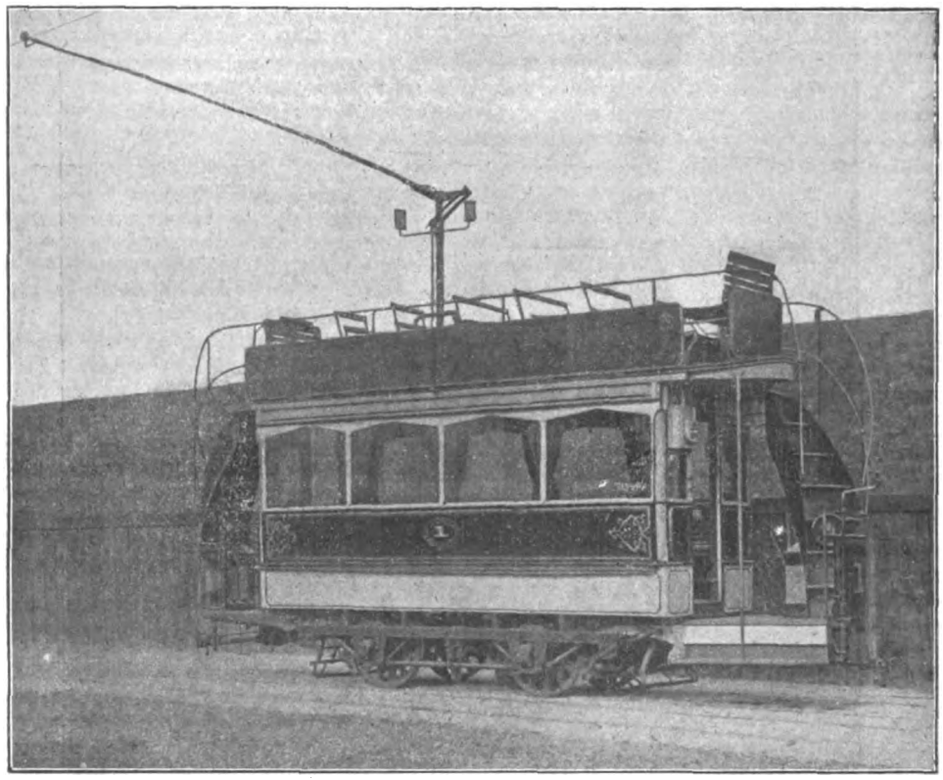
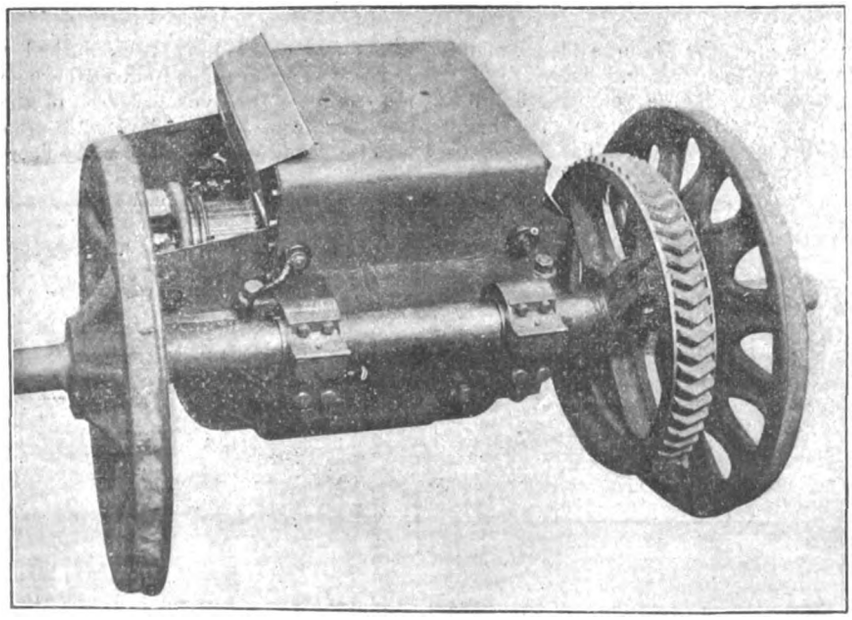
should a heavier service be demanded. Each set is equipped with a heavy flywheel of the same weight as is usual with direct-coupled GGS Willans engines.

An interesting feature in the general arrangement is the provision of an auxiliary plant, consisting of a secondary battery and dynamotor driven from the generating dynamos. The cells are charged simultaneously with the working of the line whilst the load is light, but at moments of excessive demand they supplement the current supplied to the cars by the generating dynamos, and thus render the load less variable and increase the working capacity of the system. The arrangement also serves at 100 volts for driving the feed pump, lighting the station, and moving the cars in the car barn; and as the current from the accumulators is available at all hours, it is possible to run late or early cars when the engines are not at work. The dynamotor is of the improved type now being constructed by the Electric Construction Company, with a double-wound armature for 500 volts, 30 amperes, and 135 volts, 85 amperes. The efficiency of conversion is 85 per cent. It runs at 800 revolutions. The secondary battery consists of 53 E.P.S. 31 K cells.



Side View of Car with Dickinson Trolley.

The switchboard stands in the engine room, and is provided with single-pole automatic cut-out switches for each circuit, and also with single-pole throw-over switches for each dynamo, thus serving to connect them with either of the two circuits into which the line is divided. On the other pole are placed fuses enclosed in glass tubes, with spring connections, enabling them to be instantaneously replaced. Dead-beat



View of Motor, Gearing and Casing.

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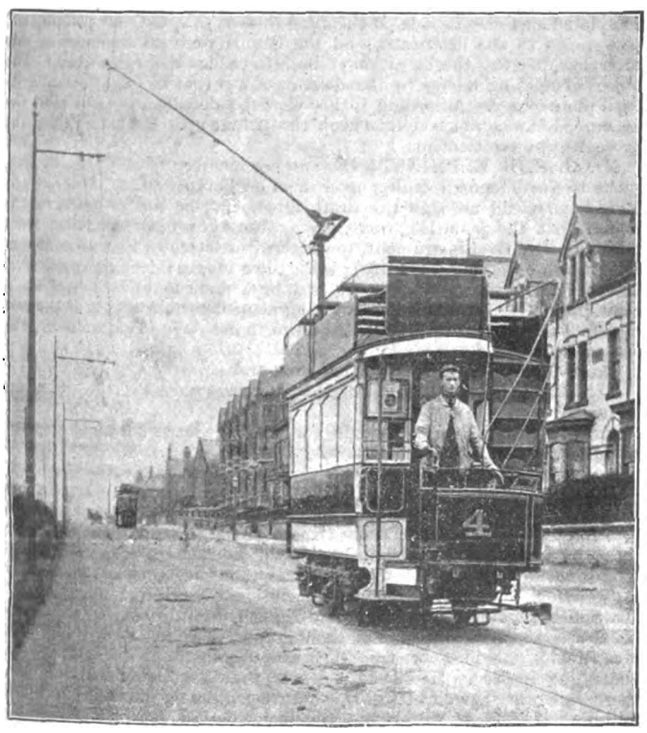
Weston ammeters are used on the line circuits, and "E.C.C." ammeters on the dynamos. The voltmeters are Kelvin electrostatic, and suitable switches are provided for the transformers, lighting circuits, &c., the dynamos being provided with regulating resistances. Across the terminals of the automatic cut-outs are placed resistances to carry 60 amperes. These, when through excess of current the switches open, still permit half the normal current to pass into the line, racing of the engines and dislocation of the traffic due to complete cessation of current from transient causes being thus avoided. The sparking across the switches is, moreover, greatly reduced, and the attendants can with impunity close them to ascertain whether working can be continued, or whether permanent short circuit exists.

The general arrangement is the same as on the South Staffordshire Tramways, being the side pole system as originally designed by Mr. A. Dickinson. No attempt at ornamentation has been made in the poles, but owing to their position at the side of the road, and the entire absence of span wires, they are wholly free from any unsightliness.

The advantageous position of the station, and the moderate length of the line and service, render feeders unnecessary, two trolley wires of No. 0 B.W.G. sufficing to carry the current.



End View of Car.

One of these wires takes the up, and the other the down service, and they are cross-connected at two points, so as to supplement one another. One circuit takes the line on the side of Hartlepool, and the other on the side of West Hartlepool, sectional insulators being placed half way in either direction, so that in the event of an accident happening to one of the trolley wires, pressure can still be maintained on the other. Two wires also do away with the necessity of any turn-out switches, and simplify the working. The poles are placed on the kerb, 120ft. apart on the straight part of the line, but somewhat nearer on the curves. To keep the trolley wire as nearly as possible at a uniform distance from the centre of the track, the length of the arms varies from 4ft. to 12ft. The height of the trolley wire above the line is 21ft., except at two points where bridges on the North-Eastern Railway cross the road, necessitating a reduction to 16ft. It might be thought that the depression of the trolley poles here required would cause trouble in working, but such has not proved to be the case. The insulators are of the "Ætna" type, the wires being clipped in long ears without soldering. The poles were supplied by Messrs. J. Russell and Sons, of Wednesbury, and are taper steel tubes 29ft. long, 6in. diameter at the ground level, and 2½in. diameter at the arms. At the curves 7in. poles are used, and terminal poles 12in. diameter are provided to take the end strain of the wires.

The rails are used as an uninsulated earth return. Electrical continuity between the rail joints is secured by means of duplicate bonds as well as by the fish-plates. The bonds consist of No. 4 B.W.G. copper wire wrapped round and soldered to the end of a taper iron stud, which is driven hard into a rymered hole in the web of the rail, fixed by means of a nut and washer. The whole is then coated with a tar compound and embedded in the roadway. The rails are connected from the points where they pass nearest the generating station to the switchboard by means of an insulated underground 19/12 B.W.G. cable, 50 yards long, and the line by four 19/15 cables drawn into iron pipes.

A recording voltmeter, a leakage indicator, and earth plates are provided at the station in accordance with the Board of Trade regulations.

The cars, constructed by Messrs. G. F. Milnes and Co., of Birkenhead, are five in number. They each measure 22ft. over all, and seat 18 passengers inside and 20 outside. The seats in the interior are longitudinal, and on the roof are of the cross garden-seat type. The bodies are mounted on four-wheel trucks. The diameter of the wheel is 33in. and the wheel base 5ft. 6in. The springs give an easy motion to the car, free from oscillation or pitching. Each car is fitted with one motor. The armatures are drum wound with Eickemeyer coils; the cores being slotted and uninsulated. The whole of the insulation being in the coils, replacement of a defective coil is quickly and cheaply effected. There are 72 sections in the commutator and four carbon brushes are provided. The magnets are two-pole, iron-clad and of cast steel, entirely closing the armatures. The speed of the motor is 360 revolutions when the car is running at eight miles an hour. The gear wheels are cast steel, with double teeth helical and single reduction. They are cased in and run in oil. The magnets are spring suspended from the truck.

The total weight of one car fully loaded is 7½ tons, and it is found that this requires a current when running on the level of about 12 amperes. The maximum commercial efficiency of the motor is 83 per cent., and for a considerable range of speed it is over 80 per cent. At eight miles an hour 10 H.P. is developed.

Access to the motor can be obtained either from above, by lifting a trap in the car floor, or when the car is standing over the pit in the car shed by canting the lower half of the magnets and armature on the axle. The controlling gear is in duplicate, one set being placed at each end of the car on the platform underneath the stairs. The driver stands at the foot of the stairs with the regulating wheel in his left hand, and the wheel brake is within easy reach of his right hand. The spindle of the regulating switch projects from the riser of the third stair. Being interlocked with the reversing switch it can only be removed when the latter is in the off position. The handle of the reversing switch is on the top of the controller. The resistance consists of 40 platinoid spirals sheathed with asbestos and contained in vertical brass tubes. This construction has the double advantage of giving support to the coils, and, in consequence of there being a considerable mass of material, is also capable of absorbing a large amount of heat for short periods. The tubes are insulated from one another by being let into slate bases, and the ends of the platinoid wires are led direct to the switch contacts, so that insulated connections are avoided. The switch has 21 points. The movable contact is made with an iron limb, and is wound with a coil carrying the current from the trolley, and thus a travelling magnetic field is created which blows out the arc at every contact. It is also worthy of notice that when the line current is cut off the motor is short circuited, and, operating the reversing switch before the car stops, converts it into a generator and pulls up the car. This arrangement takes the place of an emergency brake. The trolley gear is, with some modification in detail, the same in design as that introduced by Mr. A. Dickinson on the South Staffordshire Tramways. It is placed in the centre of the length of the cars close to the side, and

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mounted on a strong wrought-iron plate well secured to the roof. The cars are lighted by six 16 c.p. incandescent lamps, one being placed fore and aft in the ordinary signal lanterns, one at each side of the car inside and two on the roof, attached to the trolley pillar.

Without presenting any very striking novelty, the Hartlepools line may be taken as a fair sample of what is requisite to popularise electric traction.

## LEGAL INTELLIGENCE.

### Elliott Brothers v. Sullivan.

This case came before Mr. Justice Kekewich, in the Chancery Division, on Tuesday last. The plaintiffs in their statement of claim asked for a declaration that they are entitled to manufacture and sell, as sole licensees from the defendant, an instrument known as Sullivan's Universal Galvanometer, under the terms of an agreement between the parties dated 1894; for specific performance of the same; and an injunction restraining the defendant from granting licences for the manufacture of the said galvanometer to any other firm, or otherwise interfering with the exercise of plaintiffs' rights under the said agreement. The defendant, by his statement of defence, denied the legal existence of such an agreement as the plaintiffs alleged, though he admitted that negotiations and proposals had passed between himself and the plaintiffs. He alleged that he refused to sign a draft agreement, which by its terms bound him to the plaintiffs for 14 years whilst they would be at liberty to take in hand any rival instrument they thought fit. He also pleaded that he was not bound to sign such agreement or to specifically perform the terms of such a document. He alleged that, during the negotiations for a final agreement, the price at which the instruments were to be sold and the royalty to be paid him for each instrument were agreed upon, and plaintiffs with his licence and consent manufactured and sold instruments at the price agreed upon and became indebted to him accordingly, and on applying to the plaintiffs for these royalties they sent him a cheque for £30 on account, and promised an account later, but that no such account had been delivered to him. The defendant further asked for an injunction to restrain the plaintiffs from infringing the letters patent.

Mr. Renshaw, Q.C., and Mr. Stone appeared for the plaintiffs; and Mr. Warrington, Q.C., and Mr. Jason Smith for the defendant.

Mr. RENSHAW, in opening the case, said that the plaintiffs were the well-known firm of electrical and scientific instrument makers, of St. Martin's-lane, London, and the defendant was an electrician and engineer. As the final question in the action was whether or no there was an agreement between the parties, it might save time and lead to a better appreciation of the witnesses if he went through a few preliminary details. The letters patent were No. 238 of 1893 and 10,847 of 1894, for improvements in and relating to the Deprez-d'Arsonval galvanometer, and improvements in electrical measuring and signalling instruments, described in the proceedings as Sullivan's patent. On January 5, 1893, the defendant applied for provisional protection for the first of these, and on October 3rd deposited a complete specification, which was accepted, and the letters patent were dated January 5, 1894. The second was applied for on May 30, 1894. The principal point at this stage was with regard to Elliott Brothers making experiments in aid of the invention as far as it had gone, and trying to turn it to practical use. He (the learned counsel) did not think that there was any dispute that this was so, and that Elliott Brothers had expended a considerable sum in trying to develop the invention. Soon after this a suggestion was made that Elliott Brothers should manufacture the galvanometers to be made under the invention, and the suggestion was that the remuneration to the defendant should be left to them to determine. Shortly afterwards the defendant furnished the plaintiffs with a drawing or design, showing the nature of the invention by way of improvement. The plaintiffs examined it, and spent a considerable sum upon it, and also prepared, or assisted in preparing, the complete specification. So things went on. Sometime in 1893 the defendant left this country for a time, and on returning in 1894 negotiations took place between the parties relative to a working agreement and a division of the profits, Mr. W. O. Smith, a member of the plaintiff firm, acting on their behalf. Matters went on until July 10, 1894, when, for the first time, the parties arrived at something like a basis of agreement, a document being brought forward, upon which the agreement between the parties was framed. Certain points of the agreement were on this day arranged, others being left open, and several changes were afterwards made. There was a long correspondence, beginning on July 11th, the day following the interview; and this the learned Counsel submitted, showed the intentions of the parties, and he accordingly proceeded to read the letters, prefacing them by quoting the prices embraced in the draft agreement. This set out that the defendant was to pay all the expenses of the patent applications and in continuing and maintaining the same for four years from the date of the granting of the patent. Elliott Brothers were to be the sole manufacturers of the instruments, and the selling price of the instruments and the discounts to the trade were specifically set out. Mr. Sullivan was to receive a royalty equal to an agreed percentage of the net selling price of the instruments or accessories, and to keep books of account, &c. An account had been rendered by the plaintiffs up to and including March 31st, showing a balance due from the defendant to the plaintiffs.

His LORDSHIP asked if he was to understand that he was not to regard the draft document in question as an agreement, but was to read it in the light of letters as being independent authority in support of plaintiffs' claims.

Mr. RENSHAW said that he desired to refer to the document as indicating the intention of the parties embodied in the letters, and he proposed to supplement that by putting in a description of the instrument which appeared in the electrical papers, and especially an article in *The Electrician* of March 22, 1895. as evidence that Messrs. Elliott Brothers were the "sole makers."

Mr. WARRINGTON said that he would admit that this was so; no other firm were making the instrument.

Mr. RENSHAW, in conclusion, contended that he was entitled to show by parol evidence and the letters what the agreement between the parties was, and that he could claim specific performance.

Mr. WARRINGTON said the case for the defendant was that, even if part performance of the agreement could be admitted as proper evidence, what took place was not such a part specific performance as the Court would allow for such purpose. Part performance must, in other words, be referable to the agreement.

His LORDSHIP said that he took it for granted that this was a matter of some importance, and as he thought it undesirable to have an application for a new trial, probably the case had better go on. Accordingly,

Mr. WILLIAM O. SMITH spoke to the interview of July 10, 1894, between himself and the defendant, when they discussed the terms of the agreement, the prices, and other things. He said that during their manufacture of the galvanometers the defendant frequently looked in and saw what was being done. The plaintiff also asked witness for a copy of the draft of the agreement, and he handed it to him. He thought that was in August. Defendant, later on, when witness spoke to him on the subject, said that he had looked through it, and that it was all right. On August 9th the terms were finally settled, and his firm manufactured and sold instruments on the terms thus arranged. Nothing whatever was said about its being a temporary arrangement, and he (witness) understood it was to be permanent. They had come to a definite understanding on July 10th, except as to certain fees. He produced the completed agreement made on the same lines as this, and read the different paragraphs to the defendant, and the details were all arranged at this interview, it being the intention of both to reduce them to writing. The object of sending a copy to the defendant was that he might consider its legal phraseology. According to his view the defendant was to meet the expense, but was not bound to keep the patent up. He looked upon the agreement as a settlement.

Mr. G. K. B. ELPHINSTONE, another member of the plaintiff firm, spoke to the defendant calling upon them on February 14th this year, and saying he would not sign the draft agreement for the 14 years, for the reason that the plaintiffs were not by the agreement precluded from taking up any rival instrument, to which witness replied that upon no consideration would they (plaintiffs) pledge themselves not to take up any rival device; that what was arranged had been done in other cases, but a clause might be introduced into the agreement terminating it if the sale of defendant's instrument dwindled down to nothing. This, however, the defendant declined to accept.

This evidence closed the plaintiffs' case, and

Mr. WARRINGTON submitted that there was no case for the defendant to answer.

His LORDSHIP said that might be, but if the learned counsel proposed to call evidence it should come now.

Mr. WARRINGTON then called—

Mr. HERBERT W. SULLIVAN, the defendant, who in referring to the interview of July 10th, said there was a discussion as to the prices and royalty, but he did not remember the alleged agreement further than a suggestion by Mr. Smith that they should reduce their arrangement to writing. He thought also that there was a conversation about the fees for maintaining the patent, but no conclusion was arrived at. He told Mr. Smith that he would think it over, and on July 12th he wrote him his decision. The witness was then examined as to his interview with Mr. Elphinstone in February, with whose account of the interview he generally coincided. He denied, however, that Mr. Elphinstone told him there were other agreements of this nature containing the clauses to which he objected. He admitted that the plaintiffs had experimented on the invention, and had expended some money on it; but he did not concede that that amount was £70, as Mr. Smith had suggested. He would rather put it at £50. That was down to July, as there were a few further experiments, for which they would only be paid out of any profits they could make from the manufacture of the instrument. That was their only chance of recouping this later expenditure, they having to allow him on their manufacture and sales an agreed royalty, with liberty to plaintiffs to allow a discount to a maximum of 15 per cent. Those points alone did not constitute the agreement, but they were acted upon, and he received £30 on account of the royalties. It was he (witness) who terminated the agreement as far as he could on the plaintiffs shutting him out from their premises. He denied that he was to pay the expense of taking out any patents abroad. There was a compromise on that point, under which he and the plaintiffs were to divide the cost. If they agreed on terms, the plaintiffs were to be sole manufacturers. No doubt the maximum prices were arranged.

At the close of the evidence his LORDSHIP, in giving judgment, pointed out that this was not an agreement to be performed within a year, and therefore must be reduced to writing. The plaintiffs, finding that they could not comply with this requirement, sought to avoid the consequences by saying they were entitled to prove the agreement by parol evidence. It was open to question whether that doctrine was applicable to a case of this kind, but he (his Lordship) did not think it right to decline to hear the evidence in case the action should go to the Court of Appeal. He was of opinion that, although there were negotiations by an agreement between the parties, the agreement was not completed, and he dismissed the action with costs. His Lordship also made an order that the plaintiffs were not to continue the manufacture of the galvanometers in question.

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### Jardine v. King, Mendham and Co., and Miles.

In the Chancery Division, on Tuesday, Mr. Justice North heard this case, which was an action brought by Charles Kennedy Jardine for an injunction restraining the defendants from an alleged infringement of his electrical automatic time check. The infringement was denied, and the defendants in the alternative pleaded that the plaintiff's patent was bad. The plaintiff's case was that on July 31, 1891, letters patent No. 12,982, were granted to Frederick George Manley Wetherfield for his invention of an electric automatic time check. Subsequently, whilst the plaintiff was resident in Demerara, this patent was duly assigned to him by Wetherfield. A patent for an invention described as an electric time check and register was subsequently granted to the defendant, Charles Miles, and the other defendants (King, Mendham and Co. of Bristol) were licencees from him. The invention for checking workmen's time consisted of a box, in which was a slot for the workpeople to put a card or ticket on their coming to their employment. The tickets fell into drawers or boxes, and an arrangement of electro-magnets closed certain of the drawers or boxes at certain times, forcing the tickets into other drawers, thus enabling the employers, by looking into the drawer or box in which the tickets had dropped, to ascertain at what time each individual workman arrived. The plaintiff's invention consisted of a box with a slot in it, into which the workmen on returning to work had to place a metal disc. The time the workman should arrive was marked on the face of it, and a workman coming in late put his disc in the slot and had it automatically returned to him; if the disc remained in he knew he was in time. The plaintiff claimed that the invention of which King, Mendham and Co. were licensees was an infringement of the patent legally assigned by Wetherfield to him. The defendants set up the case that the plaintiff's patent was bad by reason of a prior grant—Garnet and Moore—in 1890. The petition for the plaintiff's patent was lodged on December 31, 1891, and that of Garnet and Moore on December 1, 1890. By Section 13 of the Act of 1883 the date of the petition became the date of the patent, so that in point of time Garnet and Moore's patent was before the plaintiff's. But before July 31, 1891, there was no publication of the invention contained in Garnet and Moore's specification, so that that specification could not be relied upon in any way as an anticipation, but merely as a prior grant. Prior grant, it was contended, could not affect the case, as all the law did was to give the grantee power to get a later patent repealed upon the ground that the subject matter of the second patent had been granted to him before. The grant was good and valid so long as it lasted, but the Crown had the power, where there had been a prior grant of the same subject matter, of repealing the grant. Before the Act of 1883 he had been unable to find any instance where prior grant was a defence to an action for infringement. Since the Act prior grant was constantly used as a defence to actions for infringement, but he was not aware of any case in which it had been properly considered.

Mr. C. K. JARDINE, the plaintiff, said he lived at Demerara. He produced a machine, the purpose of which he should describe as automatically dividing the people who came to their work late from the people who came early. He did not communicate his invention to anyone in England until he had communicated with Mr. Wetherfield about patenting it in this country, and Wetherfield took out a patent for him in this country. The model of the alleged infringing instrument he had before him had four different times marked upon the face of it, but it was substantially the same as his invention.

For the defence it was submitted that in cross-examination the plaintiff had shown the differences between the two instruments. The defendants' apparatus was duplicated to work a system which could not be worked by the plaintiff's, unless his working parts were duplicated. On the question of prior grant, the defendants by their defence set up the case that the plaintiff was not the first and true inventor. If Garnet's patent was the same as the plaintiff's, that case was made out, for, though not made public until some six months afterwards, Garnet's patent was prior to the plaintiff's. That was clear proof that the plaintiff was not the true and first inventor, even though it might not be capable of being relied upon as an anticipation in the usual acceptance of the term. He said, first of all that assuming identity between the plaintiff's and Garnet's, the Crown, having granted a patent for this apparatus, would not grant it afterwards to another; secondly, he said that it showed that the plaintiff was not the first and true inventor.

Mr. BOLT, M.I.Mech.E., said he had had considerable experience of patents. Wetherfield's invention would be described as consisting of a drawer with two compartments and having two deflectors, one fixed and one stationary. The object of the first was to deflect the checks into the further drawer, and that of the second to deflect the checks into the other drawer when released by a trigger, which was operated upon at a certain time by electro-magnets. In his opinion Miles's apparatus was not substantially an apparatus on the same principle as the plantiff's. The apparatus shown in Garnet's specification, both in construction and operation, more nearly resembled the plaintiff's than it did the defendants'.

After Mr. Bolt's evidence, Mr. JENKYNS (counsel for the defence) said that their main contention was that there was no infringement. The plaintiff's claim was either a very narrow one, and did not cover what the defendants did, or it was a wide one, and in that event it was bad by reason of anticipation. He agreed that the deflector used in the plaintiff's apparatus, and the shutter in the defendants', both served the same purpose. In the defendants' machine, until the hour arrived at which the workmen were late, it might as well not be there, except that it received the discs, which could as well be received in a tray or basket. The plaintiff's apparatus, on the other hand, was in operation from the time it was started until the time it was stopped.

Mr. TERRELL, for the plaintiff, said there were three points to be determined. Was there a prior grant to Garnet and Moore, and, if so, were the defendants setting it up as a defence to the action; was there a prior publication in Llewelyn's specification; or was the defendants' apparatus an infringement of the plaintiff's? In order to establish the plaintiff's case he must show that he was right on all these three points. His submission on the first point was that prior grant could not be set up by anybody, except the prior grantee or his assignee. He further submitted that a workman, knowing of the plaintiff's invention, could have made the defendants', and that was the true test of infringement. The defendants had not only copied the plaintiff's invention, but they had copied his exact combination, the only differences being those arising out of a desire to apply the machine in a different way.

Judgment will be delivered next week.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Free Library Committee of the County Borough of Rochdale invite tenders for the electric lighting plant required at the Free Public Library, consisting of gas engine, dynamo, wiring and fittings. Specifications, &c., may be obtained after to-morrow (Saturday), from Mr. S. S. Platt, A.M.I.C.E., Borough Surveyor. Tenders must be sent in to the Deputy Town Clerk (Mr. James Leach), Town Hall, Rochdale, by noon of Tuesday, the 30th. Further particulars appear in our advertisement columns.

——— The Urban District Council of Ealing require tenders for work in connection with the extension of their electric lighting station at Ealing. Some particulars are given in our advertisement columns, and drawings, &c., can be inspected, and forms of tender obtained, at the offices of Mr. C. Jones, C.E., Surveyor to the Council, after Monday next. Tenders to Mr. Wm. Ruston, Clerk, Public Buildings, Ealing, W., by 4 p.m. on Wednesday, July 1st.

——— The Corporation of Leeds require tenders for an electrical installation sufficient for working by the overhead system a double track of tramway seven miles in length. Also for the supply of two steel boilers and accessories at the generating station for the electric tramways. Tenders to the Town Clerk, Town Hall, Leeds, by June 22nd.

——— The Sunderland Corporation require tenders for low-tension insulated cable and bare copper strip. Tenders to the Town Clerk, Sunderland, by 5 p.m. of 26th inst.

——— The Wallasey Urban District Council invite tenders for condensing apparatus and steam and exhaust pipes for their electricity supply works. Tenders by July 16th.

——— The Corporation of Cardiff invite tenders for the construction, supply, delivery and fixing of evaporative condenser and concentric cables. Tenders to Mr. J. L. Wheatley, town clerk, Town Hall, Cardiff, by 25th inst.

——— The Corporation of Burnley invite tenders for the supply and delivery of armoured concentric underground cables. Tenders by 24th inst.

——— The Colchester Town Council require tenders for wiring the Albert School of Science and Art. Tenders to the Borough Surveyor, Colchester, by 4 p.m. of 23rd inst.

——— Tenders are required for putting the existing telephone and electric bell system at the Prestwich County Asylum in thorough repair.

——— The Highland Railway Company invite tenders for various stores, including telegraph instruments and fittings, telegraph construction materials, &c. Tenders by 20th inst.

——— The Leeds City Council invite tenders for the erection of engine, boiler and economiser houses at the electric generating station for the city tramways. Tenders to the Town Clerk, Town Hall, Leeds, by Monday next.

——— Tenders are being invited by the Spanish Minister for Foreign Affairs for the construction and working of a telephone system in San Juan de Puerto Rica. The copy of the Royal Order inviting tenders may be seen at the Commercial Department of the Foreign Office, Downing-street, S.W., between 11 and 6. Tenders must be sent in to the Ministry at Madrid by August 10th, and must be accompanied by a deposit of $800.

——— The French Post and Telegraph Authorities invite tenders for the supply of 275 metrical tons of copper or bronze telegraph wire. Tenders to the Direction Générale des Postes et des Télégraphes, Rue de Grenelle, Paris, by July 2nd.

——— The Municipal Authorities of San Felio de Torello (Barcelona) require tenders for the concession for the electric lighting of the town. Tenders to El Secretario del Ayuntamiento, San Felio de Torello (Barcelona), Spain.

——— The Municipal Authorities of Cazeres-sur-Garonne (Haute Garonne), France, invite tenders for the electric lighting of the town. Tenders to La Mairie de Cazeres-sur-Garonne, France, by the 28th inst.

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TENDERS ACCEPTED.—The tender of Messrs. Leslie & Leslie has been accepted by the Hammersmith Vestry for erecting an engine and boiler house and chimney shaft in connection with their electricity supply scheme for £7,231.

——— Messrs. S. Z. de Ferranti (Limited) have secured the order for two 300-kilowatt fly-wheel alternators for the extension to the Islington (London) electricity works.

SALE BY AUCTION.—Messrs. Bradshaw Brown, Hooper and Price will, on Tuesday, the 30th inst., dispose of by public auction the surplus electrical plant, machinery, and stock-in-trade of the London and Lancashire Electrical and General Engineering Company, at Kingsland-green, Dalston, London, N.E. Some particulars will be found in our advertisement columns.

APPOINTMENTS VACANT.—The Electric Lighting Committee of the county borough of South Shields invite applications for the post of assistant and draughtsman to the borough electrical engineer at a salary of £100 per annum. Some further particulars are given in our advertisement columns, and applications for the post have to be in by 10 a.m. on Thursday, the 25th inst.

——— From our advertisement columns it will be seen that the Corporation of Paisley require a resident electrical engineer to design and superintend the laying down of an electric light installation, and to manage the same after completion. Salary £200 per annum. Applications to be sent to the Town Clerks, Messrs. Young and Martin, Paisley, by July 1st.

——— The Professorship of Civil and Mechanical Engineering at Mason College, Birmingham, is vacant. Applications to the Council by July 11th.

——— The St Helens Technical Education Committee require a teacher for chemistry, physics, and metallurgy. Salary £150 per annum and share of science grant. Applications to the Director of Technical Education, Town Hall, St. Helens, by July 10th.

——— The West Bromwich Technical Instruction Committee require an assistant lecturer and demonstrator in metallurgy, chemistry and physics. Salary, £100 per annum. Applications to the Secretary by the 30th inst.

——— The position of Assistant Lecturer and Demonstrator of Physics at Firth College, Sheffield, will be vacant at Michaelmas next. Salary £120 per annum, with allowances. Applications to the Registrar by July 9th.

PROFESSIONAL.—The Watford Urban District Council invite applications from consulting engineers prepared and qualified to advise in regard to the preparation of a county memorial to the Board of Trade for a Provisional Order under the Electric Lighting Act, and in respect to other matters, some particulars of which will be found in our advertisement columns.

APPOINTMENTS.—The Shoreditch Vestry have appointed Mr. R. F. Ferguson as resident electrical engineer. Mr. Ferguson has been engaged for about four years at the Bankside station of the City of London Company, prior to which he was at the Brighton Corporation Electricity Works.

——— Mr. V. A. Mundella, Assistant Lecturer in Physics and Electrical Engineering at Durham College of Science, Newcastle-on-Tyne, has been appointed Head of the Physics and Electrical Engineering Department of the Northern Polytechnic Institute, Holloway. Mr. H. A. Garratt, Lecturer in Engineering at University College, Bristol, has been appointed Head of the Engineering Department of the Institute.

BUSINESS FOR DISPOSAL.—Particulars are given in our advertisement columns of a machine maker's and electrical engineer's business for disposal at Edinburgh. Applications should be sent to Messrs. Ronaldson and Gordon, C.A., 3A, North St. David-street, Edinburgh.

CHANGE OF ADDRESS.—On and after June 25th the registered offices of the Metropolitan Electric Supply Company (Limited) will be removed from Winchester House, Old Broad-street, E.C., to 29, Baker-street, London, W.

BUSINESS CHANGES.—Mr. Walter C. Garrard, late of the Thames Electric Launch Company, and formerly on the staff of Messrs. Immisch and Co. and Woodhouse and Rawson United (Limited), has joined Mr. F. Ames, and from June 1st the style of the firm is Ames, Garrard and Co., art metal workers and electrical engineers, 1 and 2, Goldney-place, Goldney-road, Harrow-road, London, W.

NEW WORKS.—About 450 of the *employés* were entertained on Friday last to celebrate the completion of the extensive range of additional buildings which form the new works of Messrs. W. T. Glover and Co., at Salford. The principals of the firm, Messrs. Henry Edmunds and Godfrey B. Samuelson, presided, and the invited guests included many leading citizens of Salford, and representatives of electrical industries. During the evening the principals were congratulated upon the handsome addition which had been made to the works premises, and upon the large output and excellence of manufacture of the firm's specialities. Mr. Edmunds, in responding to the toast of "The Firm," was able to state that last year 24,000 miles of wire and cable had been manufactured, and so rapidly had their business increased during the past two or three years that they were scarcely able to cope with the work. This state of affairs necessitated the erection of additional premises, which would enable the firm to execute orders of any magnitude. In response to the toast of "The Staff," the general manager, Mr. J. Morton alluded to the almost remarkable absence of accident or fatality since the commencement of the Company's business. He attributed this largely to the great care with which the principals looked after the interests of their *employés*

DISSOLUTION OF PARTNERSHIP.—Messrs. John Dewhurst and Louis Russell, electrical engineers, 52, North End-road, West Kensington, London, have dissolved partnership.

PERSONAL.—Mr. J. C. Howell, of 24, Queen Victoria-street, E.C., informs us that he has ceased to represent Messrs. Crompton and Co. (Limited) in South Wales and elsewhere.

——— The friends of Mr. A. P. Lundberg will be glad to hear that he is regaining convalescence from the attack of erysipelas which followed a bicycle accident in April last. He desires to thank numerous friends for their inquiries.

LIQUIDATIONS.—A meeting will be held at 73, Lombard-street, E.C., on July 15th, at noon, to receive an account of the winding-up of the Gülcher (New) Electric Light and Power Company (Limited).

——— A meeting has been called for July 14th at 11:30 at Messrs. Wynne, Holme and Wynne's, 10, New-court, Carey-street, for the purpose of considering the final account of the liquidator of the Bernstein Electric Lamp Company (Limited).

——— A meeting will be held at Messrs. Hammill and Marsh's, Bank Chambers, Hardshaw-street, St. Helen's, on July 18th, to receive an account of the winding-up of Abell's Electrical Engineering Company (Limited).

——— An order has been made for the compulsory winding-up of Leete, Edwards and Norman (Limited), engineers and electricians, 366 and 368, Euston-road, London, N.W.

——— At a recent meeting of the proprietors of the Universal Electric Carriage Syndicate (Limited) it was decided to sell the property and assets to the British Motor Syndicate (Limited), and to wind up the Syndicate. Mr. W. O. Attree, 41, Coleman-street, E.C., was appointed liquidator.

BANKRUPTCIES.—The first meeting of creditors in the failure of G. H. Barnes and Co., makers of electric light fittings, Bissell-street, Birmingham, takes place at 23, Colmore-row, Birmingham, on the 25th inst., and the public examination at the County Court, Birmingham, on the 9th July.

——— Creditors of C. F. Fox, electrical engineer and contractor, of Halifax, must send in particulars of their claims to the Official Receiver (Mr. T. England), Town Hall Chambers, Halifax, by July 4th.

CHICAGO EXHIBITION, 1893.—The medals and diplomas awarded to British exhibitors at Chicago have at length been issued to H.B.M. Ambassador at Washington, and have been transmitted by him to the Foreign Office. Sir Henry Trueman Wood has been requested by the Secretary of State to undertake the duty of distributing them, and this will be done at once. Exhibitors may expect to receive their medals within about a month from the present date.

ALTERNATE-CURRENT TRANSFORMERS.—Messrs. Johnson and Phillips desire us to state "that they are the absolute and sole proprietors of all Mr. Gisbert Kapp's patents for transformers, and to point out that manufacturers claiming to put on the market transformers made from Mr. Kapp's designs render themselves and their clients liable to actions at law for infringement of the patents."

MEASURING INSTRUMENTS.—Messrs. Evershed and Vignoles (Limited), of Woodfield Works, Harrow-road, W., issue useful lists 1 and 2 of their well-known measuring instruments. List 1 deals with ammeters and voltmeters of the latest pattern, and List 2 with electrical gauges. Details in brief of each instrument are included in the lists, which also give prices of instruments reading from 10 to 1,000 amperes, and from 80 to 600 volts.

MAGNOLIA METAL.—We are asked by the Magnolia Metal Company, of New York, to state that the Company have withdrawn from any arrangement previously existing as to the agency for their manufactures in this country, and in Saxony, such agency having been terminated by three months' notice from February 9th last.

GUIDE BOOKS.—A useful Tourist Guide to the Continent is issued by the Great Eastern Railway Company, giving more than the usual interesting and complete descriptions of many show places of the Continent served by the Company's route in conjunction with its Continental ramifications. It happens that at the present time several Exhibitions and other events of interest to our readers are taking place or being organised on the Continent, including the Industrial Exhibition at Berlin, the important Pan-Russian Industrial Exhibition at Nijni Novgorod which opens this month, the National Exhibition at Geneva, and the International Telegraphic

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Conference at Buda Pesth. This guide book will prove of service to any reader likely to visit these Exhibitions, and, in connection with the last-mentioned event, the very picturesque Frankfort-Nuremburg route to Vienna is sketched.

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ASYLUM LIGHTING.—At the recent annual meeting of the Directors of the Dundee Royal Lunatic Asylum a motion was made to instruct the Committee of Management to proceed with the electric lighting of Westgreen and Gray House at an estimated cost of £1,500. It was, however, decided to ask the Committee to prepare plans and estimates, and submit the same to a special meeting of the Directors.

BINGLEY (YORKS.).—The Leeds and Liverpool Canal Company have submitted proposals to the District Council for the establishment of electricity supply works. The Council will shortly have to decide between the introduction of the electric light and the extension of the gas works, and as there seems to be some feeling in favour of the former course it has been decided to find out, as a guide for the Gas Committee, how much electric current would be required by the mills and other business establishments of the town.

CARDIFF.—It has been decided to wire the central police station for the electric light.——The new Post Offices will also be lighted electrically, and the Council have been asked to give terms for supplying between 60,000 and 80,000 units of current per annum for that purpose.

CHURCH LIGHTING.—The electric light is to be introduced into St. George's Church, Charlotte-square, Edinburgh.

CITY AND SOUTH LONDON RAILWAY EXTENSION.—An attempt was made in the House of Commons on Monday to draught into this Company's Bill, on the motion for its third reading, a clause requiring the payment by the Company to the Islington Vestry of rates upon certain property which is to be demolished during the construction of the works, the proposer (Sir Albert Rollit) and his supporters, suggesting that the clause should be included in all future Bills of a similar character. The proposal was rejected.

CROYDON.—The foundation-stone of the electricity generating station was laid last week by Alderman Miller, J.P.

ECCLES.—The Local Goverment Board inquiry into the application of the Town Council for power to borrow £20,000 for electric lighting purposes was resumed on Friday last. A number of witnesses, including Mr. Charles Dorman (of the firm of Dorman and Smith), testified to the feasibility of the scheme. Mr. Dorman said his experience was that at the initiation of every electric lighting scheme there was a great outcry, but very soon the opponents either died off or became users of the light. Evidence in opposition to the application was given. Alderman Mellor and others criticised the details of Mr. Clirehugh's scheme, and contended that in a sparsely populated district like Eccles the undertaking could not pay. Objection was also raised to the proposal to light the streets by means of incandescent electric lamps.

EDINBURGH.—The Electric Lighting Committee have now instructed the city electrical engineer (Mr. F. Newington) to take immediate steps for the introduction of the high-voltage lamps. The Royal Infirmary is being wired for the electric light, and current will be supplied from the Corporation's mains.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from June 10th to June 16th, with the ports of destination :—

*Argentina*.—Buenos Ayres, £856 ; Rosario £244 (telegraph material). *Australasia*—Auckland, £65 ; Melbourne, £780 (including £380 telegraph material); Sydney, £123 ; Wellington, £16. *Belgium*—Antwerp, £46 ; Brussels, £1,220 (electric cable £60 telegraph material). *Brazil*—Rio de Janeiro, £220 (telegraph material). *British Guiana*—Demerara, £26. *Ceylon*—Colombo, £430. *Egypt*—Alexandria, £230 (telephone stores). *Holland*—Amsterdam, £69 ; Flushing, £163 ; Rotterdam, £20. *Hong Kong*, £25. *India*—Bombay, £74 ; Calcutta, £73. *Japan*—Yokohama, £248. *Malta*, £169. *Russia*—Archangel, £22 ; St. Petersburg, £6. *South Africa*—Cape Town, £331 (including £17 telegraph material) ; Delagoa Bay, £277 ; Durban, £428 ; East London, £367 ; Port Elizabeth, £334. *Spain* — Pasages, £35. *Straits Settlements* — Singapore, £280 (including £180 telegraph material).

*Foreign made Electrical Apparatus and Material*.—Foreign made goods to the value of £7 have been exported from this country to East London (South Africa).

FULHAM (LONDON).—The Vestry have discussed the report recently prepared by Mr. F. H. Medhurst on the joint electric lighting and refuse destructor schemes, but require further particulars from Mr. Medhurst before finally deciding in the matter.

GAS.—The *Gas World* says: "It is seldom that a Local Authority is courteous enough or just enough to say anything in favour of the gas company with which it has transactions."

HORSELESS CARRIAGE BILL.—This Bill has passed the House of Lords. It has now to receive attention from the Commons.

KESWICK.—Some time ago the District Council decided to offer £2,000 for the plant and undertaking of the local electric light company, and counter-proposals have now been submitted to the Council by the Company, who offer to take over the Keswick Provisional Order to lay down new plant and mains at a cost of from £2,500 to £3,000, to pay for the cost of obtaining the Order, and to make such additions and extensions to the plant and mains as the requirements of the district may demand. The Company require the Council to enter into a contract for the lighting of the streets for 5½ years, but are willing to sell their undertaking at the end of this period on the following terms :—(*a*) The payment of £2,000, the sum now offered by the Council ; (*b*) repayment of the amount expended in carrying out the provisions of the Order and in extensions, &c., the payment of a sum for goodwill equal to 10 years' profits, based upon the last annual report of the Company at the time of taking over the undertaking, and an amount sufficient to pay £5. 10s. per cent. upon the capital of the Company, to be arrived at by adding items (*a*) and (*b*), as above set out. The consideration of the matter by the Council has been postponed for three weeks.

LANCASTER.—The Judges' Lodgings are being wired for the electric light ; 62 16 c.p. and 10 8 c.p. lamps will be used.

LEEDS.—It has, we understand, been determined by the Tramways Committee to grant leave to engineering firms tendering upon the specification prepared by the Committee and its engineers, to submit schemes of their own in addition, and these schemes will be considered by the Committee in conjunction with that prepared by Dr. J. Hopkinson. The question of the extension of the tramways to districts not already provided with this means of intercommunication is also under the consideration of the Committee, whose decision is awaited with much interest.

NEWINGTON (LONDON).—By 50 votes to 14 the Vestry have decided to appoint a special committee to consider the electric lighting question. The London Electric Supply Corporation has been informed that the Vestry themselves intend to obtain a Provisional Order.

POLICE.—William Morris, aged 57, the cashier who was charged with embezzling the large sum of about £3,300 from Messrs. Elliott Brothers, was brought up at the London County Sessions at Clerkenwell yesterday, and pleaded guilty to stealing the moneys. It was stated that the prisoner had been in Messrs. Elliott Brothers' service for 23 years, and the firm had up to last year reposed every confidence in him. The falsification of the books and embezzlement of the firm's money had been going on from 1885. When his books were investigated prisoner absconded, but was successfully shadowed and his whereabouts known. He, however, returned to London in response to an advertisement, and was then arrested. We understand that the prisoner was successful in eluding the vigilance of his employers by a somewhat simple manipulation of his books, and that the workmen's wages book was, as is so often the case, the book selected for the purpose. A remark from the Judge (Sir P. H. Edlin) that it was singular the prisoner should have been able to embezzle so large a sum of money without detection led to the statement that the prosecutor's books had been regularly audited by a first-class firm, but that nothing was discovered by the auditors. For the prisoner, it was stated that the money he had stolen had gone in maintaining a position which his salary did not justify, and that it was in consequence of information supplied by him that the large defalcations were ultimately discovered. The judge described the case as an extremely painful one, and in sentencing the prisoner to three years' penal servitude, gave it as his opinion that a sufficient and satisfactory audit of the books had not been made.

ROCHDALE.—An error appeared on page 222 of our last issue. It was incorrect to say that the tender of Messrs. Peers and Co., of Manchester, had been accepted for the lighting of the Free Library at Rochdale. Mr. George R. Peers is acting as consulting electrical engineer to the Corporation in this matter, and the sum of £500 given in the paragraph is the amount sanctioned by the Local Government Board to be expended on this work. Tenders are now being invited.

SHOREDITCH (LONDON).—The Vestry have decided to replace the lamps in the streets where the electric light mains are to be laid by 32 c.p. incandescents. The existing gas standards are to be utilised.

TELEGRAPHIC MONEY ORDERS.—It has been decided to extend the hours for the issuing and paying of telegraph money orders at all offices where business of this class is transacted from 8 a.m. to 8 p.m., inclusive of bank holidays.

TELEPHONE EXTENSIONS IN SCOTLAND.—In the House of Commons on Monday last, Mr. Hanbury stated, in reply to a question from Mr. McLeod, that the Postmaster-General had proposed to the Treasury to extend the telephone trunk lines as far north as Inverness. It was not at present possible to state approximately when the line would be opened, but no time would be lost in commencing the work when the necessary funds have been provided by Parliament.

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TELEPHONE TRUNK MESSAGES.—The Manchester Chamber of Commerce have decided to petition the Postal Department for an extension of time for trunk line telephone messages from three to five minutes, the fees to remain as now. Complaint is made that the greater portion of the time at present allowed for these messages is consumed in obtaining the attendance of the person at the other end.

TARIFF CHANGES.—Under the new Commercial Treaty between Japan and Germany telegraph wire is subject to an *ad valorem* duty of 5 per cent.

TRADE WITH JAPAN.—In a recent report to the Foreign Office on this subject Sir E. Satow (Her Majesty's Minister at Tokyo) states that there are few British firms in Japan who lay themselves out for supplying the demands of the Government, and the great railway, shipping and manufacturing firms of the country, as regards machinery, locomotives, railway material, metals, &c., but there are several native firms of the highest standing who devote almost their whole time and attention to it; and British manufacturers who desire to obtain extensive Government or other contracts are advised that their best course is to work in conjunction with these firms. It is also advisable to keep a technical expert on the spot who can furnish merchants with specifications of machinery that may be required. All contracts for Government work of the value of $500 and upwards are open to tender from traders in the country, an exception being made by the arsenals in some cases. No one is allowed to tender who has not had at least two years' experience in the particular branch of trade, and who does not pay $200 per annum in taxes. Tenders must always be accompanied with a deposit of 5 per cent., and a further deposit of 10 per cent. has to be made on the acceptance of a tender. The period for tendering is usually limited to a fortnight, and unless there is an expert on the spot considerable expense has to be incurred in telegraphing to England the full specification, and in addition great risk of misunderstandings is run. Manufacturers are warned that the conditions of contracts, and especially those of Government contracts, are rigorously enforced, and two cases are cited in support of this view, one where 450 tons out of 700 tons of galvanised iron telegraph wire, imported from Germany, were rejected because the wire had become slightly oxidised in places in transit, and in another case a quantity of telegraph wire was rejected because the diameter exceeded the figure of the specification by $\frac{3}{1000}$ths of an inch.

WEST AUSTRALIA.—The Westralian Electric Lighting and Supply Company (Limited) have received a telegram from Coolgardie, stating that electric lighting formally commenced on the 6th inst.

WEST HAM.—The Corporation are considering a proposal to apply to the Local Government Board for sanction to borrow £67,000 for the purpose of establishing electricity supply works.

WOOLWICH.—The Bath Committee of the Vestry are considering the question of lighting the public swimming and private baths electrically.

# COMPANIES' MEETINGS AND REPORTS.

## Electric and General Investment Company (Limited).

The seventh ordinary general meeting of the shareholders of the Electric and General Investment Company (Limited) was held at Winchester House, Old Broad-street, London, yesterday, Mr. George Herring presiding.

The SECRETARY (Mr. J. Cecil Bull) read the notice convening the meeting, the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN: Gentlemen, I do not think that I need occupy much of your time to-day—all the information that you want is really embodied in the report; but I shall be very happy to reply to any questions that may be asked as to any points not made clear in the accounts. The second paragraph in the report is the only one of real importance to you. It says that the profit and loss account shows a gross profit for the year amounting to £10,105, and that we set aside £2,222 by way of a provision for contingencies, leaving a net balance of £5,000 available for distribution. We then go on to tell you that we recommend that this sum should be applied to the payment of a further dividend at the rate of 30 per cent. per annum for the past six months, making, with the interim dividend, a distribution of 20 per cent. for the year upon the capital paid up on the Ordinary shares and a dividend on the Founders' shares of £20 per share for the year. The provision for contingencies is a question which I am sure must be uppermost in your minds. It means in plain language that the Directors have made a revaluation of the assets of the Company, and they consider themselves bound as an act of prudence to put aside the sum of money they have done against contingencies. No loss has been incurred in any shape or form. At the same time in a fluctuating business such as ours we have thought it better to be conservative in principle, and to face the future with ample funds in hand. The reserve fund for the Ordinary shares you have seen frequently in the accounts, and understand that the Founders' shares have no part in that. The amount under loan account is borrowed against certain securities. The item of "unclaimed dividends" I suppose belongs to some person too rich to care to call for a five-pound note. On the other side, we have investments set down at £72,102. As I have said before, they are valued at cost, not that they may be worth that amount, but then we have provided against any small depreciation or loss by the provision for contingencies. Sundry debtors amount to £8,784, while cash in hand and at the bankers is £1,150. In the profit and loss account you can see that interest, dividends, commissions, and sundry profits reach the sum of £10,105. I hope you will consider that the general charges, including Directors' fees, are very moderate in a business such as ours. We have done a great deal of work this past year, and certainly I consider, and I am sure that my colleagues are of the same opinion, that the remuneration we receive is very fairly earned. We thought it would be well on this occasion to tell you exactly how you stand in the matter of the Founders' shares, which, in plain language, amount to £110 each. Of course, I need scarcely remind you that the Ordinary shares are worth so much more in consequence of the reserve fund that we possess. He concluded by moving the adoption of the report and accounts.

Mr. J. B. BRAITHWAITE seconded the resolution, remarking that it would be of interest to the shareholders to know that for the present year the prospects of the Company's business were very good.

Mr. T. A. DENNY animadverted on the great disparity of the amount paid on the Ordinary and Founders' shares. He characterised as immoral the principle of issuing Founders' shares at all. It gave rise to a state of things that ought not to exist.

The CHAIRMAN, in reply, pointed out that Mr. Denny might give expression to his protest in an essay to some newspaper; but so far as the Directors were concerned, he could only say that they were acting in everything they did in accordance with the Articles of Association. The Directors' fees were fixed at £700; but in addition to that amount it was provided by the Articles that they should receive 10 per cent. on the profits made after a certain dividend on the Ordinary shares had been paid. It might seem strange to Mr. Denny that the founders should receive what they did, but it ought also to appear very strange to him that the Ordinary shareholders should receive so large a dividend as they did. He could only remind the meeting that it was owing to the founders and the work which they did that their property was so valuable. If it had not been for the founders he did not think that the Ordinary shares would now be worth as many shillings as they were worth pounds.

Mr. DENNY said that they were indebted to the Directors for that; not to the founders.

The CHAIRMAN replied that some of the Directors were founders. The Founders' shares were mentioned in the original prospectus of the Company.

The resolution was then carried unanimously.

The CHAIRMAN moved the payment of the dividend, and this was carried.

The re-election of Messrs. Herring and Van Tromp as directors, and of Mr. G. T. Rait as auditor was then agreed to.

On the motion of Mr. MORSE, seconded by Mr. TARRY, a vote of thanks was passed to the Chairman and Directors, for which the former briefly expressed his thanks, and the proceedings ended.

## Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited).

The seventh annual meeting of shareholders in this Company was held in London on Wednesday, under the presidency of Mr. F. L. RAWSON, who said that the profit and loss account was given for two years instead of one year, as twelve months ago the Company was in a very difficult position—from which it had (he said) satisfactorily emerged. The Company was now practically free from debt. With regard to the amount owing to the Directors for fees, &c., he was prepared to take some of the securities held by the Company at par, and no doubt other Directors would also do so in order to wipe off this obligation. The result of the appointment of a receiver has been that, by getting a reduction in settlement of accounts with the ordinary creditors, they made a net profit of £698. 10s. 9d. The amounts paid for carrying on the Company, with the exception of the amounts for maintenance of patents, had been but nominal, nearly all the work having been done by the Directors themselves. With the exception of the patent fees and the Directors' fees, the cost of carrying on the Company was at present extremely small, and now that the Company has been got into safety again, and the work of the Directors was not so onerous, they could again reduce the Directors' fees. The progress of the Elmore companies was comparatively slow, but it was sure, and it is only want of money that has prevented large extensions of the business. Since their report was sent out the turnover of the Copper Company had again increased by over 10 per cent.; the average selling price was about 7 per cent. higher, whilst the working expenses were less, and the manufacturing profit considerably more. With regard to the German Company, the sales continued to increase, being 50 per cent. more now than they were at this time last year, and they have this week given the order for an extension of their plant by 50 per cent. They had no very full particulars with regard to the French Company. The Wire Company, which also manufactures copper sheet, was constantly opening new accounts, and their superior product was gradually securing a better price than that of the ordinary article. Their attention had been called to the Demoulin system of deposition. He had come to the conclusion that the Demoulin patent was an absolutely worthless document. The inventor claimed that, by coating the surface of the copper as it is being deposited with grease, he gets a better tube, as the molecules of copper are not deposited on the projecting molecules first deposited, which are covered by the grease; but they are deposited in the interstices until they become level with the projecting molecules. He (the Chairman) was certain that this process would work better without any grease, which can be no improvement and in my opinion the improved result claimed over ordinary deposited copper is simply due

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to the fact that he uses something in the bath which acts a rubber or burnisher. It was originally well known to the Elmores that even such a substance as a piece of leather or felt pressed against a revolving tube would considerably improve the quality of the deposited copper, and this was fully covered in the Elmore patents. There is the objection, however, that the copper continually wears away any soft substance, the particles remaining in the bath, where they do harm. With the Elmore process, as now worked, the agate which acts as a burnisher is so hard that there is no objection on this score. If the Demoulin improvement is due to the burnishing effect, and not to the grease, then it is unquestionably an infringement of the Elmore patent. Even if the Demoulin process were not an infringement of the Elmore patent, and the application of the grease had been an advantage, those working the process would be in the same position as the Elmores were five years ago, namely, with all their difficulties before them, only they would have this trouble in addition, that all the readiest means for getting over the difficulties that have arisen in copper mandrils by electro-depositing have been patented by the various Elmore companies, and they would find it extremely difficult, even if it were possible, to invent other means of getting over them. The Elmores got over the objections to this by the copper mandril and the compound mandril. The owners of the Demoulin process have to discover some other method of getting over this difficulty, and it would be many years before they could get the process at work on a commercial scale, even if the Demoulin process or patent is any good.

Mr. JULIUS RUNGES said there were several things about the balance sheet which he did not like. Debentures to the amount of £3,000 had been issued. He moved that the accounts be received but not adopted, and that a committee of shareholders be appointed to investigate the affairs of the Company and report to an adjourned meeting.

The CHAIRMAN said that if the amendment were passed the Directors would regard it as a vote of censure. They would, however, give the shareholders the fullest information.

A discussion followed, but ultimately the amendment was not pressed, and the motion adopting the report and accounts was carried, with two dissentients.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**BRITISH MOTOR CARRIAGE AND CYCLE COMPANY (LIMITED).**—This Company was registered, on June 5th, with a capital of £200,000, in £1 shares, to acquire, develop, work and deal with every description of motors, cycles, vehicles, ships, boats, launches, flying machines, and carriages, and to carry on the business of motor carriage, &c., builders, electricians, electrical and mechanical engineers, machinists, &c.

**DAY AND NIGHT ADVERTISING COMPANY (LIMITED).**—This Company was registered on June 10th, with a capital of £5.000, in £1 shares, to acquire certain letters patent relating to the invention known as "Upward's surface changing machine," to enter into an agreement with Messrs. A. R. Upward and R. Dalmar, and to carry on the business of electrical, other advertising, and electrical engineering in all its branches.

**LLANDRINDOD WELLS ELECTRIC LIGHT AND POWER COMPANY (LIMITED).**—This Company was registered on June 15th, with a capital of £5.000, in £5 shares, to carry on in Llandrindod Wells, Radnor, the business of an electric lighting company in all its branches, to supply electricity for lighting the roads, streets, public places and public buildings in the district, and to carry on the business of electrical and mechanical engineers, and manufacturers of and dealers in electric, magnetic, telegraphic, and telephonic apparatus.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).**—The annual return to May 27th has been filed. The nominal capital of £1,300,000, in £10 shares, has been taken up, the full amount called and paid.

**WIGSTON ELECTRICAL AND ENGINEERING COMPANY (LIMITED).**—The annual return, made up to March 16th, has been filed. The capital is £25,000, divided into 2,000 Ordinary and 500 Preference shares of £10 each. 575 of the former have been taken up, and 200 have been issued as having £6 paid. £9 per share has been called on 375, and £3 per share on 200, resulting in the receipt of £3,895.

**WOKING ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return to May 6th has been filed. The nominal capital is £20,000, in £1 shares, of which 15,009 have been taken up. All of these have been issued as fully paid.

**WOOLWICH DISTRICT ELECTRIC LIGHT COMPANY (LIMITED).**—The annual return to March 17th has been filed. The nominal capital is £10,000, in £1 shares, and 9,250 of these have been taken up. 668 have been issued as fully paid, and the full amount has been called on the remainder.

**GREENWOOD AND BATLEY (LIMITED).**—The report of the Directors of this Company for the year ended 31st March last states that after providing for debenture interest and expenses of management, writing off £5,000 for depreciation, and providing £650 for doubtful accounts and allowances, there is a net profit of £11,576, and adding balance from last year, there is a sum of £12,045 available for division. The Directors recommend that a dividend of 10½ per cent., being 7 per cent. cumulative dividend for the year 1893-94 and half of the sum in arrear for the year 1894-95, should be paid on the Preference shares, which will absorb £10,541, leaving a balance of £1,504 to carry forward.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31 7/8d. per oz. (June 18th). Consols (2¾ per cent.) 112⅝—112¾ for money, 112¾—112⅞ for account; 2½ per cent. 106¼—107 (June 18th). Stock Exchange Settling Days: Consols, July 1st; Stocks and Shares Continuation Days, June 24th and July 15th; Ticket Day, June 25th; Pay Day, June 26th; Mining Share Carry-over Days, June 23rd and July 11th.

**AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).**—The coupons on this Company's Four per Cent. Mortgage Debentures, due on July 1st, will be paid on and after that date at Parr's Bank (Limited), Bartholomew-lane, London, E.C., and the debenture register will be closed from the 24th to the 30th inst. Coupons should be left three clear days for examination.

**BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).**—The transfer books of the Four and a-Half per Cent. Second Debenture Stock of this Company are closed from the 18th inst. to 2nd prox. inclusive, to prepare for the payment of interest on July 1st.

**CALLS DUE.**—The Directors of the Central London Railway Company (Limited) have made a call of £2 per share, payable on September 1 next.

**CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).**—The transfer books of this Company will be closed from June 16th to 30th inclusive, for the payment of interest on Debenture stock and interim dividend on Preference shares for the half-year ending 30th inst.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended June 14th were £877, against £862 in the corresponding week of 1895, an increase of £15. The total receipts for the half-year amount to £22.342, against £22,299 for the corresponding period of 1895, an increase of £43.

**CONTINENTAL METROPOLITAN TRAMWAYS COMPANY (LIMITED).**—At the extraordinary meeting of this Company, held on Wednesday, for the purpose of considering a resolution approving a provisional agreement entered into with the Compagnie Française pour l'Exploitation des Procédés Thomson-Houston, and empowering the Directors to carry same into effect, the Chairman (Mr. B. H. Van Tromp) stated that the French Thomson-Houston Company, who had purchased and equipped the Havre and Rouen tramways on the overhead electrical system, were anxious to commence operations in Paris on an extensive scale, and they had offered them £392,800 for their undertaking. The Thomson-Houston Company would also take over the bonds or obligations entered into in Paris by them, and as £100,000 was still due on these bonds, they were really getting nearly £500,000 for their property. The resolution was adopted, and the distribution of the money amongst the shareholders will be as follows:—£5. 10s. per share to the Preference, £5 to the Preferred Ordinary, and £3 to the Ordinary.

**DEMOULIN'S COPPER PROCESS.**—It is stated that the Rio Tinto Company has acquired the option for one year of purchasing the English patents connected with M. Demoulin's system for treating copper ore by electricity

**GREAT NORTHERN TELEGRAPH COMPANY.**—Coupons falling due on July 1st next on this Company's shares should be presented for payment between 11 and 2 at Messrs. C. J. Hambro and Son's Office, 70, Old Broad-street, E.C. Coupons three clear days for examination.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 14th inst. amounted to £1,176. The amount for the corresponding week last year was £1,268; decrease, £92.

**METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).**—An extraordinary general meeting of the shareholders of this Company will be held at Winchester House, Old Broad-street, London, on Tuesday next, the 23rd inst., at noon, to consider the recommendation of the Board of Directors that the capital of the Company be increased to £1,000,000 by the creation of 50.000 shares of £10 each, and (if thought fit) to pass a resolution in accordance with this recommendation.

**MIDDLESBOROUGH (U.S.A.) TOWN AND LANDS COMPANY (LIMITED).**—At the general meeting of this Company last week the Chairman (Mr. Henry Partridge), in referring to the condition of the subsidiary companies, said that the Electric Lighting Corporation, which he referred to last year as being one little bright spot in Middlesborough, was now doing still better. The demand for current was increasing, additional lamps being connected monthly, and the Corporation was now working at a profit.

**NATIONAL TEELPHONE COMPANY (LIMITED).**—The transfer books of the Three and a-Half per Cent. Debenture Stock of this Company will be closed from the 22nd to the 30th inst. inclusive, for the preparation of the warrants for the half-year's interest due July 1st.

**PACIFIC AND EUROPEAN TELEGRAPH COMPANY (LIMITED).**—The coupons on this Company's Four per Cent. Guaranteed Debentures, due for payment on the 30th inst., will be paid on and after that day at Parr's Banking Company and the Alliance Bank, Bartholomew-lane, E.C.

**WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).**—The coupons due 30th instant on the debentures of this Company will be paid by Messrs. Barclay and Co., Lombard-street, E.C., and should be left three days for examination.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended June 12th, after deducting 17 per cent of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,009.

**CRICKET.**—HEAD OFFICE EASTERN TELEGRAPH COMPANY v. COMPANIES' SHIPS.—On Wednesday, on the West London Cricket Ground, this match was played, and was won on the first innings by Head Office by 191 runs and 1 wicket, S. Wells being responsible for 113 runs, not out, and A. Jack 52 runs. Score: First innings—Head Office, 241; Ships, 50. Second innings—Ships, 101 for 8 wickets, Capt. Greey making 35 runs for his side.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, June 10. | | Price Wednesday, June 17. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending June 13. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS** | | | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 47 | 49 | 47 | 49 | 5 2 0 | Jan., Apr., July, Oct. | 48½ | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 91 | 92 | 92 | 93 | 5 1 6 | " " | 92½ | 91 |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 8¾ | 9¼ | 8¾ | 9¼ | .. | .. | .. | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 | 104 | 100 | 104 | 3 18 1 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10 | 11 | 10 | 11 | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15 | 15½ | 15 | 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15 5/16 | 15⅛ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 | 117 | 113 | 117 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | $1½ | Commercial Cable Capital Stock | 160 | 170 | 160 | 170 | 4 3 6 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 | 13 | 12 | 13 | 6 3 1 | February and August | 12¾ | 12½ |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 19½ | 20½ | 19½ | 20½ | 4 17 7 | " " | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 4 | 5 | 4 | 5 | 4 0 0 | April and October | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 | 10½ | 10 | 10½ | 4 15 3 | " " | 10½ | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 106% | 109% | 107% | 110% | 4 3 6 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ | 10 | 9½ | 10 | 4 0 0 | Jan., Apr., July, Oct. | .. | .. |
| 400,000 | 10 | 2/6 | Eastern | 17 | 17½ | 17 | 17½ | 3 14 4 | " " | 17⅝ | 17½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ | 18¾ | 18½ | 18¾ | 3 4 0 | " " | 18¾ | 18½ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 | 134 | 131 | 134 | 2 19 11 | May and November | 132¾ | 131½ |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 | 109 | 106 | 109 | 4 13 3 | February & August | .. | .. |
| 250,000 | 10 | 6/6 | Eastern Extension | 17½ | 18 | 17½ | 18 | 3 17 9 | Jan., Apr., July, Oct. | 17⅝ | 17 7/16 |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 132 | 135 | 132 | 135 | 3 0 2 | February & August | 134 | 133 |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 101 | 105 | 101 | 105 | 4 17 4 | January and July | .. | .. |
| £30,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb., 1900 | 101 | 105 | 101 | 105 | 4 17 4 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 | 108 | 105 | 108 | 3 14 11 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 110% | 113% | 110% | 113% | 3 11 1 | May and November | .. | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust | 10½ | 11 | 10½ | 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅝ | 10 5/16 |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17 | 17½ | 17 | 17½ | 3 8 7 | " " | 17⅝ | 17½ |
| 150,000 | 10 | 10/0 | Great Northern | 23½ | 24½ | 23½ | 24½ | 4 1 8 | Jan., April, and July | 23⅝ | 23⅜ |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 | 107 | 104 | 107 | 4 14 7 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 52 | 55 | 52 | 55 | 4 10 11 | May and November | .. | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | .. | .. | .. | .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 | 112 | 110 | 113 | 5 7 7 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 | 111 | 108 | 111 | 3 13 3 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 6½ | 7½ | 6½ | 7½ | 5 8 1 | April and October | .. | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 135 | 140 | 135 | 140 | 4 5 9 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph xd | 7½ | 8½ | 7 | 8 | .. | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 103 | 106 | 103 | 106 | 4 15 6 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 | 2 | 1 | 2 | .. | January and July | 101 | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 100 | 105 | 102 | 107 | 7 15 4 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1 | 1½ | 1 | 1½ | .. | " " | 1½ | 1 5/16 |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11 | 11½ | 11½ | 11⅝ | 5 2 2 | May and November | 11½ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ | 10½ | 9½ | 10½ | 5 14 3 | " " | 10⅜ | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 109 | 112 | 109 | 112 | 4 11 1 | June and December | 111 | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian | 9 | 9½ | 9½ | 9¾ | 4 12 4 | May and November | 9½ | 9½ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7½ | 6¾ | 7½ | 5 3 8 | " " | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ | 3 | 2½ | 3 | .. | " " | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 105 | 109 | 105 | 109 | 5 12 2 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 105 | 109 | 105 | 109 | 5 12 2 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 | 115 | 110 | 115 | 6 2 3 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 | 105 | 102 | 105 | 5 15 11 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 44,000 | 5 | 2/6 | Chill Telephone (fully paid) | 3 | 3½ | 3 | 3½ | .. | " | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/16 | 1/8 | 1/16 | 1/8 | .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | 5/16 | 1/4 | 5/16 | 1/4 | .. | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7½ | 8 | 7½ | 7¾ | 3 9 10 | June and December | 7⅞ | 7½ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 | 18 | 16 | 18 | 3 6 8 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16½ | 17½ | 16½ | 17½ | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6¾ | 7 | 6¾ | 7 | 3 11 5 | " " | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 | 110 | 107 | 110 | 3 4 6 | January and July | 108½ | .. |
| 58,000 | 5 | .. | United River Plate | 3½ | 4 | 3½ | 4 | .. | " " | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 100 | 105 | 100 | 105 | 4 17 1 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ | 15½ | 14½ | 15½ | 3 4 6 | " | 15½ | .. |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ | 17 | 16½ | 17 | 3 10 7 | " | 16 15/16 | 16⅝ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 | 138 | 134 | 138 | 2 13 8 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. | .. | .. | .. | .. | " | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 8¼ | 8¾ | 8¼ | 8¾ | .. | " | 8⅝ | .. |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. | .. | .. | .. | .. | " | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8½ | 9½ | 8½ | 9½ | .. | " | .. | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ | 13½ | 12½ | 13½ | 4 8 11 | " | 13 | .. |
| 8,322 | £5 | .. | House-to-House Electric | .. | .. | .. | .. | .. | " | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. | .. | .. | .. | .. | " | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. | .. | .. | .. | .. | January and July | .. | .. |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 8 | 8¼ | 8 | 8¼ | 3 12 9 | " | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | .. | .. | .. | .. | .. | " | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13½ | 14½ | 13½ | 14½ | 2 15 2 | " | 13½ | .. |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 | 123 | 120 | 123 | 3 14 5 | June and December | 122⅜ | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9 | 9½ | 9½ | 9⅞ | .. | " | .. | .. |
| .. | .. | .. | Rand Electric | .. | ⅜ | ⅜ | ½ prem. | .. | " | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 10¾ | 11½ | 11 | 11½ | .. | " | 11 | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 | 11 | 9½ | 10½ | 3 3 7 | " | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9½ | 10 | 9½ | 10½ | 3 10 0 | " | 9 15/16 | 9⅞ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1½ | 1⅝ | 1½ | 1⅝ | 5 8 8 | " | 1 7/16 | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1½ | 1⅝ | 1½ | 1⅝ | 6 17 2 | " | 1⅝ | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 | 114 | 111 | 114 | 4 0 0 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 | 2½ | 2 | 2½ | .. | January and July | 2 | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1½ | 1⅝ | 1½ | 1⅝ | 8 16 11 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 104 | 107 | 105 | 108 | 4 5 1 | January and July | 106 | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. | .. | .. | .. | .. | " | .. | .. |
| 110,000 | 2 | .. | Electric Construction | 1½ | 1⅝ | 1½ | 1½ | .. | " | .. | .. |
| 12,845 | 2 | 2/9½ | Do. 7 per Cent. Cumulative Pref. | 2½ | 3 | 2½ | 3 | 4 13 4 | September | 2 1/16 | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅜ | ½ | ⅜ | ½ | .. | " | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. | .. | .. | .. | .. | " | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23 | 24 | 23 | 24 | 4 3 4 | February & August | 23⅝ | 23½ |
| £200,000 | 100 | .. | * Do. 4 per Cent. Debentures | 105 | 107 | 105 | 107 | 3 14 9 | March & September | .. | .. |
| 15,995 | £10 | .. | International Okonite Ordinary | .. | .. | .. | .. | .. | " | .. | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. | .. | .. | .. | .. | December and June | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | 1/16 | 1/8 | ¼ | ⅜ | .. | " | .. | .. |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 | 41 | 38 | 41 | 4 7 10 | March and July | 40⅛ | 39 |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 104 | 107 | 104 | 107 | 4 15 3 | January and July | .. | .. |
| 37,514 | £5 | .. | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. | .. | .. | .. | .. | " | .. | .. |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. | .. | .. | .. | .. | " | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16 | 17 | 16½ | 17½ | 4 11 5 | March & September | 16 15/16 | 16⅞ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 17 | 18 | 17 | 18 | 3 17 9 | " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 | 114 | 109 | 114 | 4 0 0 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 42 | 44 | 42 | 44 | 2 16 10 | January and July | 43¾ | .. |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14¾ | 15½ | 14¾ | 15½ | 3 6 5 | " | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 135 | 137 | 135 | 137 | 2 18 5 | May and November | .. | .. |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway | 13 1/16 | 14 1/16 | 14 | 14½ | 2 2 10 | " | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 17½ | 17⅞ | 17½ | 17⅞ | 2 16 10 | " | .. | .. |
| 125,000 | Stock | 4% | Do. 4% Debenture | 114½ | 116½ | 114½ | 116½ | 3 10 10 | January and July | .. | .. |

In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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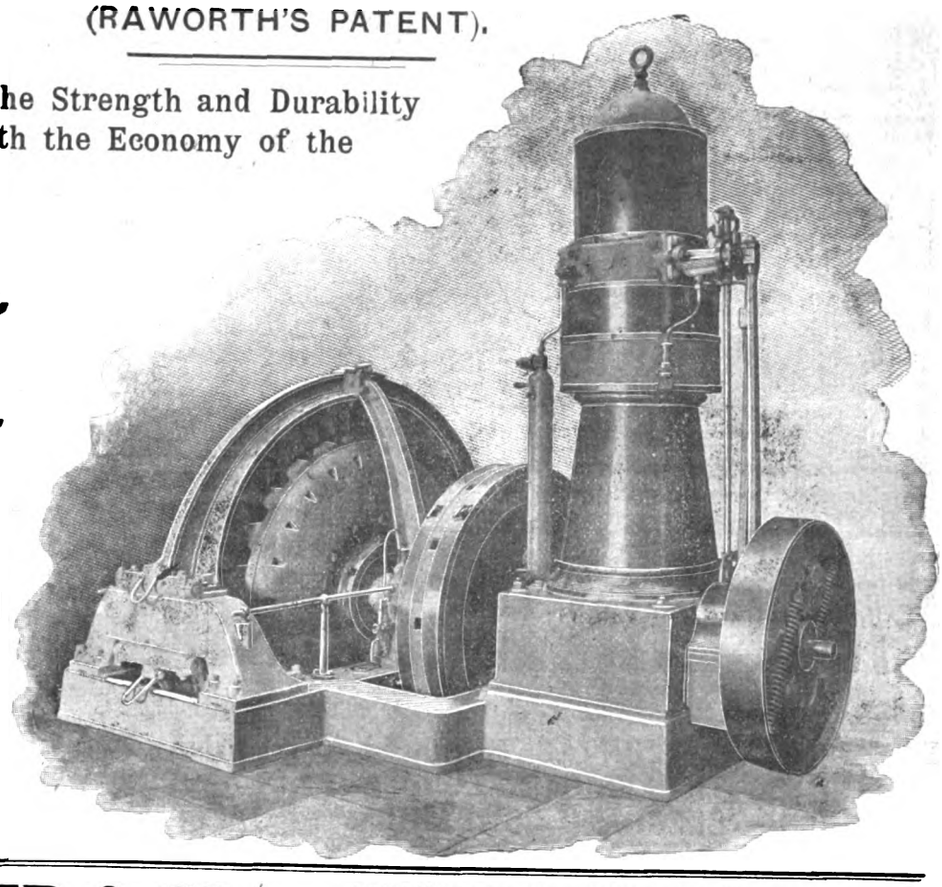

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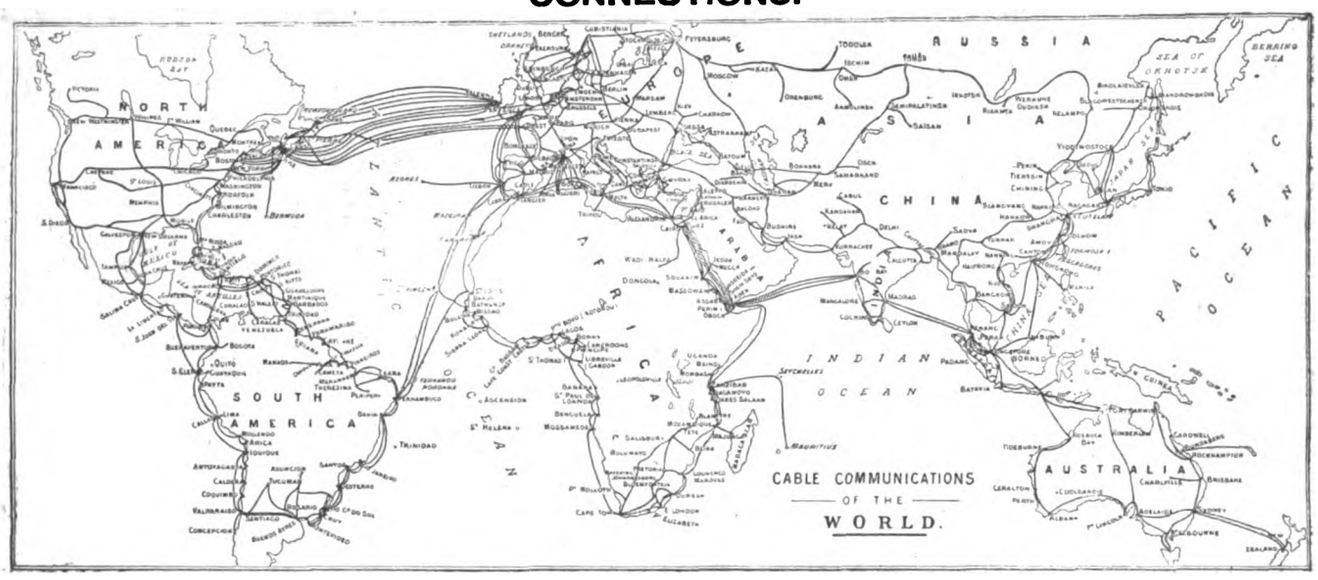
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.

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By order of the Vestry of the Parish of St. Mary, Battersea,
W. MARCUS WILKINS, Vestry Clerk.

Municipal Buildings, Lavender Hill, S W.,
23rd June, 1896.

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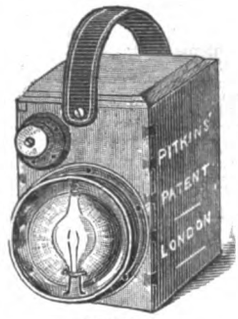

FIG. 1A.

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THE ABSENCE OF FACTS ABOUT THE NICARAGUA CANAL—Charles B. Going.
RELATION OF ELECTRICAL TO MECHANICAL ENGINEERING—Elias E. Ries.
THE DOMESTIC ARCHITECTURE OF WASHINGTON CITY—Glenn Brown.
RECENT IMPROVEMENTS IN GOLD MILLING—H. M. Chance.
MODERN MACHINE SHOP ECONOMICS. III.—Horace L. Arnold.
THE ELECTRIC VERSUS THE HYDRAULIC ELEVATOR—W. Baxter, jun.
BANK REVETMENT OF THE MISSISSIPPI RIVER—H. St. L. Coppée.
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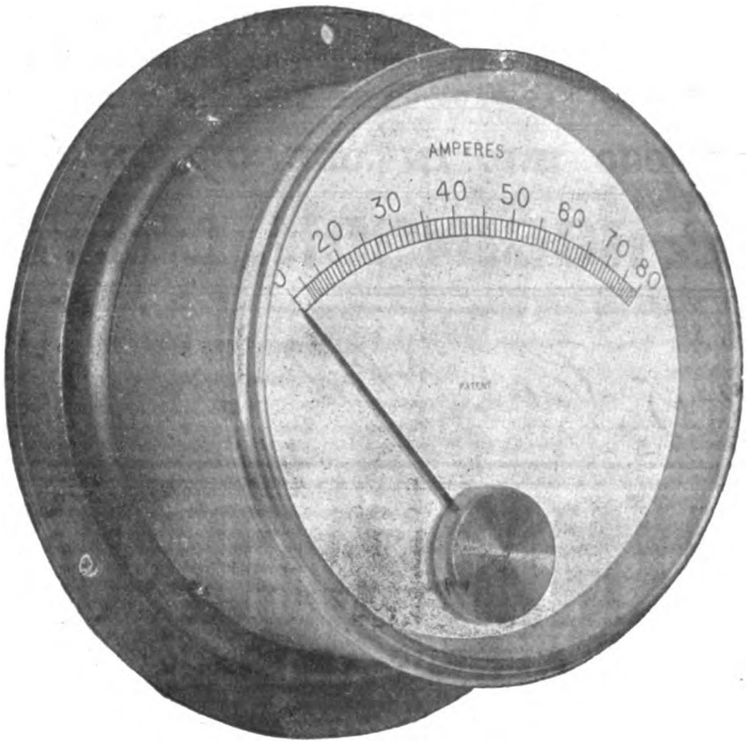


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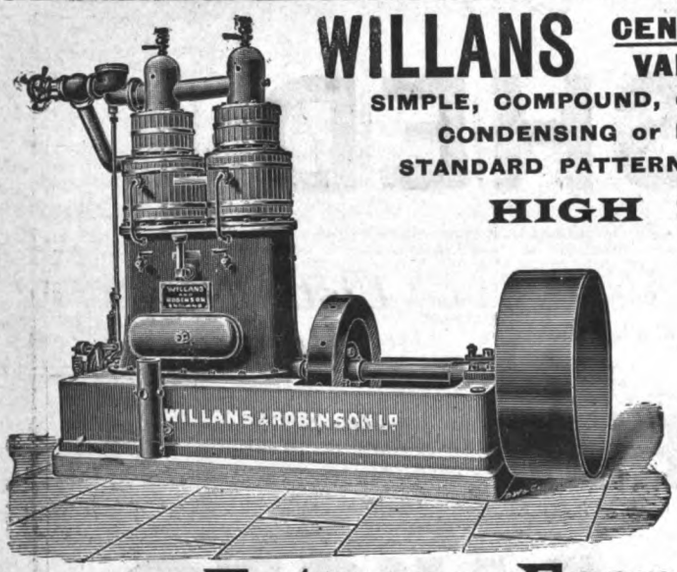


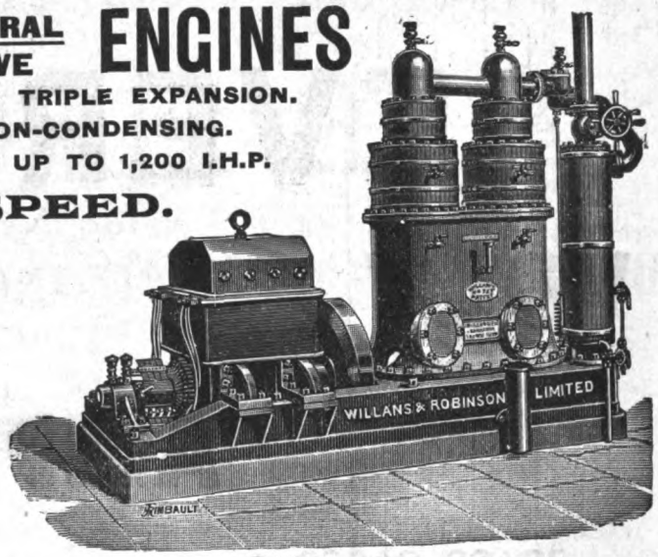


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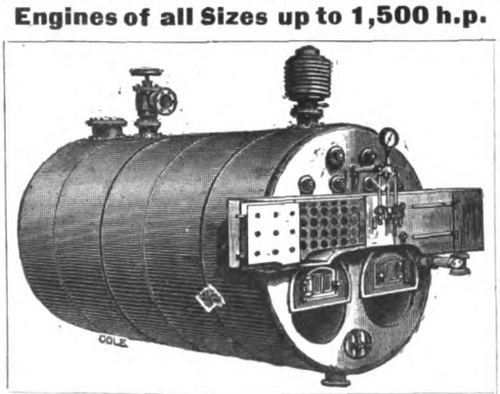


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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 945. [Vol. XXXVII. No. 9.] FRIDAY, JUNE 26, 1896. PRICE SIXPENCE.


## NOTES.

It is announced as we go to press that the Albert Medal of the Society of Arts has been awarded to Prof. D. E. Hughes, "in recognition of the services he has rendered to arts, manufactures and commerce by his numerous inventions in electricity and magnetism, especially the printing telegraph and the microphone." We offer our cordial congratulations to this veteran experimentalist; the Albert Medal has never been more honourably won.

For physicists of the teleological persuasion we can imagine no more powerful argument than that afforded by the existence of anomalous substances. Are they not evidently designed to prevent premature generalisation? If this view of the matter be correct we owe a debt of gratitude to bismuth, which, ever since 1778, when Brugmans of Leyden discovered its peculiar behaviour in the magnetic field, has never ceased to give investigators further tastes of its singularly anomalous disposition. Bismuth might indeed be taken as a standard test for truth. A theory which fits the facts so far as bismuth is concerned, proclaims itself hall-marked.

In another column will be found a communication of exceeding interest from Dr. Fleming with regard to the increase in the resistance of a bismuth wire when cooled to −186°C. in a magnetic field of some 14,000 units. At his recent Friday evening discourse Dr. Fleming announced that the resistance of electrolytic bismuth, exposed when at the temperature of liquid air, to a field of 2,750 units, increased about 4½ times. To-day he announces that with a field of 14,150 units the resistance increases more than 42 times. Now the resistance curve of electrolytic bismuth has been found to make straight for zero at the absolute zero of temperature. These two facts would appear to indicate that pure bismuth, a perfect conductor at the absolute zero of temperature, could be converted at that temperature into a perfect insulator if placed in a sufficiently strong magnetic field.

Dr. Fleming and Prof. Dewar are continuing their researches, and we may anticipate that before long they will be in a position to tell the world something about the alteration in the value of $\mu$ brought about by low temperature. If it were found that the diamagnetism of bismuth at −186 C. increased in much the same proportion as does the resistance of a wire at that temperature when exposed to a powerful magnetic field, we should have a valuable piece of experimental evidence in support of the connection believed by some to exist between the two phenomena. "A science," says J. S. Mill, "is experimental in proportion as every new case, which presents any peculiar features, stands in need of a new set of observations and experiments—a fresh induction. It is deductive, in proportion as it can draw conclusions, respecting cases of a new kind, by processes which bring those cases under old inductions. . . ." In the matter of low temperature phenomena it is evident that we still remain in the purely empirical stage.

An extraordinary hypothesis of the inertia of matter is put forward by Messrs. Houston and Kennelly, in the *Electrical World*, of New York. Starting with the fact that a magnet field moved in the ether, or an electric charge similarly moved, exhibits a quasi-inertia, the authors of this hypothesis assume that "the inertia of matter may possibly be accounted for by regarding matter as composed of molecular dynamos having closed circuits through the ether. These molecules have powerful electric charges, and it is the motion of these charges through the ether that generates a magnetic flux proportionate to the velocity." No attempt is made to evaluate the electrification which would be necessary on this hypothesis to account for the amount of inertia which ordinary matter exhibits, and it is probable that the hypothesis would not stand such a close quantitative examination. The difficulty that a moving magnet or electric charge only develops quasi-inertia in polarised space is got over by assuming that it is impossible to orientate the molecules of matter. If this could be done—as surely it is when a piece of iron is strongly magnetised—the body would possess no inertia along some one axis! We think that the mystery which Messrs. Houston and Kennelly say surrounds the inertia of matter is not appreciably dissolved by an hypothesis so much in conflict with known facts. We should be sorry to assert that either mass-inertia or gravitation were independent of the electrical condition of atoms or molecules, but if any connection exist, it must be different in kind from that outlined above.

In another column will be found an abstract of an elaborate communication recently made to the *Physical Review* by Mr. Clayton H. Sharp. The main object of this Paper is to point out that if the candle-power of a "standard candle" be reckoned from the height of the flame, instead, as is more

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usual, from the rate of consumption, the resulting liability to error is less. Of course, every lover of accuracy has long ago discarded candles; and now that, after years of labour, a 10-candle gas-standard has been authoritatively recommended for adoption, it may seem to some a work of supererogation to devote time and trouble to the discovery of the best way of using standard candles. However, Mr. SHARP's Paper supplies us with a number of very excellent reasons why standard candles should *not* be used, and hence serves a useful as well as a scientific purpose, since the faults of candles are neither so widely known nor so fully excogitated as they ought to be.

AFTER setting up the complex measuring apparatus indicated in Fig. 2, and after taking a great number of precautions, the reader is informed that provided the candle has not recently suffered from a sudden drop in candle-power he may (O, most lame and impotent conclusion!) have some reason to hope that the error is less than 2 per cent., and is not likely to exceed 4 per cent. But, as we have hinted before, all this does not lessen the scientific value of Mr. SHARP's work, nor, indeed, does it adversely affect its utilitarian worth; on the contrary, Mr. SHARP's Paper should prove extremely useful to practical photometrists, showing, as it does, in quite unmistakable manner, the limitations of the standard candle.

FOR reasons which lie below the surface, if they exist at all, the polyphase system of power distribution has not been taken up by electric supply concerns in this country. Perhaps the apparent demand for motors is not sufficiently tempting, and the supply companies are inclined to adopt the practice of the capitalist who wanted to see the orders on the books before he would risk his money in building a factory. At any rate, if a consumer on an alternate-current system wishes for motive power he must be content with single-phase motors, and these are not always possessed of endearing qualities. Recently, however, Profs. G. FERRARIS and R. ARNÒ have devised a system by which polyphase currents may be obtained from a "phase transformer" placed on single-phase mains. By this means a subsidiary portion of the network of mains may be fed with polyphase currents, while the larger portion is supplied with the usual brand of alternate current. Since the principal objection to alternate-current motors, on the part of supply-station engineers, has arisen from the excessive idle currents developed, it may happen that the use of a phase transformer for the motor section of the load will enable more satisfactory results to be obtained.

THE London tramway question is without a doubt at once momentous, and, thanks to the Tramway Act of 1870, tangled. Another certainty is the utter inadequacy of the present tramway system of London, and this, whether we regard the matter merely from the point of view of the "rapid transit" requirements of the biggest city the world has ever seen, or from the more sentimental point of view of what befits the dignity of the capital of the British Empire. But, admitting frankly the difficulty and complexity of the problem, it must be confessed that the solution apparently favoured by the Highways Committee of the London County Council is of the pettifogging species. We never suspected that the individual components of the County of London Tramways Syndicate were guilty of philanthropy, but whatever the profit which they proposed should accrue to themselves, their offer was not, on the face of it, unhandsome, and it conferred two crowning mercies: electric traction and unification. The complicated agreement which the London County Council decided on Tuesday, by 61 to 56 votes, to enter into with two tramway companies secures neither of these blessings, though it is true that there are clauses looking towards electric traction, as the Americans would say. The reasons, it would seem, which had most weight with the Highways Committee in inducing them to recommend the adoption of the agreement with the North Metropolitan and London Street Tramway Companies, were the greater immediate relief it afforded to the rates and the comparatively short term (14 years as against 21 or 28).

Now, however much the London rates may be relieved, Londoners will experience no relief; the relief fund, we may be sure, will always be intercepted on its way to their pockets. An efficient and an extended tramway system, on the other hand, would be a distinct and a tangible relief, and one which we venture to think would be appreciated, even though it were known that a few nefarious capitalists were being adequately remunerated for risks run. The truth is, our new municipal authority, in its fear lest any one but itself should make a profit, bids fair to indefinitely prolong the London tramway *imbroglio*, and to postpone the much-needed introduction of electric traction until horse-cars command a high price as museum "curios." Is it too late to suggest that the London County Council should appoint a carefully-chosen well-paid Commission to take the whole tramway question of the Metropolis into consideration, both from the financial and from the engineering standpoint, and to draw up a definite and comprehensive scheme? And, further, would it be too much to ask the Council to adopt *sans phrases* the policy advocated by this Commission? Imperfect as any human plan must of necessity be, such a scheme would have every chance of being more in consonance with the exigencies of the situation than any emanating from that well-meaning but ill-assorted aggregation known as the London County Council.

THE Brighton Town Council seem bent on spending the profits of their electrical business in fighting no less formidable a personage than Her Majesty's Postmaster-General. The DUKE OF NORFOLK, in his official capacity, is determined that a certain overhead telegraph wire shall be run, and 28 members of the Brighton Town Council, in their official capacity, are equally determined that the aforesaid wire shall not be run. Hence veiled threats on the one hand "to bring the case before the proper tribunal" and a cheerful readiness on the part of the Works Committee to take it there. No one renders a more valuable public service, with less disturbance and disfigurement of our streets, and with less danger to our lives, than does Her Majesty's Postmaster-General, and it is to be hoped that the decision of the Brighton stipendiary will be such as to discourage further expenditure of the ratepayers' money in such an unreasonable adventure.

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**Society of Arts Medals.**—The Council of the Society of Arts have awarded a silver medal to Mr. A. A. Campbell Swinton for his Paper on "Röntgen's Photography of the Invisible."

**Cable Interruptions and Repair :—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Ceara—Maranham ..... | April 28, 1896 ... | June 18, 1896. |
| Puerto Plata—Martinique..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Cadiz—Teneriffe ..... | June 6, 1896 ... | — |
| Jamacia—Colon ..... | June 10, 1896 ... | — |

**City and Guilds of London Institute.**—The courses of instruction in engineering and chemistry at the Institute's colleges, Exhibition-road, S.W., and Leonard-street, Finsbury, E.C., commence in October, and the matriculation examination is held from September 21st to 24th. Some further particulars of the sessional arrangements 1896-97 will be found in our advertisement columns.

**Hard Carbon.**—M. Moisson is reported, according to *Nature*, to have discovered a substance harder than the diamond, in the form of a compound of carbon and boron, produced by heating boracic acid and carbon in an electric furnace at a temperature of 5,000deg. This compound is black and not unlike graphite in appearance. It will cut diamonds without difficulty, and it can be produced in pieces of any required size.

**Gallant Telegraphists.**—In the course of a recent stiff fight between a rescue party and the Mashonas, telegraph operators Blakeston and Routledge were killed early while making a gallant sortie to reach the telegraph office in order to communicate the position of affairs to Fort Salisbury. Mr. Blakeston was a son of Rev. D. J. Blakeston, vicar of East Grinstead, who has now lost three sons by violent deaths. Mr. Blakeston was just 29 years of age.

**Damage by Lightning.**—A violent thunderstorm which broke over Somerset and Dorset on Monday afternoon last week was, unfortunately, attended with loss of life both to cattle and human beings. At Henstridge the storm was most severe. A man named Alfred Burt, a groom in the employ of Mr. Merthyr Guest, of Inwood, was at work hoeing potatoes in his allotment near his cottage, when he sought shelter from the storm beneath a tree, with the steel portion of the hoe resting on his boot. He was struck by the lightning and killed. At Marnhull a man named Hunt, while engaged in mowing, was killed.

**The Students of the Institution of Electrical Engineers.**—By the kind permission of Major Cardew, a party of students of the Institution will visit the Board of Trade Standardising Laboratory, 8, Richmond-terrace, Whitehall, on Saturday, July 4th, at 11 a.m. The party is limited to 20. Students desirous of being of the party must write to that effect to the Honorary Secretary of the Students' Class (G. C. Allingham, Eldon House, Lyndhurst-road, Hampstead, N.W.), as soon as possible, and those who do not hear from him to the contrary may assume that they can be included in the party.

**Society of Arts.**—The Council of the Society of Arts are prepared to award, under the terms of the Benjamin Shaw Trust, a gold medal, or a prize of £20. The medal, under the conditions laid down by the testator, is to be given "for any discovery, invention, or newly-devised method for obviating or materially diminishing any risk to life, limb, or health, incidental to any industrial occupation, and not previously capable of being so obviated or diminished by any known and practically available means." Intending competitors should send in descriptions of their inventions not later than December 31, 1896, to the Secretary of the Society of Arts, Adelphi, London, W.C.

**New Polyphase Armature.**—At a recent meeting of the Elektrotechnischer Verein of Berlin, Herr Dolivo-Dobrowolsky showed a new type armature for three-phase motors. The armature resembles a compact and massive drum, the surface of which is provided with a large number of small radially cut grooves parallel to the axis. Into these grooves are pressed copper strips, which extend at both ends over the edge of the drum, and are there connected to copper rings. Herr Dobrowolsky states that this construction is electrically equal to the old one of the Allgemeine Elektricitäts Gesellschaft, which consisted of laminated iron, through which insulated copper bars are led.

**Parallel Carbon Arc Lamp.**—A novel type of arc lamp is made by the Nowotny Electric Company, of Cincinnati. The main features of the lamp are as follows:—The carbons are placed parallel to each other throughout their entire length. The carbons are flat, and the two flat sides are close to one another, the positive carbon being twice the diameter of the negative. The arc is kept at the tips of the carbons by the use of a magnetic field, the field being generated by a coil which lies in a plane parallel to the axes of both carbons. The carbon-holders and carbons are incased in a single glass globe to protect them from the access of fresh air, thus greatly prolonging the life of the carbons. The only moving part of the lamp is one carbon-holder, which is pivoted so as to move sufficiently to allow the carbons to come into contact at their tips, or to separate to the distance necessary. A single solenoid magnet is provided to draw up an arm, fastened to the pivoted carbon-holder so as to separate the carbons and form the arc. This lamp is manufactured for continuous and alternating current.

**The London County Council and the National Telephone Company.**—At the last meeting of the London County Council the following recommendation of the Bridges Committee was agreed to :—

"That the application of the National Telephone Company to lay a telephone wire through the Blackwall tunnel be granted, and that the solicitor be instructed to prepare an agreement embodying the following conditions:—That the Company do all work in and about the tunnel and its approaches at their sole cost and to the entire satisfaction of the chief engineer of the Council ; that an annual rent of £5 be paid by the Company for the use of the space occupied by the cables ; that a rent of £5 per annum be paid by the Company for each 50 pair cable ; that a revision of the rent paid be made every seven years ; that no claim for compensation be made by the Company on account of the wires or cables for electric lighting or other purposes which the Council may find it necessary to lay through the tunnel ; *that a free exchange wire be erected and maintained by the Company between the Council's offices on Northumberland-wharf and the Company's exchange ; that free private wires for telephonic purposes be erected and maintained by the Company between the offices at each end of the tunnel ;* and that the agreement be subject to six months' notice of termination on either side."

The italics are our own.

**Electric Ploughs.**—Within the last twelve months several experiments have been made by German firms to replace animal power by electrical power in agricultural operations. The German Government have now joined the ranks of experimenters, and are carrying out some extensive trials of electric ploughs at the Sillium estate, near the Upper Hartz. No figures have so far been published. Some information, however, has been furnished by the Union Electrical Company of Berlin, who have also made experiments with an electric ploughing apparatus. The power required for this machine was 11 kilowatts when ploughing a width of 24in. and a depth of 14in. at the rate of 88 yards per minute. The area ploughed in a 10 hours' working day at this rate would be 7½ acres. The apparatus is so arranged that parallel to the motor car there runs at the other side of the field a car carrying the other end of a wire rope. The plough is hauled along this rope to and fro, and both cars are slowly moved on. The greatest difficulty seems to lie in the fixing and moving of the pulley car. The pressure employed is 500 volts.

**Portable Electric Mining Equipment.**—To facilitate the introduction of electric mining machinery, and to enable the operator to judge from actual observation the merits of the system as compared with pick mining, the General Electric Company of America has devised a complete and compact portable power plant for temporary installation near the mine mouth. The generating plant occupies the interior of a box car 40ft. 8in. long, 8ft. wide, and about 9ft. high, and it consists of a water-tube boiler of 40 H.P. working at 100lb. pressure. It supplies steam to a high-speed automatic engine running at 300 revolutions, and exhausting into the boiler flue. The generator is a three-phase 75-kilowatt machine, wound for 550 volts, and running at 900 revolutions. It is belt-driven from the engine. A small bipolar generator serves as an exciter. There is also a switchboard equipped with the necessary switches, rheostats and measuring instruments. The coal cutter which forms a part of the plant is fitted with a 20 H.P. iron-clad polyphase motor. The cutter itself is a

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chain machine making a cut 3ft. wide, 6ft. deep and 4½in. high in about 3½ minutes. It withdraws in about 10 seconds. The consumption of power under ordinary conditions is between 6 and 7 H.P. Some recent tests showed the remarkable average of 7·6 runs or cuts per hour. Taking the depth of cut at 5½ft., the width 36in., and the thickness of the coal 5ft., for a period of two weeks, the average weight of coal undercut per hour was not less than 23 tons.

**Negative Resistance.**—"It is difficult," says the *Electrical World*, of New York, "to see the necessity for the introduction of the idea of negative resistance in the electric arc, notwithstanding the fact that under certain conditions a small increase in voltage is accompanied by a decrease in current, thereby making the ratio of potential difference to current expressed as $\delta V/\delta C$ a negative quantity. Owing to the fact that the conditions of counter E.M.F., resistance and temperature are entirely changed, due to the change in the terminal difference of potential, the expression $\delta V/\delta C$ does not necessarily represent a resistance, and inasmuch as the counter E.M.F. may be considered as consisting of two parts, one being a function of the temperature of volatilisation of the carbon, and therefore a constant for constant temperature, and the other depending upon a thermo electric couple consisting of the electrode and its vapour and dependent upon the difference in temperature between the electrodes, it would follow that these two components might be combined, and the resistance of the arc could then be expressed in the simple form applicable to motors. This form will then represent what may be strictly called a real resistance, in the overcoming of which heat is produced and not absorbed. The method employed by Messrs. Frith and Rodgers seems to be practically the same as that adopted by Mr. Freedman in his experiments, the results of which were published several months ago. These experiments, and, in fact, most others, seem to leave no room to doubt the existence of a counter E.M.F."

**International Catalogue of Science.**—A circular was recently issued by the Royal Society to the foreign and other delegates appointed in connection with the forthcoming International Conference on the subject of the preparation of a catalogue of scientific literature. It is proposed that the Conference shall be held at the rooms of the Royal Society, beginning on Tuesday, July 14th. One of the earliest acts of the gathering will be to appoint an organising committee to determine the mode of procedure (including the language or languages to be used at the Conference), the course of business and the way in which votes shall be recorded on occasions when it is necessary to have recourse to formal voting. The committee of the Royal Society hopes to be in a position to bring definite proposals before the Conference with regard to its main work. Meanwhile the circular submits certain provisional suggestions and invites remarks thereon. First of all it is proposed that the International Authors' and Subject Catalogue shall be restricted, in the first instance, to branches of pure science, such as mathematics, astronomy, physics, chemistry, geology, physiology, &c.; to the exclusion of applied sciences such as engineering, medicine and the like. Secondly, it is suggested that in the proposed catalogue *all* definite contributions to science shall be thoroughly indexed, in other words that the catalogue shall not be confined to papers published in certain periodicals or to books of a certain category. With regard to the form of the proposed catalogue it is suggested that there shall be a first issue of authors' titles, subject-matter, &c., in the form of *slips* or *cards*, which shall be distributed as speedily and as frequently as possible to subscribers generally. That a further issue in book form shall take place at intervals; parts corresponding to the several sciences being, if found necessary, published separately. It is further proposed that a Central Bureau shall be established under the control of an International Council; that the whole of the catalogue shall be prepared and issued subject to the authority of the International Council; that the cost of preparing and publishing the slip and book catalogues at the Central Bureau during the years 1900-1904, in so far as the cost is not met by sales, shall be provided for by means of a guarantee fund, and that applications shall be made to governments, learned societies, institutions and individuals throughout the world, to assist in establishing such a fund. The Conference will also have to take into consideration the following matters, amongst others:—(*a*) Supposing the plan of a Central Bureau be adopted, where shall the Bureau be placed? (*b*) The mode of appointment and organisation of the International Council in charge of the Bureau. (*c*) The language or languages to be adopted in the catalogue. (*d*) The system of classification to be adopted in the index. A rough estimate as to the guarantee fund required is £10,000 per annum.——In connection with this Conference, the President and Council of the Royal Society will give an "At Home," on Monday evening, July 13th, at Burlington House. On Tuesday evening the delegates will dine with the Royal Society at the Hotel Métropole, and on Wednesday they will be received at the Mansion House by the Lord Mayor. On the afternoon of Thursday, July 16th, Dr. and Mrs. Ludwig Mond will give a garden party. The total number of delegates amounts to forty.

**Contemporary Electrical Science.**—A novel method for measuring differences of potential and dielectric constants, and generally dealing with electrostatic phenomena has been worked out by Dr. L. Lombardi, after having been discovered some years ago by Messrs. Graetz and Fomm, of Munich. In a homogeneous electric field thin rods or plates of a conducting or dielectric substance, and generally of a shape not symmetrical with respect to the field, are subject to couples tending to place their greatest diameter parallel to the lines of force. In the case of an ellipsoid the electric polarisation is uniform, and the forces are calculable from the axes of the ellipsoid, the difference of potential between the limits of the field, and the dielectric constants of the medium and of the substance of the ellipsoid. Conversely any of these are calculable when the others are known. Prof. Lombardi, in a paper published in the Annual Report of the Zürich Physical Society for 1895, proves that differences of potential may be accurately determined by this method provided the body is a true ellipsoid or a very thin plate, and the field broad enough to prevent a sensible influence of the body upon the distribution of electrification. He produced a uniform field between two metallic plates enclosed in a metallic case. The couples exerted on copper, colophonum and ebonite discs were the same at some distance from the centre of the field in various directions, but increased by 50 per cent. near the plates. The same author, in the *Elettricista*, measures capacities of condensers by means of alternating currents of very approximately sinusoidal character. He finds that with ordinary frequencies the capacities are, as a rule, smaller than with steady charges. But the difference is intimately associated with other properties of the dielectric, and may be very small. An influence of the frequency upon the capacity was not traceable with certainty. The *Nuovo Cimento* for April contains a highly interesting Paper by Prof. A. Battelli on photographic action inside a Crookes tube, and on the magnetic deflection of the photographically active rays. He introduced a sensitive film wound on a cylinder, and protected by a double layer of black cardboard into the tube itself. Patterns made of various wires were placed over the film as negatives. The side facing the cathode was strongly affected in each case, that facing the anode *or the wall* very feebly or not at all. The differences in the shadowing capacities of the different metals were much less strongly marked than in air. All this goes to show that the cathode rays contain the Röntgen rays. Glass fibres also threw shadows on the film, instead of increasing the action, as might have been expected. Magnetic deflection experiments showed that most of the photographic rays were not deflected; but the deflected cathode rays also contained active elements. In the same number we find, embedded in a heap of other Röntgeniana, an abstract of a Paper by A. Sella and Q. Maiorana, on the reversal of the Hertz effect of ultra-violet light. Instead of aiding the passage of the spark in air, both Röntgen rays and ultra-violet light impede it, provided the sparking distance is great in comparison with the size of the knobs. When it is small both kinds of rays produce the Hertz effect, and at some intermediate position they produce no effect at all. But the strangest thing is that, whereas the Hertz effect is produced by the illumination of the negative pole, the new effect is produced by illumination of the positive pole, and that pole only

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## THE ELECTRICAL RESISTIVITY OF BISMUTH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A communication was made on Thursday last to the Royal Society by Prof. Dewar and myself in the form of a letter addressed to the President, of which the following is a copy:—

[COPY.]

The Royal Institution, Albemarle-street, London,
June 18, 1896.

To the President of the Royal Society.

DEAR SIR JOSEPH LISTER: In continuing our experiments on the electrical resistance of bismuth at low temperatures and in magnetic fields by the aid of a powerful electro-magnet kindly lent to us by Sir David Salomons, we have observed the fact that a wire of electrolytic bismuth, when cooled in liquid air to a temperature of −186°C., has its resistance increased more than 42 times, if it is at the same time transversely magnetised in a field of 14,000 units. The bismuth when cooled in liquid air and thus magnetised has its electrical resistance increased more than 15 times, even when compared with its resistance at ordinary temperature (19°C.) and not in a magnetic field. There is no reason to believe we have reached the limits of this increase. Reserving further details for a full communication to the Royal Society later, We remain, yours very truly,

(Signed) JAMES DEWAR.
J. A. FLEMING.

It may be interesting to give the exact figures of observation for the information of your readers. The wire of electrolytic bismuth had a resistance of 1·46 ohms at 19°C. when not in a magnetic field. If placed transversely to the field, in a field having a strength of 14,150 C.G.S. units, its resistance was increased to 2·34 ohms at 19°C. or 1·6 times. This, of course, is a well-known effect. If the same wire, however, was placed in liquid air and cooled to −186°C. its resistance fell to 0·53 ohm. If *then* placed transversely to the field in a field of 14,150 units, its resistance immediately increased to 22·4 ohms, or 42·2 times. Hence the bismuth cooled to −186°C. and in the field of 14,150 has a resistance 15·3 times greater than when at 19°C. and not in the field. There is a certain value of the field which just neutralises the diminishing effect of the cooling on the bismuth resistance and leaves the wire when cooled in liquid air, and in the field, of the same resistance as when not cooled and not in the field.—Yours, &c.,

University College, London, J. A. FLEMING.
June 20, 1896

## A NEW LORENZ APPARATUS.

A new set of apparatus for the determination of resistance in absolute measure, by the method of Lorenz, has been designed and carried out by Messrs. Nalder Bros. and Co., of Clerkenwell, for Prof. Callendar, of McGill University, Montreal, under the supervision of Prof. Viriamu Jones, F.R.S., of the University College, Cardiff, who has had so much experience of this method, and has contributed several Papers to the Royal and Physical Societies on the subject.

The method, as is well-known, consists in rotating a disc of metal in the field of force due to a current-carrying coil, the E.M.F. induced in the disc being varied by varying the rate of rotation until it is equal to the P.D. at the terminals of the resistance to be measured when the same current passes through it and the coil. The connections are shown in Fig. 1. If M be the coefficient of mutual induction of the disc and coil, and C the current, then M C is the number of lines passing through the disc when current C flows round the coil. This number of lines is cut once by every radius of the disc at each revolution, and consequently, if the disc make $n$ revolutions per second, the number of lines cut per second, which is the E.M.F. between the centre and edge of the disc, will be M C $n$, but since the same current C passes through the resistance R, the P.D. at its terminals will be C R. Hence, since these are made equal, M C $n$ = C R or R = M $n$.

It is thus seen that the resistance is measured directly in terms of the coefficient of mutual induction, which is a constant of the apparatus, and the speed of the disc, and in conformity with electro-magnetic theory it is expressed as the product of a length M $c$ $m$ and the reciprocal of a time $n$/secs. or a velocity expressed in $c$ $m$/secs. The apparatus has thus to be constructed so that the coefficient of mutual induction of the coil and disc may be capable of calculation, and must be provided with a means of measuring the speed of rotation of the disc.

*The Coefficient of Mutual Induction.*—In order to determine resistance accurately, the coefficient of mutual induction must be very accurately determined, which involves a very exact knowledge of the dimensions of the coil and disc, and of their relative position.

*The Standard Coil.*—Prof. Viriamu Jones* in his own apparatus has adopted the use of a cylindrical coil, having a helix of wire of one layer wound on it. This form was adopted, since the dimensions could be more accurately determined, compression of inner layers being avoided, and because Prof. Jones found it possible to establish a very exact series for the calculation of the mutual induction of a circle and coaxial helix.† In Prof. Jones's apparatus the coil consists of a cylinder of brass on which a screw thread was accurately cut, and in which silk-covered wire was wound. The coil, however, from internal strains is slightly elliptical, and the silk insulation prevents a very exact determination of the diameter. In the apparatus now constructed the standard coil consists of a massive cylinder of fine-grained well-paraffined marble 21in. external and 15in. internal diameter and 7in. axial length. On this (previously accurately trued up) a screw thread of 40 threads to the inch of nearly semi-circular section has been cut over a length of 5½in. This screw thread had to be cut with the greatest care to have a perfectly smooth bottom and sharp edges. The greatest care had also to be taken to get it perfectly circular and parallel, small variations of temperature being sufficient to cause unequal cutting. In this groove has been carefully wound 200 turns of specially drawn bare copper wire 21 mils diameter, thus allowing 4 mils of air insulation between consecutive turns. The wire thus extended over an axial length of 5in., and the ends were passed through ebonite bushes in the marble securely fixed, and led out by twisted flexible conductors. The object of the marble ring was twofold: its low coefficient of expansion, freedom from internal strain, and rigidity, tending to greater constancy of dimensions, and its insulating properties when paraffined allowing the use of bare wire. It was thus hoped that much greater perfection of form and accuracy of measurement would be attained, and this has been amply justified.

While the coil was still in the lathe two lines were cut, one on each edge of the coil, equidistant from the mean plane of the wire as given by the leading screw of the lathe. These lines are for the purpose of observing whether the mean plane of the coil is coincident with that of the disc. Each edge of the coil

**Table.**

| Diameter. | Measurements. | | |
|---|---|---|---|
| | A. | B. | C. |
| Deg. | In. | In. | In. |
| 0-180 | 21·04772 | 21·04765 | 21·04765 |
| 10-190 | 21·04795 | 21·04765 | 21·04952 |
| 20-200 | 21·04768 | 21·04755 | 21·04905 |
| 30-210 | 21·04805 | 21·04745 | 21·04818 |
| 40-220 | 21·04785 | 21·04755 | 21·04825 |
| 50-230 | 21·04808 | 21·04730 | 21·04812 |
| 60-240 | 21·04752 | 21·04755 | 21·04805 |
| 70-250 | 21·04755 | 21·04755 | 21·04822 |
| 80-260 | 21·04785 | 21·04795 | 21·04895 |
| 90-270 | 21·04812 | 21·04780 | 21·04942 |
| 100-280 | 21·04805 | 21·04815 | 21·04925 |
| 110-290 | 21·04808 | 21·04825 | 21·04898 |
| 120-300 | 21·04785 | 21·04840 | 21·04905 |
| 130-310 | 21·04828 | 21·04835 | 21·04915 |
| 140-320 | 21·04828 | 21·04815 | 21·04908 |
| 150-330 | 21·04805 | 21·04805 | 21·04932 |
| 160-340 | 21·04872 | 21·04795 | 21·04858 |
| 170-350 | 21·04778 | 21·04785 | 21·04812 |
| Mean. | 21·047960 | 21·047842 | 21·048719 |

Mean outside diameter of coil, 21·048174in. Temperature, 20·4° C.

* *Phil. Trans.*, 1891.

† *Proceedings* of the Physical Society, November, 1888; *Phil. Mag.*, January, 1889.

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was also divided on the face at intervals of 10deg. in order to fix several diameters over which measurements were taken. The diameter was measured by a Whitworth measuring machine with extra long bed, the property of Prof. Jones, who has used it in all his previous investigations and found it exceedingly accurate. The coil was laid on the bed of the measuring machine, and arrangements were made whereby it could be so exactly adjusted as to allow of the use a "feeling piece" at each end of the diameter. Each measurement was the mean of three readings, which in no case differed from one another by more than the one ten-thousandth part of an inch. These measurements were repeated over 18 diameters, 10° apart, and were taken three times over the circumference, A, near the front face; B, at the middle; C, near the back face. The table on p. 267 gives the measurements, after deducting the feeling-pieces, over the 18 diameters, each measurement being the mean of three readings. The measurements were nearly all taken at night to eliminate vibration, and the temperature was kept practically constant.

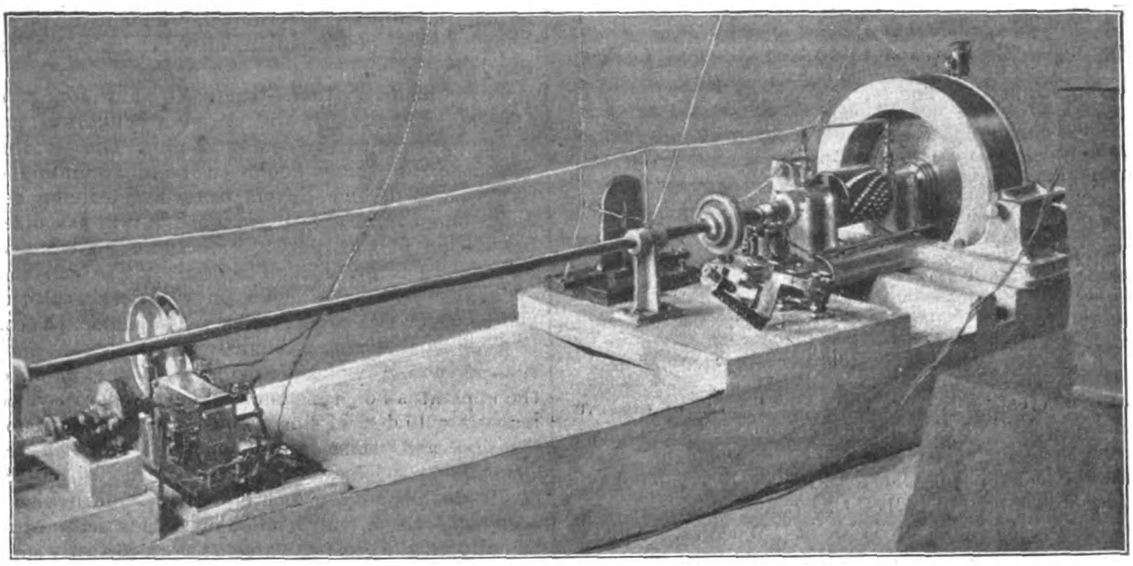

FIG. 1.—General View of Lorenz Machine. Stroboscopic Drum on right-hand, Bain Speed Recording Apparatus on left-hand.

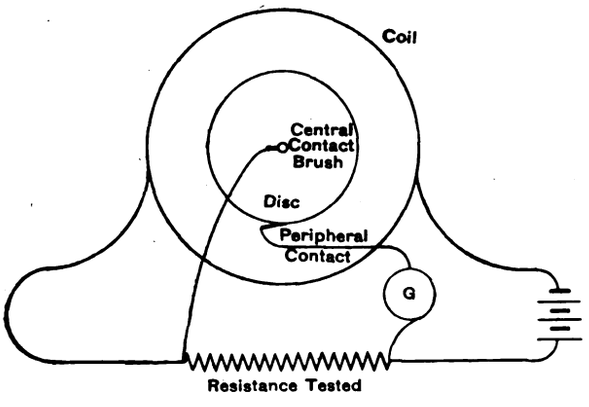


FIG. 2.—Diagram showing Circuits of the Lorenz Apparatus.

From this it will be seen that the mean diameter at the centre and edges of the coil does not differ between its largest and smallest diameters by one-thousandth of an inch. In the brass coil used by Prof. Jones the largest and smallest diameters differed by 0·0158in., showing the great superiority of the marble in resisting deformation. The observations also show a standard deviation of 0·00035in., or less than two parts in 100,000 from true circular form, while in Prof. Jones's coil the corresponding deviation would be 0·006in., or nearly three parts in 10,000. The correction for ellipticity of the marble coil is thus negligible, and the accuracy with which its diameter is known exceeds by far anything which has hitherto been accomplished.

*The Disc.*—The rotating disc is nearly identical with that in the apparatus used by Prof. Jones, except that great care has been taken to protect all bolts, &c., used in fixing it to the shaft from the action of the mercury which is used in the contacts. It consists of a phosphor-bronze casting, which is bolted on to a boss on the end of the phosphor shaft, but is carefully insulated from it by ebonite. The heads of the bolts

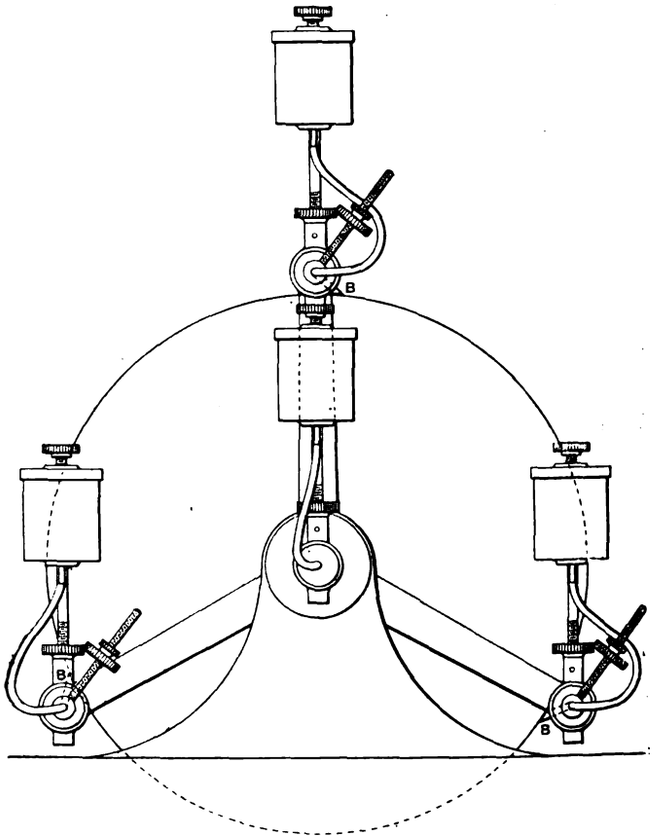


FIG. 3.—End View of Disc showing Mercury Brush Device.
B. B. B. Mercury Brushes.

are recessed in the boss, run in with wax, and covered over with a plate to prevent mercury entering and impairing the insulation. The disc was first carefully turned up, and was finally ground true in its own bearings. Measurements were

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then taken of its diameter, but only over four diameters, as it was practically uniform. The diameter of the disc is 13in., and the width of its edge $\frac{3}{16}$in.

*The Measurement of the Speed of Rotation.*—This apparatus consists of two parts, a stroboscopic device for regulating the speed and keeping it constant, and a counting mechanism which registers the number of revolutions on a chronograph. For regulating the speed a cylindrical drum is mounted on the axle of the disc, on which are painted several rows of black and white teeth. When this is rotating it is observed through two slits attached to the prongs of an adjustable tuning fork. It is then possible to adjust the speed so that one row of dots appears stationary, and the regulation can be effected with great accuracy. For the exact measurement of the speed an electrical contact is made at each revolution of the shaft, and, by means of worm gearing, a second contact at each 10 revolutions. These contacts are registered on a Bain recording telegraphic apparatus, together with the record of a standard clock, in which electrical contact is made every second on the escapement wheel. The Bain apparatus is made with an electrical regulation by Foucalt currents induced in a disc by an electromagnet, thus enabling it to be run rapidly at the beginning and end of the observations, and slowly during the intervals.

*General Arrangement of the Apparatus.*—The arrangement of the apparatus will be best understood from the general view and diagrams (Figs. 1, 2 and 3). The disc mounted on its shaft revolves in the two large bearings, which are scraped dead true, and prevent any end shake of the disc. The whole of the bedplate, bearings and all metal parts are of phosphor bronze which has been carefully tested for magnetic properties. On the shaft between the bearings is the drum with the black and white teeth, and at the end remote from the disc the counting mechanism is fixed. The shaft terminates in a flexible leather coupling by which it is connected to a 6ft. length of phosphor bronze shaft, fixed by a similar coupling to an electro-motor, which is thus at such a distance as not to sensibly affect the coefficient of mutual induction.

The bed plate is carried forward and supports a cradle for the reception of the marble coil. This cradle is supported on screws in such a manner that any motion can be given to the coil, horizontal, vertical, or rotatory. The bed plate also carries in front a bar, serving the double purpose of protecting the coil, and carrying the brushes which make contact on to the disc. Three of these brushes are carried on a star turning about the axis and make contact on the edge of the disc, the fourth is central and fits in a recess in the centre of the disc. All these brushes are tubular and are connected to vessels containing mercury, having cocks by which a constant stream of mercury can pass on to the disc at the contacts, thus securing perfect electrical continuity. In the former apparatus only one brush was used at the periphery, but since the potential at all points of the disc should be the same if it is coaxial with the coil, and would be different if this condition is not fulfilled, a galvanometer connected between any two brushes should enable one to centre the coil electrically. The brushes can all be regulated so as to bear exactly on the centre of the edge of the disc, and have adjustable weights by which their pressure on the disc can be adjusted.

As it is of the greatest importance that the running of the apparatus should be perfectly regular, the lubrication of the bearings has to be specially attended to. This is effected by pumping the oil through sight-feed lubricators by means of a small centrifugal pump attached to an electric motor, keeping up a constant circulation at great pressure.

*Adjustment of the Coil.*—The coil being in place it is necessary to have some means of determining whether it is in its correct position relatively to the disc. For this purpose an attachment has been made to fix on to the disc, which carries a micrometer and a reading microscope. This attachment being clamped on the disc, the micrometer screw can be made to touch the wire, and readings can be taken at a number of points, thus finding out any error of centreing. The reading microscope is so adjusted that when the mean planes of the coil and disc are identical, the cross wires in its field are on either of the lines cut on the edge of the coil equidistant from its mean plane. By the kindness of Prof. Ayrton, the apparatus will be tested at the Central Technical College, and a determination will be made by Prof. Viriamu Jones and Prof. Ayrton.

Messrs. Nalder, Bros. and Co. wish to express their indebtedness to their assistant, Mr. C. V. Drysdale, for his valuable assistance in the design and carrying out of this piece of apparatus.

## THE CROMPTON POTENTIOMETER: ITS USE AND CAPABILITIES.—VII.*

BY W. C. FISHER, ASSOC.MEM.INST.C.E.

In the previous article the writer mentioned that, if properly and consistently treated, there was no difficulty in constructing reliable standards of manganin, and that from innumerable curves taken not one was known to materially differ. This last statement should be qualified by the addition of the words, "provided the alloy was received from the same source"; for, as is shown by Figs. 45, 46 and 47 (which will be explained in detail later), there is a decided difference in the character of the curves in each, which is mainly attributable to the fact that the three batches of material were obtained from three sources. As the subject is an interesting one, and has been productive of several communications at various times, accompanied by curves which served to show that the nature or treatment of the alloy was not quite understood, it is hoped that the following series of curves and description will prove useful.

Prof. Lindeck, in a Paper read before the British Association shortly after the introduction of manganin, gave, amongst other interesting information relating to it, a temperature curve, which is nominally taken as characteristic of that alloy; this curve is given in Fig. 44, in which it is seen that the resistance steadily rises as the temperature is increased until 45°C. is

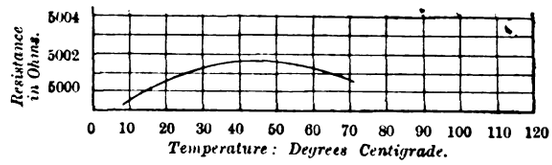


FIG. 44.

reached, when it commences to fall, and presumably continues to do so though the curve is not carried beyond the range of 70°C. By proper treatment of the alloy this curve can be practically reproduced in the case of any sample of the true alloy, as is shown in the case of Figs. 40, 46, 47 and 48, where the final curves, after annealing and ageing, have assumed the curvature of that shown in Fig. 44, differing only in the position of maximum value; otherwise the temperature coefficient remains practically the same.

Commencing with Fig. 45, in it we have a series of curves taken with sheet material at the time of its early introduction into this country by Messrs. Abler Haas and Angerstein; the curves indicated by the same distinctive letter are common to one particular sheet. The marked difference in character from the "Lindeck" curve will be noticed; the peak is very much more sharp, and the fall in value very much more steep than in the following curves, except in the case of curve K, which is less steep and is the characteristic of a sheet of the alloy similar in every respect to the former, but which had been subjected to a great deal of mechanical strain, such as hammering, &c. In all these curves, however, it is only fair to add that they were heated by means of the current flowing through them, and the temperature indicated by a mercury thermometer with nothing like the accuracy of the remaining curves, which were obtained by heating the samples in an electric oven, and measuring the temperature with a platinum thermometer. In Fig. 45 the point of highest resistance lies between 20°C. and 30°C., instead of 45°C., as given by Lindeck. This may be put down to the impossibility of obtaining the true temperature of the sheet by the mere contact of the bulb of the thermometer, whilst matters are not remedied by a slight covering of waste, &c.

* For previous articles see *The Electrician*, November 29th and December 6, 1895, January 17th and 31st, March 13th and May 1, 1896.

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In the case of Fig. 46 the curves given are those of alloy received from another source, and commencing with that on the top, we have an annealing curve of a sample of wire which is continued at foot by a heating and cooling curve of the same sample. Between these, is given a heating and cooling curve of a sample of thin rolled strip; all show a curvature very much in excess of all other samples.

Fig. 47 gives the annealing and subsequent ageing curves of a fine wire manganin coil (alloy from a third source) differing again from all previously taken, but common to all samples

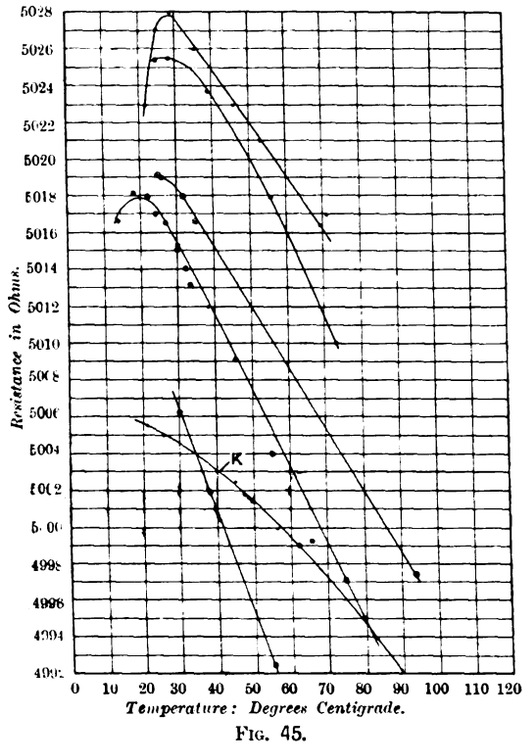


FIG. 45.

obtained from the same source. It should be mentioned that all curves are to the same scale, so that comparison may be made at a glance, and that the curve given in Fig. 40 is of this last series, *i.e.*, the alloy is obtained from the same source, the general outcome, therefore, being that from normal temperature to about 45°C., after thorough annealing and ageing, the alteration in resistance is so slight as to be negligible for all practical purposes, amounting as it does to

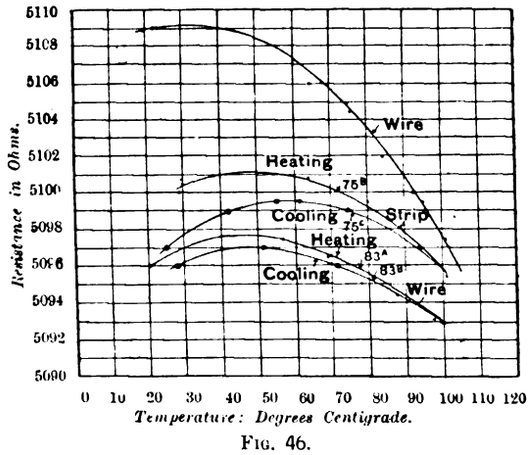


FIG. 46.

about 1 in 10,000 or 0·00033 per cent. per degree Centigrade; and here it should be pointed out that there is a general tendency in more recent deliveries for the curve to be flatter from normal to 45°C. than has hitherto been the case. This promises to wipe out the positive followed by negative temperature error, leaving a far better state of things in a purely negative one, inasmuch as if allowance has to be made one has not to think of the direction. As in the case of other alloys there may now be differences either in actual process of manufacture or in its constituent parts. In any case, manganin requires considerable humouring and a certain amount of care and patience in the production of reliable standards, which is unnecessary with other alloys, and which may account for the sceptical views of it that one sometimes hears and sees ventilated. One thing is certain, one has not got to the bottom of its eccentricities in half a dozen, much less one solitary test, as is shown by Figs. 47 and 48, which give the cycle of temperature curves during the process of annealing and ageing. The curves are those of two identical coils of 5,000 ohms of fine manganin wire heated in the same manner but differing only in method of construction. At first it was thought the vagaries shown in Fig. 48 were accidental, but similar tests of other coils similarly constructed were productive of identical curves, which may therefore be taken as characteristic of the method of treatment. It will be noticed that while the annealing or first heating curves differ considerably, in the first case being a steady drop, and in the second a rapid fall succeeded by a rise followed by another drop—the extent of which is unknown—the cooling curve in both being gradual, the final or ageing curves are almost identical, amounting in the end to a drop of 0·12 per cent, when heated from 35°C. to 85°C., or an average of 0·0024 per cent. per degree centigrade. The reason for 35deg. being the lowest reading is the enormous time that

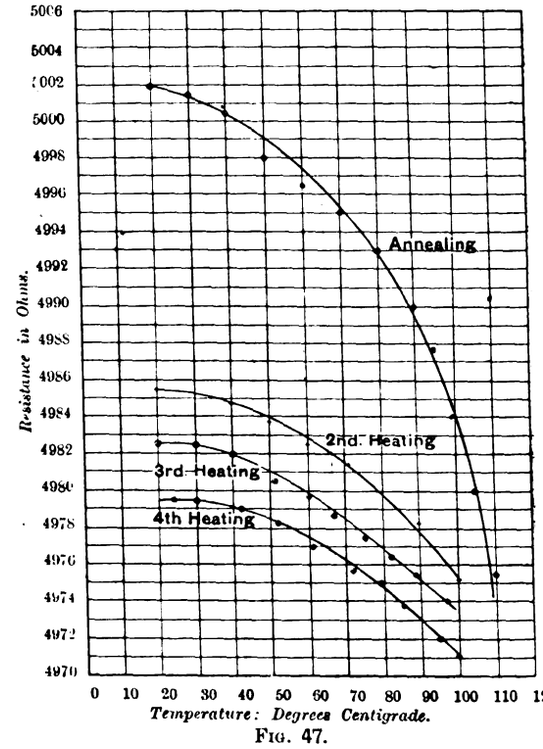


FIG. 47.

would have to elapse before the oven dropped to normal temperature; but, as indicated by the curves, the alteration in resistance from normal temperature to 30deg. is really negligible and practically immeasurable. It may also be taken that the reason for some of the cooling curves crossing succeeding heating curves is due to the oven door being partially opened for economy in time; the consequent rush of cold air chilling the thermometer caused the recording of a lower temperature than actually existed in the coil. From these curves may well be imagined the feelings of the man who, not knowing the traits of this alloy, took the first or annealing curves as the true temperature curves, or any one curve as being common to the alloy under all methods of treatment.

The writer has heard it stated that manganin in the form of fine wire cannot be relied on, that it rapidly deteriorates and alters in value. In the case of coils properly prepared and treated such is not his experience; on the contrary, from tests made of coils having a total area exposed to the atmosphere of 7 and even 14 sq. ft., it stands far better than was expected. Of course, if in annealing one treats fine wire in the same way as one would treat a sheet or bar, one must expect failure. The treatment in tempering a hair-spring is

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slightly different to that adopted in tempering even a chisel, and it is there possibly that mistakes have been made, for it does not require very many degrees in excess of annealing to destroy the ductility of manganin, and make it as short as burnt metal usually is; moreover, one runs great risk of charring the silk covering if there be any, and an insufficiency of shellac. In any case much reliance cannot be placed upon continental instruments supposed to have coils of this alloy, for, unfortunately, its price per pound is not a nominal figure, whilst other alloys may be had which are very much cheaper; and as detection is impossible in an ordinary way, the temptation to substitute the cheaper for the better is possibly too great to be resisted. Only recently an instance came under the writer's notice, in which, for convenience, an alloy was obtained from a different firm to that previously dealt with. Both firms had the same name for it, and it was supposed to be identical. Suspicions were aroused, and chemical analysis made. The result was that instead of a proportion of 30 per cent. in the first place, we had 3 per cent. and 20 per cent. of

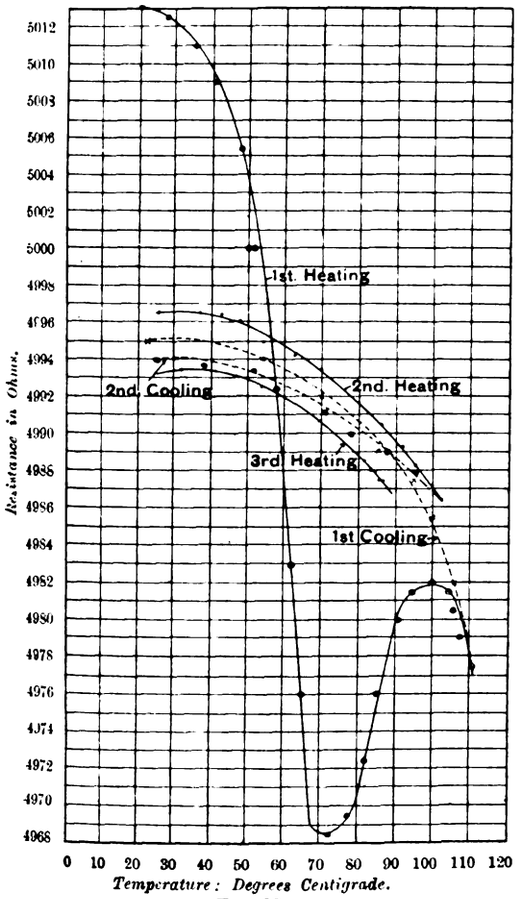


FIG. 48.

another metal added. Which was correct under the cognomen adopted was impossible to say, but the first alloy served its purpose, the second did not.

In addition to its other little foibles, manganin is not easy to solder. There is a particular or critical heat at which it may be done as easily as copper, but one cannot define it; practice alone ensures it. The surface must in any case be absolutely clean; if gilded, however, the whole difficulty disappears.

In the construction of resistance boxes and coils it is, as a rule, customary to wind the wire upon bobbins in successive layers. This is all very well where the current passing is inappreciable, but when it becomes necessary to pass current of any appreciable amount then temperature difficulties arise which are almost unending, more especially if the coils are ratios, and have, therefore, to bear a constant value to each other. The difficulty is easily seen; wound upon bobbins, layer upon layer, there arise differences of temperature between the inside layers and outside. Between the larger and smaller bobbins, &c., their values become uncertain, and measurement of their actual temperature impossible. One can, of course, float them in oil, twiddle a stick or paddle therein, read the thermometer, and say we have the temperature. But have we, except under special circumstances? To the practical engineer the thought of the oil business, with agitation by means of a paddle-wheel, motor, and central station behind it, is not pleasant. Is there no other method possible of a more practical nature? Cannot standards be made substantial enough to carry decent currents without heating (one hears of insulation tests with low voltage condemned, but nothing is said of resistance measurements with the almost infinitesimal forces usually used), cannot they be efficiently lagged in conjunction with platinum thermometers by means of which almost infinitesimal changes in temperature can be instantly indicated? Wherein lies the difficulty?

In the case of the potentiometer method of measuring high voltages, ratio coils have to be used, and the following is a description of a set of the same mounted and usually called the voltbox. All are alike in construction, differing only in the number or value of ratios; that ordinarily used for voltages up to 300 or 600 volts as a maximum is shown in Fig. 49, and consists of two glass tubes fixed, as shown, between the struts screwed to brass standards. One tube has respectively a 50$\omega$, 450$\omega$ and 4,500$\omega$ coil wound thereon, or 5,000$\omega$ altogether; the second has a single coil of 5,000$\omega$, the total box being 10,000$\omega$ in resistance. From this it will be seen that there are at once accurate standards of 50, 500, 5,000 and 10,000 ohms. Also by suitable connections to terminals accurate ratios of 200/1, 100/1 and 10/1 are made, so that $\frac{1}{10}$th, $\frac{1}{100}$th or $\frac{1}{200}$th of a total voltage may be carried to the potentiometer and measured, and the result multiplied by 10, 100 and 200 as the case may be. There is not the slightest difficulty in adjusting these coils accurately to 1 in 25,000, either collectively or individually, and it is possibly in the measurement of resistance that the potentiometer method scores best off other methods, for all being done from potential points, there is no question of dirty contacts, no necessity for that most wasteful and abhorrent metal—mercury, which insidiously works its way into every hole and corner that it ought not, destroys or mars the appearance of adjacent instruments, and ought—as set in example by the Board of Trade laboratory—to be strictly ostracised from any self-respecting test room.

It should be stated that the wire is wound in one layer from end to end of the tubes, and is of manganin, and as it is all of the same gauge, and current is passed through the whole in series, and the box being airtight, any heating that does take place is evenly distributed, and in the case of ratios is entirely immaterial. When used as standards the voltage is naturally less and heating reduced accordingly. In any case the greatest heating should not be more than 30°C. approximately, the error produced being, as shown by previous curves, negligible for all practical purposes. Moreover, a smaller gauge wire may be used than upon a bobbin, and it is easier to wind a tube more nearly non-inductive than a bobbin. Add to this the fact that the whole of the wire is visible, and that half the surface of the whole wire is open for radiation direct and the remaining half by radiation through the tube, and we have sufficient reason for departure from the general routine.

## THE MANUFACTURE OF CALCIUM CARBIDE.

An account of the manufacture of calcium carbide, as carried out at Froges, near Grenoble, has recently appeared in the *Zeitschrift für Elektrochemie*, from which we abstract such portions as appear to be of interest. A waterfall capable of yielding 500 H.P. to 1,000 H.P., according to the time of year, was formerly utilised at Froges for the production of aluminium, but since the price of that metal has fallen considerably, and a large works for its manufacture has been started elsewhere by the same company, the smaller factory at Froges has been used more or less as an experimental station, calcium carbide and 10 per cent. ferro-aluminium being the commodities chosen to be made in a tentative manner until their remunerativeness is put beyond doubt. The whole of the plant and apparatus is of the simplest description. There are two dynamos,

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each giving 6,000 amperes at 60 volts, which are used for feeding the furnaces, and a smaller machine of 65 amperes at 110 volts, serving as an exciter. Each large dynamo can feed three furnaces, but at the present time only one of each set is in use at a given moment; they are, of course, used in turn. The furnaces are of the old Héroult type for the production of aluminium, and have not been altered for their change of function. The body of the furnace forms the cathode, and the anode is a large carbon rod suspended above the central cavity. The fused product flows away through an opening in the body of the furnace, so that the method, though crude, is practically continuous. The actual process of manufacture is far from complex. A mixture of coke and lime is filled into the central cavity, the anode is lowered, an arc is formed, and the operation is pushed on until the workman judges by the size and colour of the flame issuing from a hole in the cover of the furnace that the formation of the carbide is complete. The exit hole is then opened, the fused charge flows out and a new quantum of raw material is shovelled in at the top. A charge is worked off in about 40 minutes. In the event of the manufacture of calcium carbide proving a stable and remunerative trade, it is proposed to fit the furnaces with automatic feeding arrangements whereby the process may be truly continuous and the output may be consequently increased. At present each furnace can turn out about 300 kilogrammes of carbide per day of 24 hours; but, on account of the demand being by no means great, it is found sufficient to run only during an ordinary working day, so that the total output of the factory does not exceed 300 kilos per day. The supply can at any time be increased both at Froges and at the new works at La Praz, should a considerable demand for calcium carbide arise.

It is to be regretted that no estimate of cost is appended to the article.

## ELECTROLYTIC WHITE LEAD.

In the *Journal* of the American Chemical Society (1895, XVII., 835-842) will be found a Paper by R. P. Williams describing the working of the electrolytic process for the manufacture of white lead invented by Mr. A. B. Brown, of Boston, U.S.A. In this process a sodium or potassium nitrate solution is electrolysed in a series of wooden vessels divided by porous partitions into two compartments, one containing a pig-lead anode, and the other a copper cathode. The solution is run in from an overhead tank, and on the passage of the current the anode dissolves, forming lead nitrate, whilst sodium hydroxide is formed in the cathode compartment, and free hydrogen is evolved, the copper being unacted upon. The primary reaction which takes place is probably that shown by the following equation :—

$$2NaNO_3 + 2H_2O + Pb = (2NaOH + H_2) + (PbO_2 + 2NO_2).$$

The lead nitrate and sodium hydroxide solutions thus formed are drawn off separately, and mixed in quantitative proportions, with the result

$$Pb(NO_3)_2 + 2NaOH = Pb(OH)_2 + 2NaNO_3,$$

that a white precipitate of lead hydroxide is formed, sodium nitrate being left in solution. An automatic rotary filtering device is employed to continuously separate the amorphous precipitate of lead hydroxide from the sodium nitrate solution, which is pumped back into the reservoir and used over and over again. This regeneration of the sodium nitrate is one of the economic features of the process. The final step is the admixture of bicarbonate or normal carbonate of sodium with the lead hydroxide, whereby a precipitate of pure lead carbonate is obtained according to the following equation :—

$$Pb(OH)_2 + HNaCO_3 = PbCO_3 + NaOH + H_2O,$$

and the resulting sodium hydroxide has only to be recarbonated to render it available for use once more. Thus the two main agents in the process—sodium nitrate and sodium bicarbonate—do duty over and over again, with but slight addition to make up for loss. The original alkaline nitrate solution may be of any convenient strength, but 1lb. per gallon (10°B.) is recommended as being sufficiently concentrated.

At an experimental station worked for several months at Cambridge (Mass.) under the direction of Mr. A. B. Brown, the inventor of the process, 500lb. of white lead were turned out per day, and the process was found economical as compared with the old methods, inasmuch as it uses pig-lead as it comes from the furnace without remelting, whilst in the Dutch process it has to be cast into "buckles" of definite size, and after the action of acetic acid from one-half to one-third of the lead employed is left uncorroded, and has to be recast. Again, every reaction takes place rapidly, instead of requiring from two to six months as by the other mode. There is also a great saving in materials and labour; no free acid, either acetic or nitric, is used, and the process is clean and non-poisonous. The product is pure, as the sodium hydroxide removes any impurities which may be present in the raw material; for instance, any salts of aluminium or zinc would be dissolved, and it removes organic matter. The white lead produced is globular, and so fine that no grinding is required; in fact, a special brand of cloth has to be made to filter it. The Dutch and electrolytic paints have been exposed side by side for two years, and no difference can be detected in durability or opacity. The covering power of the new paint is from 12 to 20 per cent. higher than that of the Dutch, which is stated to owe its superiority to that made by most other processes to its globular character. The practical failure of the French rapid precipitation process is attributed to the low covering power of the product ("Clichy white"), resulting from its crystalline form. The new material being globular, and even finer in texture than the Dutch, has therefore an improved covering power.

## ELECTROCHEMICAL ACTINOMETRY.

This formidable title is chosen as the heading of an article by M. Maréchal appearing in *L'Eclairage Electrique* and transcribed into the *Zeitschrift für Elektrochemie*, whence we select such portions as are of interest.

The apparatus described is designed to measure the electrical energy resulting from the impingement of light upon a copper plate covered with a thin film of oxide and opposed to a second plate with a clean metallic surface. Both plates dip into a solution of a haloid salt of an alkali metal, and the non-oxidised plate is protected from light by a suitable envelope. The electrolyte should be dilute, *e.g.*, it should contain about 1 gramme of the salt per litre. On connecting the electrodes with a sensitive galvanometer it is found that the potential difference between the plates responds to small variations in the lights falling on that which is exposed, and that the plate with the film of oxide is always positive to the plate with a clean surface. Diffused daylight gives a reading of some thousandths of a volt, and direct sunlight one of nearly 0·1 volt.

The author has observed that for comparatively weak sources of light (taking daylight as a standard), *e.g.*, the oxyhydrogen light, the voltage is inversely proportional to the square of the distance of the source of light, *i.e.*, it is proportional to the intensity of the light; with sunlight, on the other hand, the voltage lags behind the light intensity. Using monochromatic light it is found that the voltage is much influenced by the wave length of the impinging ray. Using sodium chloride or bromide as the electrolyte, the effect increases from the red end of the spectrum, gradually to a maximum at the green or green-blue portion; with sodium iodide the maximum voltage ranges from the yellow to the green-blue. Blue rays give only a feeble result, and the violet almost none. By promoting selective absorption the sensitiveness of the arrangement can be greatly increased. For this purpose it suffices to dip the oxidised copper plate in a weak solution of some colouring matter. Thus, using the dyestuff known as "crystal green" the sensitiveness of the couple is increased three or fourfold, while, with "malachite green," the increase is some eight times the original value. In this case the sensibility of the plate is naturally greatest for red rays.

It appears that in all the cases quoted the light does not act by virtue of accompanying heat radiations nor by its so-

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called chemical rays of the violet and ultra-violet, but by what Maréchal dubs its "actinicity." The reaction brought about by the impinging light may be simply represented thus:

$$4CuO + 2NaI + H_2O = 2NaOH + CuI_2.3CuO.$$

Numerous uses for the actinometer are suggested. It may be employed for the direct electrical registration of optical signals. Needless to say it is also proposed as a photometer.

From the description of which the foregoing is a digest, it seems that the actinometer is an ingenious contrivance for measuring a somewhat mixed quantity; but there is no evidence to show that the particular value measured is identical with that other complex entity, the special fraction of vibrations of a particular class which affects the normal human eye with the sensation known to the possessor of that organ as light.

## NEGATIVE RESISTANCE.

There is a great whetting of swords and sharpening of spears, and the evil spirit of war is glooming threateningly over a certain section of the Physical Society. The question at issue is one of terminology, and a little more; the outcome of recent discussions and experiments concerning the electric arc. The facts which Mrs. Ayrton and Mr. Frith have recently furnished can, it appears, be very comfortably reconciled with their view of the theory of the arc, by assuming the arc to possess a *negative resistance*. And, moreover, it is not easy, *primâ facie*, to bring these facts into conformity with experience by the simple device of assigning to the arc a "back electromotive force." The phenomenon, for instance, that *in a circuit of next to no resistance*, do what you will with current and carbons, *an arc is always erratic*, and only can be made steady by inserting resistance, is a mystery which gives almost a potential quality to resistance. Again, the power-curves, deduced from voltmeter and ammeter when an alternating voltage is superadded to a steady-current arc, constitute evidence apparently in favour of the heresy that there is a lurking negative resistance.

We have accustomed ourselves to use the word "resistance" in a sense practically identical in analogy with that in which dynamics employs the term "friction"; and that any electrical system of currents and conductors can engender *negative* resistance is as heterodox a notion as that any mechanical system can be possessed of *negative friction*. If an engineer asserted that his shafting was provided with bearings which aided instead of retarded the rotation, he would, to say the least, be lightly spoken of. It is not unnatural that some electricians should be found sufficiently wanting in courtesy to gibe at an expression so *new* to them as "negative resistance."

"Resistance" is the youngest member of the electrical trinity, and we have learned to regard it as the most tangible. Its measurement has become the cardinal operation of all electrical testing; its standards are as nicely determined as anything we are accustomed to regard as *fixed*; and that its sign is always positive is, or was, quite as certain as that you could not photograph through a brick-wall.

On the other hand, the "back electromotive force" of the arc is always a fugitive quantity. In electrolytes, cables and land lines, a similar will-o'-the wisp may have deluded us under the title "polarisation"—an unfortunate term, too often associated with such theories as are "all carvèd from the carver's brain." Is there any necessity for crystallising our knowledge of the arc at its present primitive stage? A man of less astuteness than Prof. Silvanus Thompson could reduce "negative resistance" to an absurdity; and a man of greater ignorance than Prof. Ayrton might have risked the heretic suggestion, but whether he would have stated his case so plausibly is another matter.

When Finsbury and South Kensington are at loggerheads, experiment alone can aid us. If the arc has resistance, experiment should tell us its linear dimensions, and its *locus* between the carbons. And, if the resistance is negative, experiment ought to tell us which dimension makes it so? Perhaps the *locus* is negative; we suspend our judgment, and confess that "back electromotive force" introduces a confusion only a little less confounded.

## THE TELEPHONE AT THE SPRINGHILL INFIRMARY, BIRMINGHAM.

The telephone system at Springhill Infirmary, Birmingham, was laid down to prevent loss of time in calling medical aid to any part of the institution. The infirmary comprises a main block, through the length of which there runs a corridor some

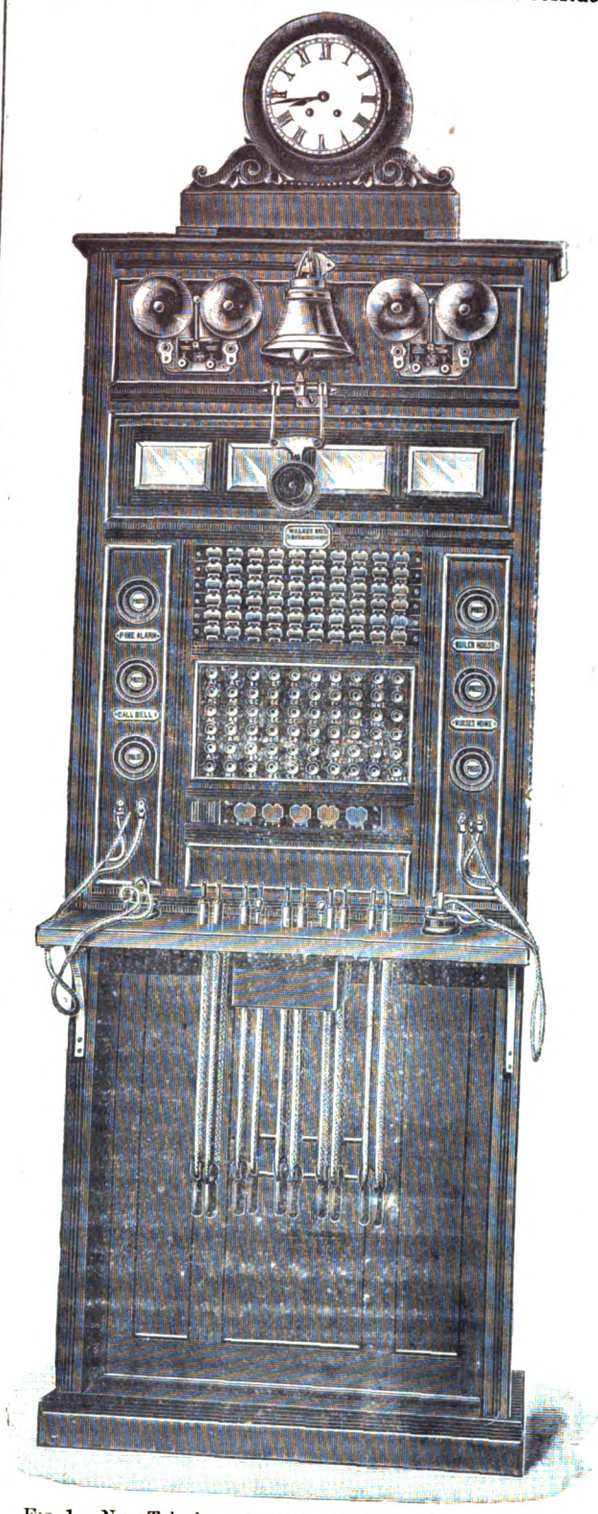


FIG. 1.—New Telephone Switchboard: Springhill Infirmary.

100 yards long. On either side of this corridor are short passages and staircases leading to the various wards. This block has accommodation for over a thousand patients. In addition to the main block, there are situated in various parts of the extensive grounds the wards for epileptic patients, male and female; the nurses' home and other departments. In such a large and scattered establishment the rapid summoning of

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assistance becomes a matter of prime importance, hence the introduction, some four or five years ago, of a very complete system of telephones, call bells and alarms.

The installation has recently been overhauled and reorganised, and a new switchboard fitted up. The centre panel of the switchboard (Fig. 1) is occupied by sixty drop indicators and spring jacks, of the Western Electric Company's pattern, by means of which telephonic communication can be made with every ward,

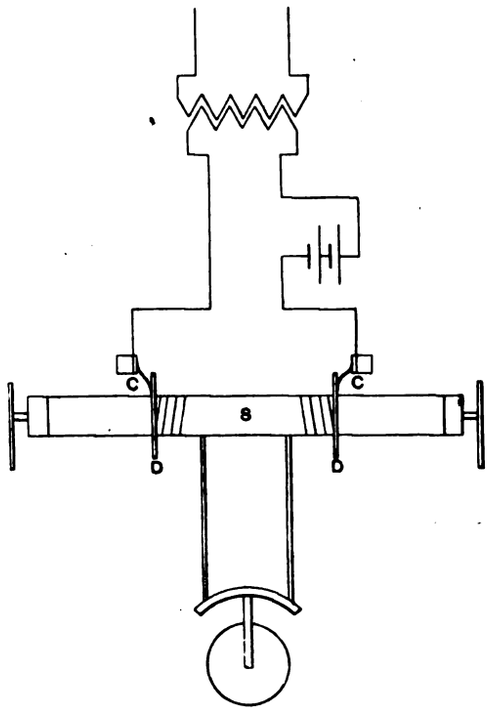


FIG. 2.

the nurses' home, the medical officers' quarters, and a number of other points. The usual adjuncts, "ring offs," plugs and cords, speaking and ringing keys, are placed below. The transmitter, which is of Hunningscone type, is suspended by flexible cords, and is rendered adjustable for height by an arrangement of spring rollers, similar to those used for railway carriage blinds. The roller with the cords and connections is shown in Fig. 2. The roller *s* carries two metal discs, *d*, insulated from each other, to which the ends of the transmitter cords are attached.

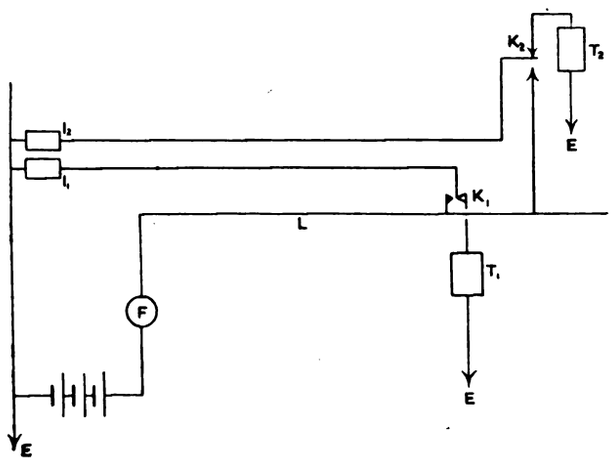


FIG. 3.—Showing fire alarm in connection with two telephone circuits.

These discs rub against contact springs, *c*, keeping the circuit complete for all positions of the transmitter. This device has been patented by Messrs. Walker Bros., of Birmingham, who supplied the new switchboard. Above the centre panel there is a series of glazed frames which carry lists of code signals, and instructions to the attendant. Above this, again, are three bells, the two outer ones being magnet-bells, which are used for emergency alarms when special assistance is urgently required in either of the epileptic wards. The centre one is a deep-toned Jansen-type bell; it can be rung from every point where a telephone set is stationed, and is used only in case of fire. The fire alarm and telephone circuits are so arranged that when the fire bell is rung, the indicator which corresponds to the station from which the alarm is given is dropped. Fig. 3 shows how this result is obtained on two circuits. The bell F with a battery of sufficient size is connected to the earth terminal on the switchboard, and to a lead L, which has branches to two way keys $k_1$, $k_2$, one at every telephone set. These pushes (Fig. 4) when in their normal position maintain the telephone circuit intact, but when one of them is depressed, it completes the bell circuit by way of the telephone line and indicator $i_1$, $i_2$.

Side panels on the switchboard carry pushes which are connected to single stroke bells, for signalling purposes, in the boiler house, the nurses' home, the local fire station, and one, which is perhaps the most interesting, and certainly the most important, is connected to single stroke bells in every ward, arranged to all ring simultaneously. The use of this is to enable the attendant to call the attention of any particular medical man wherever he may be. For example, Dr. Z is wanted urgently in ward A. The nurse in charge of the ward would

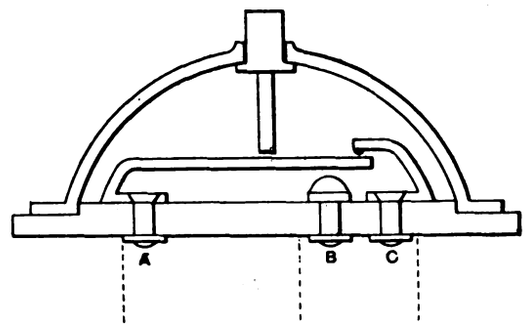


FIG. 4.

go to her telephone and ask that Dr. Z might be summoned. The switchboard attendant presses his switch the number of times which is Dr. Z's code signal, and the doctor, wherever he may be in the building, knows immediately that he is wanted somewhere, and by going to the nearest telephone learns where and why. This of course saves a lot of running about, and the time which was formerly lost in finding the necessary help is reduced to a minimum.

## A METHOD FOR THE USE OF STANDARD CANDLES IN PHOTOMETRY.*

BY CLAYTON H. SHARP.

The fundamental assumption on which is based all American and English practice in the use of candles as a standard of light in photometry is that the intensity of light emitted by a candle is, within certain arbitrary limits, proportional to the rate at which the material of the candle is consumed. Supposing this assumption to be in a measure justifiable, we could scarcely imagine it to be rigorously exact. The purity and hygrometric state of the air, which Liebenthal† has recently shown to have such a large influence on the intensity of the Hefner light, can scarcely be of inappreciable inflence on the candle flame. But no matter how nearly this assumption approximates to the true state of affairs, the fundamental and inevitable difficulty with this definition of the light unit still remains. It is this: What we ought to know is not the mean rate of consumption during the period over which the measurements extend, but the rate at the instant

*Abstract from the *Physical Review*, Vol. III., No. 6. 1896.

† Liebenthal, "Ueber die Abhängigkeit der Hefnerlampe und der Pentanlampe von der Beschaffenheit der umgebenden Luft." *Elektrotechnische Zeitschrift*, XVI., p. 655, 1895. *Zeitschrift für Instrumentenkunde*, XV., p. 147.

‡ For evidence confirming this statement see an article by John Methven, read before the Southern District Association of Gas Engineers and Managers, *London Gas World*, 1889, p. 572. A translation into German will be found in Dingler's *Polytechnisches Journal*, 1890, Vol. 277, p. 276.

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at which a photometer setting is made. Since it is impracticable to determine this quantity, the mean rate has been used for correcting observations. That this cannot be a proper method of procedure on the assumption made is shown by a study of the enormous and quick variations to which the quantity of light emitted by a candle is subject. Curves* showing these instantaneous variations have been obtained by the use of a sensitive bolometer which, when exposed to the radiation of a candle flame, would respond to every change in the intensity of that radiation. It is quite possible that a series of photometric settings should be made in such a way that their mean would give a value considerably lower than the mean ordinate of an intensity curve covering all the time between two weighings of the candle. Moreover, in the bolometric investigation it was found that corrections to the mean ordinates of the various curves for deviations from the normal rate of consumption did not serve to reduce these ordinates to a common value; or, in other words, that the energy radiated was not proportional to rate. Since the radiant efficiency of a candle flame does not change with its size,—provided that it does not smoke,—this would be true for luminous radiation as well as for total radiation. This is in accord with the observations of Tyndal † and the results of Von Jolly, who showed that on a mountain summit candles have a shorter flame and diminished intensity, with the same rate of consumption. Recognising these facts, the German photometrists have insisted that the flame height is the significant factor, and that candle measurements should be made only with a standard height of flame. They would clean the wick of the candle, wait until the flame height becomes normal, and then set the photometer.‡ There are certain objections to this method of procedure, although it undoubtedly gives better results than the English practice. In the first place, it must be a time-wasting and patience-trying operation. Moreover, it is very doubtful if snuffing the wick of a standard candle is an allowable operation, since the shape of the flame depends on the particular curl which the wick assumes, and is normal only when the wick has its natural curl. A more desirable

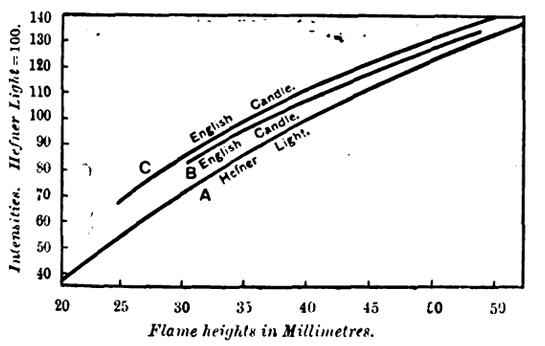


FIG. 1.—Curves by Liebenthal.

method would be to measure, at the instant the photometer setting is made, the height of the candle flame; then, knowing a relation between the height of the flame and the intensity of light emitted, to reduce the instantaneous intensity to the intensity at normal flame height.

The first question, then, becomes: Does any definite relation exist between these quantities? Giroud has shown that the slender, pointed flame of his bec-bougie varies at the rate of about 2 per cent. per millimetre, the relation between flame height and intensity being nearly linear. Liebenthal§ has drawn curves (*see* Fig. 1) showing this relation in the case of the Hefner lamp and of the English standard candle. For the former the relation is approximately linear for small variations, and shows for variations between 35mm. and 45mm., 2·6 per cent. per millimetre. The two English candle curves are practically straight lines for all ordinary variations, and show 2·1 per cent. and 1·9 per cent. per millimetre respectively, for variations between 40mm. and 50mm.

The present experiments were suggested by the results of the bolometric tests of candles. They were undertaken first for the purpose of investigating this relation between flame height and intensity, and second, to determine whether the use of this relation would not make it possible to get more consistent results than can be obtained by correcting for rate of consumption.

Two methods were employed to determine the flame height-intensity ratio. In the first method the intensity of the radiation of the candle was measured by the bolometer in the way previously described. To measure the height of the flame, a long camera was constructed, having its lens and ground-glass plate at a fixed distance from each other. The ground-glass plate was graduated empirically to read directly in millimetres the height of objects focussed upon it. The candle was placed on a pan attached to a spiral spring of such a length that its elongation would be just equal to the length of the candle. By this arrangement the top of the candle was kept at a constant height above the floor, and when once the image of the base of the flame had been accurately adjusted on one of the lines of the camera screen (to facilitate which the screen was capable of a slight vertical movement), it remained there during a considerable period of time. Hence, to measure the height of the flame at any instant, it was necessary only to glance at the image of the *top* of the flame and to note its position on the screen. It will be noticed that this camera device is, to a certain extent, a modification of Krüss' optical flame measure which has been in use a number of years. Extended to take in the bottom of the flame, and combined with the spring balance, it enables measurements to be made with great quickness and with a sufficient degree of accuracy by an observer who is located so far from the flame as to leave it entirely undisturbed by his movements. The magnifying power employed was about two, and heights were measured only to 0·5mm. Greater closeness of measurement was deemed unnecessary on account of the ill-defined nature of the base and tip of the flame. The actual base of a candle flame is difficult to observe on account of the small quantity of light which it emits. The procedure adopted was to set on the line of demarkation between the charred and uncharred portions of the wick, since this was found usually to mark the base of the flame. In case a close inspection of the candle showed the base of the flame to be slightly above this point, a further adjustment of the screen was made.

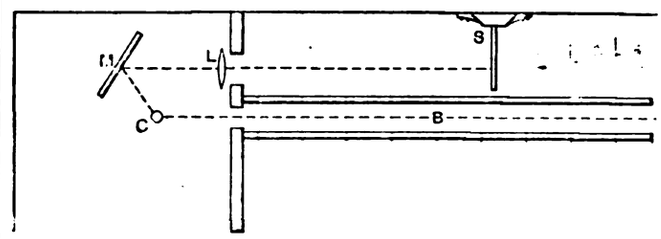


FIG. 2.—Arrangement of Photometer.

In order to ensure great steadiness of the flame, the candle was placed in a roomy, well-ventilated box having a glass window. Having put the candle in position before the bolometer, and having adjusted the camera properly, the bolometer screen was raised and simultaneous observations were made of galvanometer deflections and flame heights. These readings were corrected for any change in sensitiveness of the bolometer and any drift of the galvanometer needle, and were plotted, using flame heights and galvanometer deflections as co ordinates.

In the second method a Lummer-Brodhun photometer was used. At one end of a photometer bar 200in. long was placed a 110-volt glow-lamp. This was maintained at a voltage of 100 by means of a storage battery. Being run at low efficiency, its colour was about the same as that of a candle, and its change in candle power during the time it was in use was too small to be detected. At the other end of the bar was the candle, supported by its adjusted spring. The candle was always placed so that the curl of the wick was perpendicular to the axis of the bar.* The arrangement for measuring flame heights is shown in Fig. 2, which represents a projection of the apparatus on a horizontal plane. B is the photometer bar, C the candle, M a mirror placed behind the candle in such a way as to reflect the rays from it through the lens L, which projected them on a graduated screen S placed immediately behind the bar. The mirror was carried on a movable support so as to admit of an adjustment of focus. This arrangement was adopted, since by its use one observer could do all the work. The method was simply to make a rather quick photometer setting, and then instantly to note the position of the top of the flame on the screen, reading the position of the photometer afterwards.

In some of the earlier measurements a kerosene lamp with an

* Sharp and Turnbull, "A Bolometric Study of Light Standards," *Physical Review*, Vol. II., p. 1. This article will be referred to frequently.

† Tyndal, "Heat as a Mode of Motion." Also Dr. Frankland, *Philosophical Transactions*, 1861.

‡ In the original directions for the proper use of the German Vereinskerze, however, it is stated that snuffing is unallowable, and that measurements should be made only when the quietly-burning flame has reached a height of 50mm. *See* "Beschluss der Versammlung des Vereines des Gas- und Wasserfachmänner Deutschlands," &c. Dingler's *Polytechnisches Journal*, 206, p. 329. This is a reprint from the *Journal für Gasbeleuchtung und Wasserversorgung*, 1872, November 12th. On the other hand, *see* the report of a committee of the Verein von Gas- und Wasserfachmännen as transcribed in *La Lumière Électrique*, XXXIV., p. 178. Here snuffing the wick is recommended. *See also* Krüss' book, "Elektrotechnische Photometrie."

§ Liebenthal, "Photometrische Untersuchungen über die von Hefner-Altenseck'sche Lichteinheit," *Elektrotechnische Zeitschrift*, IX., p. 96, 1888.

* For the variation of the intensity of candle as a function of the azimuth of the plane of the wick, see Methven, *loc. cit.*; also an article by Sugg, in the *Journal for Gas Lighting*.



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Argand burner similar to the ordinary student-lamp burner was used as a secondary standard. The upper part of the chimney was covered by a closely fitting cylinder of ferrotype iron in such a way that the top of the flame was entirely hidden. This furnished a very steady source of light after it had been burning long enough for the parts to become thoroughly warmed, and its intensity was unaffected by slight adjustments of the height of the flame, provided only that the flame was always high enough. Unfortunately, its intensity varied enough from day to day to make

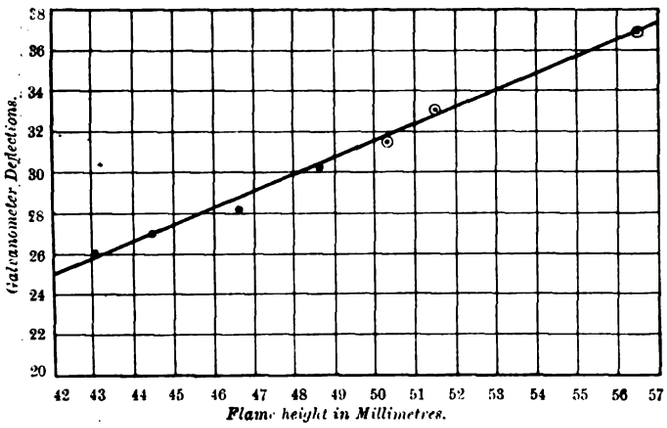


FIG. 3.—Bolometer Curve.

its indications unreliable without a daily calibration, and it was replaced by the more convenient and accurate glow-lamp. Observations of variation of intensity with flame height are not affected by this fact.

The observations were treated in the following manner:—The various observed values of flame height were collected in such a way that heights of 41mm., 41·5mm. and 42mm. formed one group; 42·5mm., 43mm. and 43·5mm. another, &c. The mean

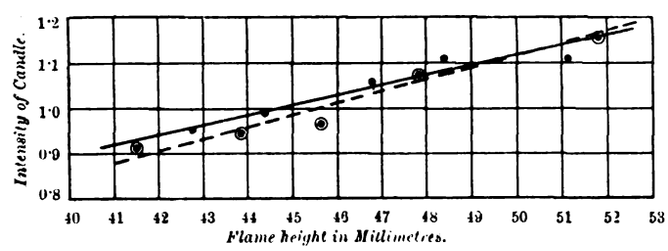


FIG. 4.—Photometer Curves.

height of each group was found, also the mean bar-reading corresponding to it. The candle-power of the standard was found by taking the mean of all the heights and bar-readings, and reducing, by means of an approximate correction, to a standard flame height of 45mm. Using this value for the intensity of the glow-lamp, the intensity of the candle corresponding to each group was computed. By means of a curve plotted from these values the percentage variation per millimetre of flame height was determined.

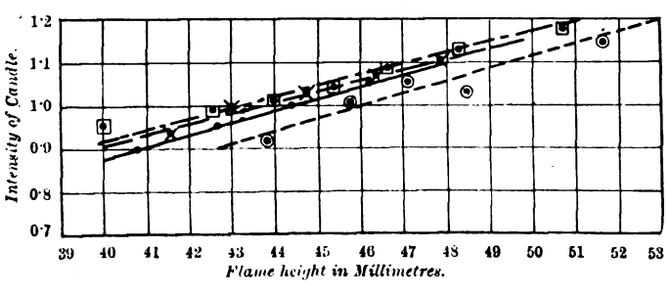


FIG. 5.—Photometer Curve.

In order to find the relative accuracy of this and of the ordinary method of using candles, the following observations were made:—A candle burning normally was weighed by the "method of transits," was transferred to the spring balance, and ten or more photometer settings made, the flame heights also being noted. The candle was then weighed again, and another group taken. A number of such sets of observations were made on several days, and since the glow lamp was used as a reference standard these sets are comparable with each other. The mean value of the candle power of the glow lamp given by each of these sets of observations was corrected for rate in the ordinary way, and was

**Table I.**

| Bolometric. | Per cent. | Photometric. | Per cent. | Photometric. | Per cent. |
|---|---|---|---|---|---|
| 1894. | | 1895. | | 1895. | |
| Nov. 29 | 2·2 | July 27 | 3·3 | Dec. 3, E, F, G | 2·3 |
| Dec. 5 | 2·7 | Oct. 30 | 3·4 | " H | |
| 1895. | | Nov. 1, I | 3·3 | | |
| Feb. 23, I. | 2·2 | " II. | 3·3 | | |
| " II. | 2·5 | Nov. 6, I | 2·2 | Dec. 4, I, J, K, L, M, N | 2·6 |
| " III. | 3·2 | " II. | 2·7 | | |
| March 21, I., II. | 3·1 | Nov. 27, I | 2·7 | | |
| " | | " II. | 2·9 | | |
| Oct. 4 | 2·7 | Dec. 2, A.M., A, B | 2·7 | | |
| | | " C, D, D' | 2·8 | | |
| Mean | 2·7 | | | Weighted mean of all. | 2·7 |

also corrected by reducing from the mean flame height to the standard height of 45mm., using the mean value of the relation between intensity and flame height as determined from all the observations, both bolometric and photometric. The deviation of each value obtained for the candle power of the glow lamp from the mean value obtained from all the observations was computed, and this deviation was reduced to per cent. A comparison of the percentage deviations given by the two methods shows their relative accuracy, while the absolute values of the percentages show the error which one is liable to make in using candles in either of the two ways.

The results obtained in the various sets of observations are shown reduced and plotted in Figs. 3 to 6, and in Table I. Figs. 3 and 6 show results obtained with the bolometer, connecting the

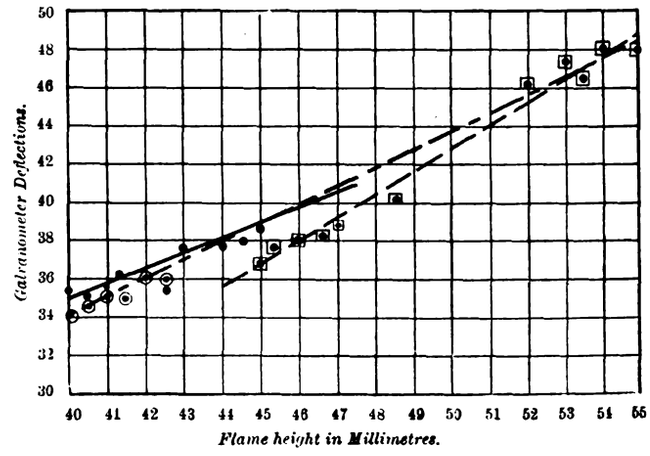


FIG. 6.—Bolometer Curve

height of the candle flame with the intensity of the radiation as measured by the galvanometer. Figs. 4 and 5 show similar results, the photometer, however, being used instead of the bolometer to test the radiation. The variation found in the intensity expressed in per cent. per millimetre is shown in Table I. An inspection of the curves will show that while the relation between flame height and intensity is a fairly definite one for any given group of observations, there is a considerable range of variation in the values for it as obtained from different groups. Moreover, the relation sometimes changes during one burning of the candle. Fig. 6 illustrates this peculiarity in that there is a group of points marked ◘ which lie considerably below the line plotted to represent all the observations; and that the slope of the flame height-intensity curve plotted from the points marked ◘ is materially different from that obtained from other groups of points. This may be due to a change in the shape of the wick. The fact that this relation is not absolutely constant does not vitiate the proposed method of treating candle observations; for since the deviations of flame height from 45mm. is seldom more than 10 per cent., if our assumed value for this relation is in error by as much as 20 per cent., our reduced value for candle-power would be in error by no more than 2 per cent.

The mean deviation from the mean of observations corrected in this way was a little over 2 per cent., and fourteen out of twenty values were in error by 2·1 per cent. or less. In the case of corrections for rate, the mean deviation was over 6 per cent., while but one out of fourteen values deviated by less than 2 per cent., and only four by less than 4 per cent. In other

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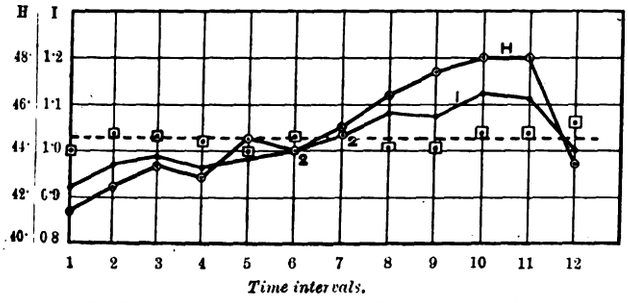
words, by correcting for flame height an error of less than 2 per cent. may reasonably be expected, and the probability of making an error greater than 4 per cent. is small; while in correcting for rate, errors of 8 per cent. and 9 per cent. are of common occurrence. The values corrected for rate might, perhaps, be more consistent if the rule were followed to reject all observations in which the rate fell below 114 or above 126 grains per hour. Similarly, the errors in the values corrected for flame height might be smaller if observations made at extreme flame heights were to be rejected. Indeed, it is one of the chief advantages of the method that the observed flame height furnishes a criterion for the rejection of any observation which is regarded as doubtful. In this discussion, however, in order to be equally fair to both methods, no observations have been rejected.

The results of these photometer observations confirm fully those obtained by the use of the bolometer in determining the variations of light standards, and show very conclusively that the fundamental assumptions on which the bolometric tests were based, were entirely justifiable.

In the "Bolometric Study of Light Standards" it was shown that the British candle is subject to sudden variations in intensity which are sometimes as large as 15 per cent. Many of these sudden drops were noticed while making the photometer observations, and they all had the same characteristics as are shown by the bolometer curves. Fig. 7 shows a group of these observations. Assuming that the time intervals between the various photometer settings were equal, points were plotted showing the relation between intensity of the candle and time and between flame




H = Flame height in Millimetres. I = Intensity of Candle.

FIG. 7.—Variation of flame-height (H) and intensity (I) of English candles. Dotted line shows intensity reduced to standard flame-height.

height and time. It will be seen at once that the two curves are of very similar characters. The flame height gradually increased, and with it the intensity until, when the height of 48mm. had been reached, there was a sudden drop, the change in intensity amounting to 12 per cent. These curves evidently show in an imperfect way variations precisely similar to those which are so faithfully reproduced by the galvanometer needle. In view of these qualitative and quantitative results it would seem to be impossible to doubt the reliability of the bolometer as an instrument for making such tests.

## THE ELECTRICAL RESISTANCE OF ALLOYS.*

BY LORD RAYLEIGH, SEC. R.S.

The recent researches of Profs. Dewar and Fleming upon the electrical resistance of metals at low temperatures have brought into strong relief the difference between the behaviour of pure metals and of alloys. In the former case the resistance shows every sign of tending to disappear altogether as the absolute zero of temperature is approached, but in the case of alloys this condition of things is widely departed from, even when the admixture consists only of a slight impurity.

Some years ago it occurred to me that the apparent resistance of an alloy might be partly made up of thermo-electric effects, and as a rough illustration I calculated the case of a conductor composed of two metals arranged in alternate laminæ perpendicular to the direction of the current. Although a good many difficulties remain untouched, I think that the calculation may perhaps suggest something to those engaged upon the subject. At any rate it affords *à priori* ground for the supposition that an important distinction may exist between the resistances of pure and alloyed metals.

The general character of the effect is easily explained. According to the discovery of Peltier, when an electric current flows from one metal to another there is development or absorption of heat at the junction. The temperature disturbance thus arising increases until the conduction of heat through the laminæ balances the Peltier effects at the junctions, and it gives rise to a thermo-electromotive force opposing the passage of the current. Inasmuch as the difference of temperature at the alternate junctions is itself proportional to the current, so is also the reverse electromotive force thereby called into play. Now a reverse electromotive force proportional to current is indistinguishable experimentally from a *resistance*, so that the combination of laminated conductors exhibits a false resistance, having (so far as is known) nothing in common with the real resistance of the metals.

If $e$ be the thermo-electric force of the couple for one degree difference of temperature of the junctions; $t$, $t'$ the actual temperatures; then the electromotive force for one couple is $e(t-t')$. If we suppose that there are $n$ similar couples per unit of length perpendicular to the lamination, the whole reverse electromotive force per unit of length is $n\,e\,(t-t')$. Again, if C be the current corresponding to unit of cross-section, the development of heat per second at each alternate junction is per unit of area $273 \times e \times C$, the actual temperature being in the neighbourhood of 0° C. This is measured in ergs, and is to be equated to the heat conducted per second towards the cold junctions on the two sides. If $k$, $k'$ be the conductivities for heat of the two metals, $l$ and $l'$ the corresponding thicknesses, the heat conducted per second is

$$(t-t')\{k/l+k'/l'\};$$

or if $l/(l+l')=p$, $l'/(l+l')=q$, $l+l'=1/n$, the conducted heat is

$$n\,(t-t')\{k/p+k'/q\}.$$

In this expression $p+q=1$, the symbols $p$ and $q$ denoting the proportional amounts by volume in which the two metals are associated. Thus, when a stationary state is reached,

$$273 \times e \times C = n\,(t-t')\{k/p+k'/q\}.$$

This determines $(t-t')$ when C is given; and the whole back electromotive force per unit of thickness is $r\,C$, where

$$r = \frac{273 \times e^2}{k/p + k'/q}.$$

This is the expression for the false resistance per unit of thickness, which, it should specially be noted, is independent of $n$, the number of couples. The number of couples which co-operate is indeed increased by finer lamination, but the efficiency of each is decreased in the same proportion by the readier conduction of heat between the junctions. It is scarcely necessary to point out that the false resistance is called into play only by currents which flow *across* the laminæ.

In my original calculation the metals chosen for illustration were iron and copper. In this case (Everett's C.G.S. system of units, p. 192) $e=1{,}600$. The conductivities are to be measured in ergs. For iron, $k=0{\cdot}164 \times 4{\cdot}2 \times 10^7$; for copper, $k'=1{\cdot}11 \times 4{\cdot}2 \times 10^7$. Thus, if the metals are in equal volumes ($p=q=\frac{1}{2}$),

$$r = \frac{2 \times 273 \times 1{,}600^2}{4{\cdot}2 \times 10^7 \times 1{\cdot}27} = 26{\cdot}2.$$

This is the thermo-electric addition to the true specific resistance, and is about 1½ per cent. of that of copper. Such an addition may seem small; but it should be remembered that for the more distinctively thermo-electric metals $e$ is much larger, and that it enters by its square. In any case it seems desirable that this complication should be borne in mind. The consequences which follow from recognised laws for laminated structures, however fine, must surely have some bearing upon the properties of alloys, although in this case the fineness is molecular.

* From *Nature*.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, June 26th.**

PHYSICAL SOCIETY.

*5 p.m.* Meeting at Burlington House. Papers to be read: (1) "Admittance and Impedance," by F. Bedell; (2) "On the Properties of a Body having a Negative Resistance," by Prof. S. P. Thompson; (3) "On Bare Wire Resistances," by H. F. Burstall.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p m.

## BOOKS RECEIVED.

"A Practical Treatise on the Otto Cycle Gas Engine." By William Norris. (London: Longmans, Green & Co. Price 10s. 6d).

"Jahrbuch der Elektrochemie; Berichte über die Fortschritte des Jahres, 1895." By Dr. W. Nernst and Dr. W. Börchers. (Halle-a.-S.: Wilhelm Knapp.)

"Electric Wiring Specifications for Incandescent Lighting." By George H. Kimber. (New York: C. H. Irwin and Co.)



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## THE UNITED STATES TELEGRAPHS.

It is seldom we criticise anything pertaining to America without fear of hurting the susceptibilities of our over-sensitive kinsmen on that side the Atlantic; but in the matter of national telegraphy we are spared this embarrassment by their doing all the fault-finding themselves. This they do in terms which we should not venture to employ, and with such complimentary references to the telegraph system of our own country that, even if inclined to join in an outcry against the American systems, our pen would be disarmed. The telegraphs of the States are in the hands of one, or at most two, huge companies, which have no doubt the defects common to all great monopolies. But whether the work is badly done, or whether the charges are excessive, it is not for us to say. The Americans, however, who ought to know best, condemn the companies on both counts, and point to England as furnishing a model for imitation, whilst their own is held up as an example of extortion and inefficiency. For twenty years past efforts have been made from time to time to transfer the telegraph to the States' control, or otherwise amend matters; and it is said that not a year has gone by without some Bill being laid before Congress or Senate to effect one or other of these objects. Why those efforts have failed is more than we can explain; but that they have failed is certain, the numerous telegraph corporations which once served the United States having been meanwhile amalgamated, one by one, until we see them now all practically under the domination of the Western Union Telegraph Company—a company so vast and powerful that apparently the Government is afraid to tackle it, because of the financial and political difficulties that would have to be faced were any such project seriously entertained.

There was a time when it would have been easy to purchase the companies in detail, acquire the whole of their rights on reasonable terms, and exercise them in a perfectly legitimate way. But that opportunity was missed; and we now see the Government year after year pressed to adopt measures which can hardly be called legitimate, and which indeed strike us as being little better than confiscatory. These projects generally take the form of competition on the part of the States—a competition which, if effective, is most unfair to the other

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competitor; if not effective, most unsatisfactory to the public; and in either case most extravagantly wasteful of money and plant. Such a competition, if consistently pursued, can have no object other than to bring the offending monopoly to terms, an object which cannot be achieved without virtually duplicating the existing system and waging a war of rates. In England it is held that no Government would be justified in adopting that course against the National Telephone Company; and we believe that similar principles of action will prevail in the United States. The shifts that are resorted to in order to evade or surmount obstacles to popular telegraphy in that country tend to convince us that confiscation in any guise whatever has ceased to find favour there. One of these ingenious projects has just reached us, outlined in the evidence of Mr. PATRICK B. DELANY before a Committee of the Senate inquiring into the feasibility of what is called "Postal Telegraphy by the Machine System." From the point of view of the State this system may be described as a fast-speed telegraph monopolised by the Government, at very cheap rates, between principal towns and cities where the traffic would suffice to warrant that mode of signalling. From another and perhaps more accurate point of view the suggestion is one for realising Mr. DELANY's high-speed telegraph visions. As all the world knows, that eminent inventor has done wonders in the way of phenomenal transmission of electric signals—so phenomenal, indeed, that ordinary telegrams are wasted upon it. Accordingly, Mr. DELANY would increase the maximum number of words to 50 at least, so that, in fact, people would conduct their letter-writing by telegraph, and the State would enjoy the privilege of conveying correspondence by wire instead of by post. We have the greatest admiration of Mr. DELANY's mechanical skill; but we have also the greatest respect for the American Senator's cuteness; and we shall be immensely surprised if the inventor, in this instance, gets the better of the statesman.

Nothing, probably, would tempt the Government of the United States into the course recommended by the promoters of the "machine system," except the possibility of diverting to itself the best part of the traffic from the Western Union wires, and reaping such a profit on the business as would supply funds for buying out the remainder. At its best, however, the process would be a long one; and meanwhile, supposing the "machine system" to be as eminently successful and as immensely popular as its advocates assume that it would be, the rest of the country not blessed with centres of industry and affairs like New York, Chicago and Washington, would be left to the mercy of the maimed and exasperated monopolists. We are glad to observe that some healthy misgivings on this score were betrayed by the Committee, who asked some pointed questions both of Mr. DELANY and a Mr. BELL who followed him on similar lines, representing the Typographical Union. The first-named witness, of course, had no concern with anything but his own device, and he made no pretence that it could be economically applied to wires the traffic on which would not keep it fairly occupied at high speed. But Mr. BELL was more candid—or perhaps we should say less cautious. He would not recommend anything being done at a loss to the State, not even for the benefit of the Press, and obviously not for those smaller communities which cannot supply matter enough to keep a fast-speed "machine system" postal telegraph going at its fastest. Of course all this can only mean that the State is to work only such lines as offer a sure source of great profit, whilst the rest of the country is to be left without the benefit of State interference. Or, to put the case more bluntly, where the existing companies can be robbed of their monopoly they are to be robbed; but where it would not be profitable to interfere, the monopolists are to be let severely alone. As the aggregate of the "let alone" area is by far the largest, both in extent and population, we may be pretty sure the States Government will not adopt a suggestion so partial and one sided as this.

A great portion of Mr. DELANY'S argument before the Senatorial Committee consisted of references to the British telegraph system, which he favourably contrasted with the system prevailing in the United States. There is nothing in this country at all comparable with what Mr. DELANY desires to introduce into America, so that his comparisons may be accepted as perfectly genuine and disinterested. From these we learn that not only is the British the most efficient telegraph system in the world, but that it is the most liberal and self-sacrificing. We knew this already, but we did not expect to receive testimony from America that it was also a paying concern. It seems that in America, as in these islands, the opinion is prevalent that British telegraphy under State control does not pay. Mr. DELANY's comment on this is much the same as our own in an editorial note last week. With characteristic eloquence he exclaims: "This is a misleading and truth-impoverished statement." It has never been in our power to command language such as this, but we have said something of a kind which follows: "It is well understood in England that the telegraph branch of the Post Office has not a distinct financial head, and that the Post Office accounting bureau arrange disbursement and expense items from a standpoint not in accord with the ideas prevailing among the heads of the telegraph service, and that if the telegraph branch kept its own books the yearly exhibit would show a handsome profit." Of course, we are much obliged to this witness of unimpoverished truth; but it in no way helps him with his argument for a partial acquisition of the telegraphs by the United States, to be worked by entirely novel and untried methods, and on principles of competition which are essentially more objectionable than the worst forms of monopoly. We bought and paid handsomely, too handsomely, perhaps, for our telegraphs, and have not grudged the money. If the United States cannot, or will not, do the like, it had better try its hand at regulating the monopoly in the public interest—a task we should imagine far easier and less risky than attempting to extinguish it by arbitrary and rapacious competition.

## ELECTROMAGNETIC THEORY.—LXXXVII.*

BY OLIVER HEAVISIDE.

(*Continued from page 141.*)

§ 350. At the very beginning of the treatment of the subject of diffusion there presented itself to our consideration the execution of a differentiating operation which, according to ordinary notions of differentiation, was unintelligible. This was the operation concerned in the function $p^{\frac{1}{2}}1$, where $p$ is the time differentiator, and 1 is the special function of $t$ which is zero before and unity after the moment $t=0$. Instead of the operand being 1, it may be any function of the time. The square root of a differentiator occurs in the fundamentals of the physical subject, namely, the generation of a wave of diffusion. It is necessary and inevitable; also, when studied, it is found to facilitate working.

In order to avoid introducing the idea of fractional differentiation from the theoretical standpoint, I took the value of $p^{\frac{1}{2}}1$

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as known experimentally, § 241 equation (A). There is no question as to its value; it is settled by Fourier's investigations in the theory of the diffusion of heat in conductors. But, without this reference to a known result, we should be justified by the consistency of the results obtained by the assumption that the function $p^{\frac{1}{2}}1$ was of the form employed. For the general formulæ for diffusive waves were obtained, and then series of reflected waves, and finally these were converted to series of normally subsiding states. The same process was also carried out for Bessel waves and normal series.

There will be a good deal of use made occasionally of fractional differentiation in the following, when it turns up. The theory of the matter, also, will not be overlooked. But the primary object of the chapter now beginning is electromagnetic waves, and the generalisations will take a subsidiary place as they are suggested. Those who may prefer a more formal and logically-arranged treatment may seek it elsewhere, and find it if they can; or else go and do it themselves.

At present, merely for the sake of completeness, I introduce one example of the experimental discovery of the meaning of $p^{\frac{1}{2}}1$, founded upon the old diffusive methods. We found in § 240, equation (7), that when an infinitely long cable, with constants R, S (resistance and permittance per unit length), is subjected at its beginning to impressed voltage $e$, the current produced on the spot was expressed by

$$C = (Sp/R)^{\frac{1}{2}}e \tag{1}$$

If $e$ is constant, we have to find what $p^{\frac{1}{2}}1$ means. Now, we can work out this problem in Fourier series, first for a finite cable, and then proceed to the limit. Thus, let the cable be of length $l$, and be earthed there. Then, if $s^2 = -RSp$,

$$V = \frac{\sin s(l-x)}{\sin sl}e \tag{2}$$

is the potential V at $x$ due to $e$, as in § 265, equation (1), since it makes $V = e$ at the beginning and $V = 0$ at the end. The algebrisation by the expansion theorem (§ 287, equation (43), or in any equivalent way) makes

$$V = e\left(1 - \frac{x}{l}\right) - \frac{2e}{\pi}\sum\frac{\pi}{l}\frac{\sin sx}{s}\epsilon^{-s^2t/RS}, \tag{3}$$

where, in the summation, $s$ has the values $\pi/l$, $2\pi/l$, $3\pi/l$, &c.

Observing that the step from one $s$ to the next is $\pi/l$, and that it becomes infinitely small when $l$ is made infinitely great, we see at a glance that $l = \infty$ converts (3) to

$$V = e - \frac{2e}{\pi}\int_0^\infty ds\,\frac{\sin sx}{s}\epsilon^{-s^2t/RS}. \tag{4}$$

That is, there is a conversion of the Fourier series to a definite integral, the previous finite step $\pi/l$ becoming the infinitesimal step $ds$. The current at the beginning, $x = 0$, is got by $C = -R^{-1}(dV/dx)$, and then putting $x = 0$. This makes

$$C = \frac{2e}{R\pi}\int_0^\infty \epsilon^{-s^2t/RS}ds. \tag{5}$$

Comparing with (1), and removing unnecessary constants, we see that

$$p^{\frac{1}{2}}1 = \frac{2}{\pi}\int_0^\infty \epsilon^{-s^2t}ds, \tag{6}$$

which is a well-known integral. Perhaps the easiest way to evaluate it (by an ingenious device, also well-known), is thus:

$$(p^{\frac{1}{2}}1)^2 = \frac{2}{\pi}\int_0^\infty \epsilon^{-x^2t}dx \times \frac{2}{\pi}\int_0^\infty \epsilon^{-y^2t}dy = \frac{4}{\pi^2}\int_0^\infty\int_0^\infty \epsilon^{-(x^2+y^2)t}dx\,dy$$
$$= \frac{1}{\pi^2}\int_0^\infty 2\pi r\,dr\,\epsilon^{-r^2t} = \frac{1}{\pi t}\left[-\epsilon^{-r^2t}\right]_0^\infty = \frac{1}{\pi t}. \tag{7}$$

So, taking the square root, we arrive at the required result,

$$p^{\frac{1}{2}}1 = (\pi t)^{-\frac{1}{2}}. \tag{8}$$

The above is only one way in a thousand. I do not give any formal proof that all ways properly followed must necessarily lead to the same result.

It should be noticed, in passing, that the operator $C/e$, which is rational when $l$ is finite, reduces to the irrational form in (1) just when the Fourier series passes into the definite integral by making $l$ infinite. At the same time the infinite series of waves involved in the Fourier series reduces to a single wave.

§ 351. On the basis of the result just obtained, we are in possession of the value of $p^{m+\frac{1}{2}}1$, when $m$ is any integer, positive or negative. Thus, when $m$ is positive, we have whole differentiations to perform upon $p^{\frac{1}{2}}1$. For example,

$$\left.\begin{aligned} p^{\frac{3}{2}}1 = pp^{\frac{1}{2}}1 = p(\pi t)^{-\frac{1}{2}} &= -\frac{t^{-\frac{3}{2}}}{2\pi^{\frac{1}{2}}}, \\ p^{\frac{5}{2}}1 = \frac{1.3}{2.2}\frac{t^{-\frac{5}{2}}}{\pi^{\frac{1}{2}}}, \qquad p^{\frac{7}{2}}1 &= -\frac{1.3.5}{2^3}\frac{t^{-\frac{7}{2}}}{\pi^{\frac{1}{2}}}, \end{aligned}\right\} \tag{9}$$

and so on. When $m$ is negative we must perform integrations from 0 to $t$. Thus,

$$\left.\begin{aligned} p^{-\frac{1}{2}}1 = p^{-1}p^{\frac{1}{2}}1 = p^{-1}(\pi t)^{-\frac{1}{2}} &= \frac{2t^{\frac{1}{2}}}{\pi^{\frac{1}{2}}}, \\ p^{-\frac{3}{2}}1 = \frac{2^2t^{\frac{3}{2}}}{1.3\,\pi^{\frac{1}{2}}}, \qquad p^{-\frac{5}{2}}1 &= \frac{2^3t^{\frac{5}{2}}}{1.3.5\,\pi^{\frac{1}{2}}}, \end{aligned}\right\} \tag{10}$$

and so on.

We also know the value of $p^{m+\frac{1}{2}}t^n$, where $n$ is integral, or is an integer $+\frac{1}{2}$. Say it is integral and positive. Let the operand be $t^n/\underline{n}$ where $\underline{n}$ is the factorial function $1.2.3.\ldots.n$. Then

$$p\frac{t^n}{\underline{n}} = \frac{t^{n-1}}{\underline{n-1}}, \qquad p^n\frac{t^n}{\underline{n}} = 1, \qquad p^{-n}1 = \frac{t^n}{\underline{n}}; \tag{11}$$

and now introducing the index $\frac{1}{2}$, we get

$$p^{m+\frac{1}{2}}\frac{t^n}{\underline{n}} = p^{m-n+\frac{1}{2}}1 = p^{m-n}\frac{1}{(\pi t)^{\frac{1}{2}}}. \tag{12}$$

Here $m - n$ is integral, so we have the former cases again, as in (9) and (10). Now the fundamental property of $\underline{n}$ is

$$\underline{n} = n\,\underline{n-1}, \tag{13}$$

with the addition that its value must be fixed for any one value of $n$, for instance, $\underline{1} = 1$. It follows that $\underline{0} = 1$ also, and that $\underline{n}$ is $\infty$ for all negative integral values of $n$. Consequently (11) and (12) are also valid when $n$ is negative. For example, $p1 = 0$, provided $t$ is positive. It is really an impulse at the moment $t = 0$. Also $p1 = t^{-1}/\underline{-1}$, and this is zero, unless $t$ is also zero.

Comparing results, it will be observed that if we use the formula (13) when $n$ is an integer $+\frac{1}{2}$, as well as when it is an integer, and introduce the datum that

$$\underline{-\tfrac{1}{2}} = \pi^{\frac{1}{2}}, \tag{14}$$

the above results in generalised differentiation are valid with the extended meaning of $n$. Thus

$$\left.\begin{aligned} \underline{\tfrac{1}{2}} = \tfrac{1}{2}\underline{-\tfrac{1}{2}} = \tfrac{1}{2}\pi^{\frac{1}{2}}, \quad \underline{\tfrac{3}{2}} = \tfrac{3}{2}\tfrac{1}{2}\pi^{\frac{1}{2}}, \quad &\text{&c.} \\ \underline{-\tfrac{3}{2}} = -2\underline{-\tfrac{1}{2}}, \quad \underline{-\tfrac{5}{2}} = \tfrac{1}{2}\tfrac{2}{3}\underline{-\tfrac{1}{2}}, \quad &\text{&c.} \end{aligned}\right\} \tag{15}$$

we shall now have

$$p^n1 = \frac{t^{-n}}{\underline{-n}}, \qquad p^{-n}1 = \frac{t^n}{\underline{n}}, \qquad p^m\frac{t^n}{\underline{n}} = p^{m-n}1, \tag{16}$$

when $n$ is any integer, or is midway between two consecutive integers; and the same as regards $m$.

The extension to the case of $n$ being any real number, positive or negative, is not difficult, but we do not want it at present. The above can be applied to numerous electromagnetic problems without going further into the meaning of generalised differentiation. That $\underline{-\frac{1}{2}}$ is $\pi^{\frac{1}{2}}$ is, as far as the above is concerned, merely a convention or definition, the factorial notation being convenient for showing the system involved, and for the expression of results.

§ 352. After the above little mathematical excursion we may return to the physical problem out of which it arose, but generalised to include self-induction and leakage. Let the cable have the four constants R, K, L, S, in the notation previously employed, the additional L and K being the inductance and leakage per unit length. Then the current produced by $e$ impressed at the beginning of an infinitely long cable is

$$C = \left(\frac{K + Sp}{R + Lp}\right)^{\frac{1}{2}}e, \tag{17}$$

that is, R is generalised to $R + Lp$ and $Sp$ to $K + Sp$. See Vol. I, § 221, equation (12).

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Now this is a far more developed case than the former. Ways of algebrising it have to be found. The previous mode of attack will be found to be enormously complicated. But we can find what (17) means pretty straight out from itself, without the circumbendibus involved in evaluating complicated integrals by rigorous methods.

Notice some special cases first. If only R and S are finite we have the former case. But if R and S are zero, whilst L and K are finite, we have a similar case. Thus

$$C = (K/Lp)^{\frac{1}{2}}e = 2(Kt/L\pi)^{\frac{1}{2}}, \qquad (18)$$

by using the value of $p^{-\frac{1}{2}}1$. The current increases to infinity according to the square root of the time. This is a curious case of leakage conductance and inductance only, and is purely a magnetic problem.

Next, all four constants being finite, $p=0$ in (17) produces the steady ultimate state $C=(K/R)^{\frac{1}{2}}e$. Here $(R/K)^{\frac{1}{2}}$ is the effective steady resistance reckoned at the beginning of the circuit. In the extreme case $R=0$, no steady state is reached, of course.

Further, let $R/L=K/S$. Then $p$ goes out from (17), which again reduces to $C=(K/R)^{\frac{1}{2}}e$. This is the distortionless case, § 209. It now holds good always, whether $e$ is steady or not, the cable behaving towards the impressed voltage as though it were a mere resistance.

Again, putting $p=ni$ in (17) will produce the simply periodic current that results when $e$ is simply periodic, by reducing it to the form $C=(K'+S'p)e$. The developed formula was given in § 221, Vol. I., and need not be repeated.

Finally, $p=\infty$ in (17) gives the *initial* value of C when $e$ suddenly jumps from zero to a finite value, viz.,

$$C = (S/L)^{\frac{1}{2}}e = e/Lv, \qquad (19)$$

if $v$ is the speed of propagation, or $(LS)^{-\frac{1}{2}}$.

In the theory of a plane electromagnetic wave the equation corresponding to (17) is

$$H = \left(\frac{g+\mu p}{k+cp}\right)^{\frac{1}{2}}E, \qquad (20)$$

where H and E are the electric and magnetic forces, $c$ and $\mu$ the permittivity and inductivity, $k$ and $g$ the conductivities, electric and magnetic respectively. It can be treated in the same way, and, in fact, it represents the same problem physically, except as regards the constant $g$. This was explained in Chapter IV.

§ 353. Now let $e$ be constant after $t=0$, and zero before, and consider the case in which K is the only constant that vanishes. Then

$$C = \left(\frac{Sp}{R+Lp}\right)^{\frac{1}{2}}e = \frac{e}{Lv(1+2ap^{-1})^{\frac{1}{2}}}, \qquad (21)$$

if $a=R/2L$.

The suggestion to employ the binomial theorem is obvious. It will expand the operator in powers of $p$, and so substitute a series of easy operations for an unintelligible one. Thus, expanding in rising powers of $a/p$,

$$C = \frac{e}{Lv}\left\{1 - \frac{a}{p} + \frac{1.3}{\lfloor 2}\left(\frac{a}{p}\right)^2 - \frac{1.3.5}{\lfloor 3}\left(\frac{a}{p}\right)^3 + \ldots\right\}1. \qquad (22)$$

Here we have only whole integrations. So the immediate result is, by the third of equations (11) above,

$$C = \frac{e}{Lv}\left\{1 - at + \frac{1.3}{(\lfloor 2)^2}(at)^2 - \frac{1.3.5}{(\lfloor 3)^2}(at)^3 + \ldots\right\}, \qquad (23)$$

a convergent solution in rising powers of the time. The straightforward and rapid way of getting the result is remarkable.

But the binomial theorem furnishes another way of expanding the operator in (21), viz., in rising powers of $p$. Thus,

$$C = \frac{1}{Lv}\frac{(p/2a)^{\frac{1}{2}}}{(1+p/2a)^{\frac{1}{2}}}e = \frac{1}{Lv}\left\{1 - \frac{p}{4a} + \frac{1.3}{\lfloor 2}\left(\frac{p}{4a}\right)^2 - \frac{1.3.5}{\lfloor 3}\left(\frac{p}{4a}\right)^3 + \ldots\right\}\left(\frac{p}{2a}\right)^{\frac{1}{2}}e. \qquad (24)$$

Here we know already the value of $(p/2a)^{\frac{1}{2}}e$, viz., $e/(2\pi at)^{\frac{1}{2}}$. We have, therefore, merely to perform whole differentiations upon it to produce the solution with the same directness in this form :—

$$C = \frac{e}{Lv}\frac{1}{(2\pi at)^{\frac{1}{2}}}\left\{1 + \frac{1^2}{8at} + \frac{1^2 3^2}{\lfloor 2(8at)^2} + \frac{1^2 3^2 5^2}{\lfloor 3(8at)^3} + \ldots\right\}. \qquad (25)$$

This is a divergent series. So much the better. It is easier to calculate except when $at$ is so small as to bring the point of convergence too near the beginning.

Equations (23) and (25) are equivalent. Comparing (25) with (3) § 336, we see that (25) is the same as

$$C = \frac{e}{2Lv}\epsilon^{-at}H_0(at), \qquad (26)$$

where $H_0(at)$ is the divergent zeroth Bessel function which was shown to be numerically equivalent to $2I_0(at)$. Therefore (23), being convergent, should represent

$$C = \frac{e}{Lv}\epsilon^{-at}I_0(at). \qquad (27)$$

That it does may be verified by multiplying together the ordinary series for the exponential and the convergent Bessel function ; (27) then becomes (23).

Besides the very direct way of getting the results (which, I may remark, are quite correct*), there are several points to be noticed. Thus, we find the use of the binomial theorem is justifiable, to substitute an infinite series of separate integrations or differentiations for the operator involving the radical. Next, that the convergency of the series in powers of $p$ obtained does not enter into the question at all. Either (24) or (22) is divergent when $a/p$ is numerical. But both are valid, though one gives rise to a convergent final result, the other to a divergent one. As regards the practical use of the latter, *see* § 335 for the present. The question will arise again.

Notice further that we obtained (23) from (21) through (22) without any use of fractional differentiation. But if we take the special case of the same got by making $L=0$, we reduce (21) to the form (1), and cannot now escape from $p^{\frac{1}{2}}$. This is curious. The lesser seems to contain more than the greater. The explanation is to be seen in the other way of expanding the operator. The reduced form of (24) is (1), and both involve $p^{\frac{1}{2}}$. It still remains remarkable, however, that we can escape from $p^{\frac{1}{2}}$/, and so evaluate it by generalising the problem involved in (1).

§ 354. Observing that in the form (27) we have an exponential factor, a third mode of algebrising (21) is suggested—viz., by putting in the exponential factor at the beginning. This is the way. We have

$$\left(\frac{p}{p+2a}\right)^{\frac{1}{2}}1 = \epsilon^{-at}\epsilon^{at}\left(\frac{p}{p+2a}\right)^{\frac{1}{2}}1, \qquad (28)$$

obviously. Now, here $\epsilon^{at}$ may be shifted to the right, provided we simultaneously change $p$ to $p-a$. This makes the last become

$$= \epsilon^{-at}\left(\frac{p-a}{p+a}\right)^{\frac{1}{2}}\epsilon^{at}, \qquad (29)$$

and now it is $\epsilon^{at}1$ or $\epsilon^{at}$ that is the operand, not 1. (If an operand is always understood to be at the end, the unit operand may be omitted in general, just as in arithmetical and algebraical operations, and it is sometimes an advantage to omit it.) So far only makes a pretty change ; but we can go further. For

$$\epsilon^{at} = \frac{p}{p-a}, \qquad (30)$$

with unit operand understood. Compare with (3), § 265. Substituting (30) in (29), reduces it to

$$\epsilon^{-at}\left(\frac{p-a}{p+a}\right)^{\frac{1}{2}}\frac{p}{p-a} = \epsilon^{-at}\frac{p}{(p^2-a^2)^{\frac{1}{2}}} = \epsilon^{-at}\frac{1}{(1-a^2/p^2)^{\frac{1}{2}}}, \qquad (31)$$

with unit operand again. Now expand by the binomial theorem and algebrise. We get

$$\epsilon^{-at}\left\{1 + \tfrac{1}{2}\frac{a^2}{p^2} + \frac{1.3}{2^2\lfloor 2}\frac{a^4}{p^4} + \frac{1.3.5}{2^3\lfloor 3}\frac{a^6}{p^6} + \ldots\right\}$$

$$= \epsilon^{-at}\left\{1 + \frac{a^2t^2}{2^2} + \frac{a^4t^4}{2^2 4^2} + \frac{a^6t^6}{2^2 4^2 6^2} + \ldots\right\} = \epsilon^{-at}I_0(at), \qquad (32)$$

* How *Know* that (27) is right? Because, when $t$ is turned to $(t^2-x^2/v^2)^{\frac{1}{2}}$ in the $I_0$ function, the result is the complete wave of current entering the cable. The partial characteristic is satisfied, as well as the terminal condition. This generalisation will occur further on.

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as required. *See* (23), § 338. Introduce the omitted factor $e/Lr$ into equations (28) to (32) to produce the working of the electrical problem.

Here again, there are points to notice. The transformation from (28) to (30) depends upon the property $p^n \epsilon^{at} = a^n \epsilon^{at}$. That is, the potence of $p$ is, under the circumstances, simply $a$, when $n$ is integral. So

$$p^n (u\epsilon^{at}) = \epsilon^{at} (p+a)^n u, \qquad (33)$$

if $u$ is a function of $t$. Thus $\epsilon^{at}$ may be shifted to the left by increasing $p$ to $p+a$. Similarly

$$f(p) (u\epsilon^{at}) = \epsilon^{at} f(p+a) u, \qquad (34)$$

if $f(p)$ is a rational integral function of $p$. We find that this process is justifiable (by results) in the case of the irrational functions of $p$ we have had in question.

Having changed the operand and obtained (29), we then change it to unity again, through (30). This is expressed by

$$f(p)\,1 = \epsilon^{-at} f(p-a)\epsilon^{at} = \epsilon^{-at}\frac{pf(p-a)}{p-a}1. \qquad (35)$$

The result is to come to an entirely different kind of operator. Instead of the first power of $p$ under the radical sign, we have the square of $p$ in (31). The subsequent expansion and correct algebrisation in (32) are obvious.

But there is another thing to be noticed. Previously we had $p$ with the + sign under the radicals. Now it has the − sign. Furthermore, it will be found that the alternative method of expanding (31) fails. This point will be noticed again.

Collecting results as regards $I_0(at)$, disconnected from unnecessary constants, we have

$$I_0(at) = \epsilon^{at}\left(\frac{p}{2a+p}\right)^{\frac{1}{2}} = \epsilon^{-at}\left(\frac{p}{p-2a}\right)^{\frac{1}{2}}$$
$$= \left(\frac{p-a}{p+a}\right)^{\frac{1}{2}}\epsilon^{at} = \left(\frac{p+a}{p-a}\right)^{\frac{1}{2}}\epsilon^{-at} = \frac{p}{(p^2-a^2)^{\frac{1}{2}}}. \qquad (36)$$

The operand is $\epsilon^{at}$ or $\epsilon^{-at}$ when at the end. At the beginning they are factors only. The operand is 1, when no time function is written at the end.

So far there is only one constant essentially concerned along with $p$, viz., $a$. But in the general case, when K is not neglected, there are two constants involved. To this development I now proceed.

CORRECTIONS. In Article 86, equations (80), (81), (85), (87), (94), *for* $)_a$ *read* $)_t$. And after equation (87) *read* $(-1<m<0)$.

*(To be continued.)*

## THE CONTROL BY MUNICIPAL AUTHORITIES OF CONSUMING DEVICES AND THE WIRE CONNECTING THEM TO THE MAINS.*

BY C. H. WORDINGHAM.

The subject of regulations as to the carrying out of the connection within a consumer's premises of his consuming devices to the electric supply mains is one which has engaged the attention of electrical engineers and the officials of fire insurance companies from the days when electric lighting was first introduced; and, far from diminishing, interest in the subject has lately been keener than ever. The discussion that has taken place has had reference almost entirely to the determination of the best of several rival systems of protecting and insulating the conductors. There are, however, many other points in connection with the question which are of vital importance to municipalities who are in possession of electric supply stations, and it is with these questions that the author proposes chiefly to deal, as they may be most profitably discussed at a meeting such as the present Convention. The question of the regulations themselves may appropriately be thrashed out at meetings of societies like the Institution of Electrical Engineers, or the Northern Society of Electrical Engineers; at the same time, it is highly desirable that a uniform set of rules should be adopted by municipal Corporations.

Before starting to make regulations, it is well to examine what powers the body making the regulations has to enforce them; and this is a subject on which much doubt appears to exist, both in the minds of engineers and contractors for wiring. There can be no doubt that under the Board of Trade regulations supply must compulsorily be discontinued if the insulation resistance of an installation does not reach 10,000 ohms; but, most certainly, if the insulation resistance exceeds that amount, the undertakers cannot of necessity be compelled to connect, although most wiring contractors seem to suffer from the delusion that this is the case. It was distinctly stated by the Board of Trade officials, at the meeting called in Westminster to discuss the Board of Trade regulations recently issued, that under their Provisional Orders municipal bodies have the power to make such regulations as to the work on a consumer's premises as will prevent this consumer becoming a source of danger or unsatisfactory supply to any other consumer. The clauses in the Order which are relied upon for this are under the heading of supply, the words being:—

"Provided also that if the owner or occupier of any such premises as aforesaid uses any form of lamp or burner or uses the energy supplied to him by the undertakers for any purposes or deals with it in any manner so as to unduly or improperly interfere with the efficient supply of energy to any other body or person by the undertakers, the undertakers may, if they think fit, discontinue to supply energy to such premises as long as such user continues.

"Provided also that the undertakers shall not be compelled to give a supply of energy to any premises unless they are reasonably satisfied that the electric lines, fittings, and apparatus therein are in good order and condition, and not calculated to affect injuriously the use of energy by the undertakers or by other persons."

So far, good; but, unfortunately, the Board of Trade officials did not seem at all certain as to how far this clause could be pressed, and it was quite clear that they considered that their duty ended when they had secured the safety of the public, their view apparently being that they should not interfere with the Englishman's proverbial castle. Much as one wishes, as a supply-station engineer, that the Board of Trade could see their way to allow a municipality to draw up regulations, and to submit them to the Board for approval, such regulations, when approved, being endorsed by the Board of Trade and becoming binding on consumers, it can be readily understood that there are difficulties in the way of a Government department so doing. It might be resented by the public, and it might be a precedent which, with far-reaching operations, would involve difficulties in other directions. It is futile to discuss this solution of the difficulty, since there does not appear to be the slightest chance of the Board of Trade acting in the desired manner.

The case is different, however, with a municipality. It already interferes to a very large extent on a consumer's premises, with material benefit, it may be remarked, to the consumer—notably in the case of sanitary arrangements, and also to a great extent with regard to fittings in connection with water supply, and to a less extent with gas pipes and fittings. Moreover, from the author's experience there can be little doubt that consumers of electric current would gladly welcome some efficient supervision on the part of the municipal authorities. At the present time, much as it goes against the grain, the electrical engineer has to say to the consumer: "We have certain regulations which we enforce, but these regulations are merely intended to prevent your becoming a nuisance or a danger to other people. We have nothing whatever to do with the way in which your contractor chooses to carry out your work." Now, this is not a right state of things. It must be notorious to all present that in every town there are many contractors whose one aim and object is to obtain work at any price, and then by scamping the work, to make some profit; the last thing they think of is to make a good, durable, and efficient job. These men are not the majority, but they exist in considerable numbers, and their presence works most serious mischief to those firms who honourably desire to do good work at a fair price. Indeed, it may be said that cheap and inefficient wiring is a crying evil at the present time. From every point of view the operations of the unscrupulous wiring contractor should be restrained. From the consumer's point of view, he should be protected against the danger and expense of bad wiring; from the point of view of the electrical trade generally, unfair and dishonest competition should be stopped; and lastly, from the point of view of the Corporation, shorts and leaks, which have to be sought with much trouble, should be avoided.

From what has already been said, it will be gathered that it is exceedingly difficult to enforce regulations with no better authority than that given in the Provisional Order, and some other means must be sought. In the case of Glasgow, the requisite power has been obtained by a side wind in a most ingenious manner. The following words have been inserted as Clause 65 in the Glasgow Building Regulations Act, 1892: "Any installation for electric light in any building shall be subject to such regulations and conditions for securing the safety of the public and for the prevention of fire as the lord provost, magistrates, and Town Council of Glasgow, being the authority empowered to supply gas and electric light within the city, may reasonably require."

* Paper read before the Municipal Electrical Association.

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This clause appears to be an exceedingly useful one, though it seems rather an omission not to state who is to be the judge of what the "reasonable" requirements of the Corporation may be. In the Provisional Order it is provided that disputes should be referred to arbitration, but not so in this Act.

The author would go further than simply getting authority to enforce regulations, and would obtain powers quite apart from those the Corporation have as undertakers. This might be done by constituting them, through their engineer, an advisory body to the consumer who chose to avail himself of their advice—that is to say, any consumer, no matter how small, could, by the payment of a fee, small in the case of very small consumers, obtain the services of the Corporation to draw up a specification for the wiring, and to watch the carrying out of the work, power being given, as in any ordinary specification, to have the work done in a definite, predetermined manner.

The consequences of such action on the part of the Corporation would be far-reaching, and the effects most beneficial to the consumer and to the undertaker. At the present time many possible consumers are lost, some because they are not in a position of themselves to know the advantages and disadvantages of electric lighting, and do not care to trust to an ordinary contractor for advice, but who would regard the engineer to the Corporation as being in an independent position; others because they are too trusting, and believe statements made to them that a supply can be produced more cheaply by their own plant, when very often the public supply would be far cheaper, the object of the contractor being to sell as much material as possible; and lastly, those who seek expert advice, but who are unable to distinguish between the genuine consulting engineer qualified for his position and the contractor masquerading as a consulting engineer. As electric supply is cheapened, and the possibilities of electric motive power are increased, occasions will arise very frequently in which manufacturers and others will desire to have reliable expert advice, and in most towns who is better qualified to give this than the engineer to the Corporation? He is presumably well found in commercial and technical experience, and is unlikely to give other than straightforward advice; for most such engineers, it is to be hoped, are imbued with the same feelings that actuate the members of the Corporation whom they represent—viz., that a Corporation exists for the good of the citizens generally.

The author is quite aware that the proposal which is here made is likely to lead to violent opposition from consulting engineers. A cry would be set up that the Corporation was competing with them, and that it was unjust to do so. This raises the whole question of municipal control *versus* private enterprise. This is not an arena for the discussion of political or social problems, but all those present are committed to the principle that there are certain undertakings best placed in the hands of the Corporation; and, once this principle is admitted, it is difficult to see why the idea should not be carried out in its entirety, and consumers not only be supplied with current, but be guarded in such a manner that they can make proper use of the supply. Moreover, it is doubtful whether the competition would be keen, for, except in the case of very small consumers, the fee charged should be comparable with that charged by a consulting engineer, and the consumer would be under no compulsion to consult the Corporation, though he should be urged, if not compelled, to consult some person of experience. In this way the practice of consulting engineers would in the long run probably be largely increased, although a large part of the work might be done by the Corporation. Another consideration is that there are not many consulting engineers even in large towns, and it is doubtful whether the most lucrative part of their work lies within the city itself.

Another obvious remedy for the evils which are under consideration is for the Corporation to itself employ a staff of workmen and carry out the wiring. Though there is doubtless much to be said for this, the author is of opinion that it is unwise for a Corporation to embark upon this business for several cogent reasons: (1) There is considerable risk of financial loss attached; (2) The consumer would regard the guarantee furnished by the Corporation carrying out the wiring as applying to far more than the work for which they were actually and properly responsible. (3) Such action would very largely increase the difficulty of enforcing regulations upon contractors when they were selected by consumers to carry out the wiring. (4) Such objections as there are to competition with consulting engineers would apply with manifold force to competition with wiring contractors.

Having now discussed the necessity for regulations and the best means to enforce them, it remains to consider what points it is requisite to control. It is highly desirable that wiring rules should be as uniform as possible, and this Association will have accomplished a very useful work if it can succeed in inducing its members to adopt a standard set of regulations. At the outset it is evident that the conditions desired to be attained from the supply station point of view are not necessarily identical with those to be obtained from the fire insurance point of view. At the same time, if the course suggested in this Paper were adopted, it would be necessary to include the *desiderata* of both these authorities in the standard rules. Moreover, all systems of supply do not require quite the same regulations; thus, the insulation resistance of a consumer's premises need not be nearly so high when the system is a high-pressure one with separate transformers to each consumer, or when it is a high-pressure supply, with isolated distributing mains fed through transformers, as in the case of a general supply at low pressure. The last case is on all fours with the supply of water known as "constant." In the old system of water supply the water did not pass directly to the consumer's taps, but through a reservoir. Any leak, therefore, on the consumer's premises did not directly affect the water mains, provided the extremity of the service pipe was properly controlled; but with a constant supply, in which the full pressure of the mains is on every pipe, tap, and fitting, it is absolutely necessary that all these should be strong and thoroughly tight, and the water authorities compel the consumer to make them so. Similarly in the case of a low-pressure supply, every wire, every switch and fitting, is part and parcel of the supply mains, and a leak anywhere in a consumer's house becomes a leak on the system which has to be localised; and engineers do not need to be reminded of the trouble and annoyance this entails on them. Therefore the rules as to insulation resistance may well be more stringent for a low-pressure supply. At the same time, high insulation is always desirable, and the high-pressure stations might retain the same rule, for the sake of uniformity.

The author does not propose in this Paper to attempt to draw up a complete set of regulations. The task of doing this should, in his judgment, devolve upon a committee of this Association, power being given to this committee to confer with other bodies interested in the subject, and to make recommendations to the next Convention; but he would suggest various points, which, in his opinion, should be prominent in the rules, and these points might be thoroughly discussed at the present Convention, so that the proposed sub committee might be guided by the general sense of the members of the Association in preparing their report, the final adoption of which by the Association would thus be greatly facilitated.

First, and perhaps of greatest importance, is the insulation resistance. The standard decided upon should be such as experience has shown is attained when average thoroughly good work is carried out. It is of no use setting up a standard which can only be attained by drying the switches and fittings with calcium chloride, and warming the ends of the cables with blow-lamps. Moreover, allowance should be made for exceptional circumstances, such as wet plaster in new buildings, the standard not being enforced, if the work appears to be good, until time has been allowed for the moisture to dry out. In connection with the standard of insulation resistance set up, definite rules should be made as to methods of making and covering joints, if joints are employed, and of the distance to which non-insulating coverings of cables should be pared back, and as to the types of switches, fuses, lampholders, &c., which are allowed. The quality of the cable, the nature of its insulating covering, and the method of supporting the wires, should also be defined.

Second. Next in importance to the question of insulation resistance is proper provision against sudden demands of undue magnitude being made on the mains, and in the case of multiple wire distributors, which are becoming universal, the proper subdivision of the lights, so that efficient balancing may be attained. In connection with this, the number of lights allowable on a single circuit must be defined, and also the number of lights controlled by one switch. Regulations must be made as to the gradual starting and stopping of motors, and the adjusting of arc lamps, so that excessive currents at starting shall not be taken. Regulations should also be drawn up for the proper control of electric welding, electrolytic processes, and electric furnaces. Proper provision must be made to prevent a short circuit being made of sufficient magnitude to seriously disturb or cause a cessation of supply: under this heading the number and position of the fuses and their carrying capacity should be provided for, and regulations drawn up as to flexible conductors, and the placing of temporary consuming devices or those which have to be frequently moved in position.

Thirdly. In view of the probable earthing of one conductor in most systems of supply, and even apart from this, it is important that every precaution should be taken to prevent a consumer from obtaining a shock, and, with this view, regulations should be drawn up to prevent any person unintentionally touching a circuit conveying current. This will apply to switches, fuses, lamps, heating devices and motors. These last are liable to be placed in unskilled hands, and should be constructed in such a manner that the brushes require little or no rocking or adjustment during running, such adjustment as is necessary being made without having to touch the conductor. Under the heading of personal danger should be included proper provision against hot particles of carbon drop-



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ping from arc lamps, and the fixing of the lamps at such a height that they can be passed under with safety.

Experience has shown that installations are often completed before any notice is given to the engineer that a supply of current is required, and in this way proper supervision is impossible. The regulations should provide that notice be given to the Corporation before the wiring is begun, and, in the author's opinion, a fully-equipped standardising and testing department should be set up, and samples of material be submitted of sufficient size that proper tests could be made of them to see that they are up to the required standard. Samples also of switches, cut-outs, distribution boards, &c., should be submitted for approval, and the more important, if not all, should be tested and stamped by the Corporation, as is done with water fittings.

Above all things, the author would urge that the regulations be comprehensive, not too numerous, and, most important of all definite; the words "shall" and "will" being used for "should" and "would," and as little as possible being left to the discretion or caprice of the inspector.

Much might be done to raise the standard of work done by wiring contractors were a system of authorising electric light fitters, on similar lines to the authorisation of gasfitters which at present exists in some towns, to be drawn up. This question might well be considered in connection with regulations for wiring, It is a complicated matter, however, and beset with many practical difficulties, among which may be mentioned—(1) Should the contracting firm or the individual workmen be authorised? (2) Should the municipal authority itself make the inquiries, and if necessary an examination; or should it accept the inquiry and examination of such a body as this Association, or the Institution of Electrical Engineers, or the Northern Society of Electrical Engineers? (3) What power has the municipal authority to insist upon the authorisation of such fitters?

The foregoing Paper is intended to promote discussion of the subject with which it deals, and to lay down certain suggested lines on which action might be taken. It is not, however, the author's intention to dogmatise on the matter. He is aware that there are many difficulties to contend with in this question, and that up to now it has been found impracticable to adopt any uniform standard, and he does not hope to succeed in a task where others, far abler than himself, have failed. At the same time, if this Association does not aim at producing a universal standard set of regulations, but only at agreeing on a standard for all municipalities, a very great deal will have been accomplished, and matters simplified for consumer, contractor and engineer. In conclusion the author begs to propose the following resolutions for adoption by this Convention:—

*Resolved.*—That this Convention of the Municipal Electrical Association is of opinion that the need of a standard set of regulations for controlling the fixing and connecting of consuming devices supplied from municipal electric supply stations is urgent, and that such regulations should be drawn up and adopted by members of this Association.

*Resolved.*—That a sub-committee of members of this Association be formed to draw up a draft set of regulations, and to inquire what powers exist for enforcing such regulations when made, and also to ascertain how further powers for this purpose may be obtained if necessary; the sub-committee to have power to confer with any person or body of persons having special knowledge of or interest in the matter, and, subject to the approval of the Council of this Association, to obtain legal advice on the matter. The sub-committee to present a full report of the work to the next Convention.

## DISCUSSION.

Mr. ROBERT HAMMOND said that those who were present at the Conference at Westminster would remember how strongly they expressed themselves upon the subject of the Paper. They ought by means of such conventions as these to get the really practical opinion of the profession and place it before the Board of Trade. He was thoroughly with Mr. Wordingham on one point, and that was that the municipal engineer should have the power of inspecting the work, and being paid for the inspection. Mr. Wordingham remarked that he was aware that such a proposal was likely to lead to violent opposition from consulting engineers, but he (Mr. Hammond) disagreed with that; he did not think that opposition from consulting engineers need be expected. Anything that raised the standard of work was a benefit to the consulting engineer.

Mr. W. A. CHAMEN thought that most contracting engineers would be very pleased to see the standard of work raised, and his firm had always found that a good set of rules was a very great benefit from their point of view. He thought the idea of a corporation taking up the work themselves would be a very bad plan indeed. He happened to know that the President held views directly opposite to Mr. Wordingham, and it would be interesting to hear what he had to say upon the subject, but he (Mr. Chamen) thought the corporation should have as much control as they could.

Mr. J. S. RAWORTH thought they were falling into an error in thinking that electric light wanted so much regulation. The fact was that the very worst electric installation was very much better than gas. If they got an installation that did not quite come up to their notions on the subject, yet they had made a distinct advance, and the gentleman who had spoken on behalf of the fire insurance offices had, he thought, made a very good point when he said that the business of the offices was to collect the fees and not so much to inspect, because after all the offices did not reduce the fees because the electric light was put in, and as their risk was reduced by substituting electricity for gas they were in a better position than before. He remembered the time when some insurance companies reduced their premium 20 per cent. on the adoption of electricity, but now they say, "We shall not increase your premium if you comply with our rules." With regard to bad work on electric lighting installations, he certainly had never seen any of it. He had taken tours on the Continent, and had always found that the very best work over there was very much worse than the worst in this country. Some of the old specimens of wiring that they had in the upper storey of the Brush offices came to his mind. They were carried out by pupils according to their own ideas, and the wires were laid among *books*, dropped under boards, run up walls, and pulled through wooden partitions, but the place was not burned down yet. He asked them not to invade the consumer's castle any more than they could help. If they went into a house and turned up the carpets they would have the consumers turning round and saying, "Oh! we will go back to gas and be blown up rather than have all this bother." They took gas or water into their houses, and they got an ordinary plumber to arrange their pipes just as they pleased. He did not think there was any great necessity for all these rules and regulations; they should be content to let the current go through the meter and be paid for it.

Mr. E. MANVILLE quite agreed with Mr. Wordingham in saying that the question of local authorities doing the wiring and fitting up of houses themselves was a very delicate one. In his opinion a great deal of progress that electric lighting might otherwise have made was not made because of people having short leases. It was natural that people with short leases should not feel inclined to invest comparatively large sums of money in fitting up their houses for the benefit of their landlords, and he thought it would be a good thing for the progress of the electric light if local authorities could see their way to fitting up such places at a rental, which might very well be carried on to the incoming tenant. He did not think there would be much fear for the invested money, because the tenant coming in would be practically certain to continue to take the light and the local authority would really run no risk.

Mr. WILLIAM ARNOT said that what was wanted was a set of regulations that would guide and regulate the contractor in his work, such regulations to be drawn up so that the municipal engineers should be able to test the contractor's work from inside, or from a certain point, without going over the whole of it. He did not agree with corporations taking on the wiring themselves, they had enough responsibilities upon them already. He agreed with Mr. Wordingham that a committee of gentlemen interested in the question should meet together, and by discussion something might be done. He thought that corporations should undertake the inspection and testing of fittings in consumers' houses so far as would enable them to fulfil the conditions the Board of Trade had put upon them.

Mr. H. TALBOT said that in Nottingham they had a set of rules, and only went round and made an inspection now and then.

Alderman CAREY felt inclined to advocate the idea that the corporation should do the work. He thought it would give more satisfaction to the ratepayers in every possible way.

Mr. W. HARPUR (Cardiff) was strongly opposed to the corporation doing the work, but he thought there should be some control by the local authority over the wiring of premises

Mr. FARADAY PROCTOR said he had never found any difficulty in imposing regulations upon wiring contractors. In Bristol they never connected a person unless he had complied with their regulations.

Mr. J. E. STEWART said he thought corporations ought to take no responsibility at all with regard to installations. The Board of Trade rules were very clear about inspecting the meters, but he did not think they said anything at all about inspecting the wiring. It placed a responsibility upon a corporation which ought to be borne by the fire offices. If the fire offices neglected their duty, it was not for the corporations to do it for them. If consumers wanted their houses inspected, it should be done by the corporation engineer on a fee being paid, but it should not be made compulsory.

Mr. ALBION T. SNELL thought Mr. Wordingham had succeeded in raising a great interest in the question. With regard to the inspection of consumers' premises by corporation engineers, he thought this would be done better by consulting engineers; corporation engineers had quite enough to do in looking after their proper work, if they were to do it properly.

Mr. T. P. WILMSHURST (Halifax) said they all seemed unanimous as to the desirability of having a uniform set of regulations; but Mr. Wordingham seemed to think they had no power to enforce them, and also that the Board of Trade had no power to approve of their rules. He ventured to think that this view was not correct. Under the Electric Lighting Act of 1882, Section 6, they had the power to make or repeal bye-laws, and there were penalties in cases of breach of such bye-laws:—

> "Any local authority within any part of whose district electricity is authorised to be supplied under any licence or special Act may, in addition to any regulations which may be made under the preceding provisions of this section for securing the safety of the public, from time to time make, rescind, alter, or repeal bye-laws for further securing such safety; and there may be annexed to any breach of such bye-laws such penalties to be recovered in a summary manner as they may think necessary: Provided always that no such bye-laws shall have any force or effect unless and until they have been confirmed by the Board of Trade and published in such manner as the Board of Trade may direct."

Major CARDEW said he should have thought they would have had enough regulations. Somebody had discovered that there was a power of making bye-laws, subject to the approval of the Board of Trade. These bye-laws were for the public safety; but how far they would enable them to make new wiring regulations was a very doubtful point. Then, of

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course, it would be for the Board of Trade to consider whether such regulations would be of benefit or not. It was undesirable to tie up the freedom of the consumer any more than was absolutely necessary to secure the result wanted, viz, safety for himself and an avoidance of interference with the safety of others. He should say that in many cases bye-laws might be made especially where the electrical adviser of the corporation found it necessary on the ground of safety.

Mr C. H. WORDINGHAM, in reply, said that so many points had been raised on his Paper that he hardly knew how to answer them all. He could appreciate the difficulty of a corporation interfering too much in the consumers' premises as to the wiring to be adopted, and it was for that reason he had brought forward his suggestion that the Corporation engineer should be allowed to be consulted; he could draw up specifications and would be in the position of the consulting engineer, the work would be more personal than municipal, and there would not be the irritating feeling of the corporation interfering with the consumer. There would be very little difficulty in drawing up the specifications because all small shops and such places were very much alike. His experience of consulting engineers was that they did not think these small jobs worth much bother, so that he did not think they would be very much affected by the course he had suggested. It was most satisfactory to have Major Cardew's opinion as to their right to draw up certain bye-laws, and his own view was that the Association should draw up a small set of bye-laws.

## PHYSICAL SOCIETY.

At the meeting of the Physical Society held on June 12th, Capt. Abney (President) in the chair, Mr. CAMPBELL read a Paper on

### "The Measurement of very Large and of very Small Alternating Currents."

The author advocates the use of air-core transformers for measuring voltages and currents which are either above or below the range of the instruments available.

If an attempt is made to measure the current in the primary of an air-core transformer by observing the voltage on an open circuit secondary, it is found that the readings depend on the frequency. In order to overcome this difficulty the author uses a closed secondary with a very high inductance. In this case the primary current is proportional to the secondary current, which latter may be measured by an ammeter. The author has also investigated the case of transformers with iron cores, and of which the inductance of the secondary is large. In the case of a ring transformer with a closed magnetic circuit, if the load on the secondary consists solely of a Kelvin 100-ampere balance of very low resistance, the ratio between the primary and secondary currents is practically constant. With an open magnetic circuit transformer, however, this is not found to be so, as the ratio between the primary and secondary currents varies considerably with the frequency.

Mr. BLAKESLEY said that the author's arrangement could only be used for measuring the *current* in the primary. He (Mr. Blakesley) had shown how to measure alternating currents by means of dynamometers and without the necessity for any special apparatus.

Mr. GRIFFITHS exhibited and described his improved form of resistance-box.

This resistance-box has many novel features: (1) It permits of all the coils being compared with one another without the use of standard coils, and with great ease and rapidity. Hence it is sufficient at any time to compare any one of the coils with a standard to obtain the correction to be applied to all the coils. (2) The bridge wire can be calibrated by means of the box itself. (3) The temperature of the coils can be accurately determined, since they consist of bare platinum-silver wire wound on mica and immersed in an oil bath, which bath is kept stirred. (4) The resistance of the leads from the box to the object being tested is eliminated, as well as any error due to a change in this resistance with temperature. (5) The coils are arranged according to a binary scale, and the author claims that it is possible to measure resistances up to 105 ohms to within 0·000001 ohm. (6) All the coils, after being adjusted, have been heated to redness and allowed to cool slowly, so that all strain has been removed from the wire. (7) By having a separate pair of blocks for each plug, it is impossible for the insertion of one plug to affect the fit of a neighbouring plug. The plugs themselves are so made that no part of the plug is wider than the top of the hole, and so it is impossible to wear a "shoulder" on the plug.

Prof. A. GRAY said that Mr Griffiths had disclosed and remedied all the weak points of the ordinary form of bridge. Lord Kelvin had ordered the paraffin to be melted off the coils of one of his resistance boxes, and it was found that the resistance of the coils altered considerably, owing, no doubt, to the strain to which the wire was subjected when embedded in the solid paraffin. Lord Kelvin had made coils without paraffin, and was specially in favour of the use of the binary scale.

Prof. S. P. THOMPSON said he considered the binary scale the weak point of the author's arrangement, since it did not permit of ratios other than 1 to 1 being employed.

Mr. CAMPBELL asked what current could be safely passed through the coils.

The AUTHOR in his reply said that he believed it to be a great mistake to employ any ratio for the arms other than 1 to 1.

Prof. S. P. THOMPSON read a communication

### "On Röntgen Rays."

The author, after describing the various forms of tubes he had made, with a view of discovering the best form for the production of Röntgen rays, gave an account of the experiments he had made to try and obtain some indication of polarisation. In this connection a large number of crystals have been tested, but the experiments have all given negative results.

The author exhibited an electroscope with aluminium leaves, and inclosed in a wire gauze screen, to protect it from the influence of outside electric charges, by means of which he was able to show the discharge of a positively or negatively electrified body by means of the X-rays.

A method of obtaining dust figures by the discharge of an electrified body by the X-rays was shown, and some of the results which have been obtained were exhibited.

All attempts to obtain true reflection have failed, although it appears as if most bodies, including air, are capable of giving diffuse reflection.

Dr. SHETTLE, who was announced to give a Paper on Röntgen rays, explained that he had just discovered that the effects he had intended to describe were due to red light which had penetrated his dark room.

Prof. DU BOIS said that Galitzin had found that Röntgen rays were polarised by tourmaline, a special form of developer being employed. The behaviour of tourmaline to light waves presents some curious features; for if the wave length is increased, a point is at length reached where the ordinary and extraordinary rays are equally absorbed. For greater wave lengths the ordinary conditions are reversed. If the Röntgen rays were not homogeneous, the contradictory results obtained by different observers might be due to the fact that they were working with rays which were differently absorbed by tourmaline.

Mr. SWINTON said he had tried the effect of heating the cathode, and had obtained results which were similar to those obtained by the author. Mr. Swinton further said that he had found that the blue luminescence sometimes observed depended on the size of the cathode. With tubes in which the cathode was almost a complete hemisphere it was impossible to eliminate this blue luminescence.

Mr. APPLEYARD suggested the performance of the experiments under the surface of a dielectric.

Prof. GRAY said he had obtained some indication of regular reflection, but nothing definite.

The AUTHOR, in his reply, said that it had been found that if the Röntgen rays are reflected from a surface of sodium *in vacuo* the amount reflected is a minimum for normal incidence, and increases at oblique incidence. Comparing this behaviour with that of ultra-violet light, it supports the idea that the Röntgen rays consist of transverse vibrations.

The Society then adjourned till June 26th.

**An International Congress of Electricians.**—The Swiss Society of Electrical Engineers has convoked an International Electrical Congress, which is to take place at Geneva from August 4th to August 9th next, under the presidency of M. Turrettini. The Congress has the support of the American Institute of Electrical Engineers, the Electrotechnischer Verein (Berlin), the Electrotechnischer Verein (Vienna), the Institution of Electrical Engineers, the Société Belge des Electriciens, the Société Internationale des Electriciens, and the Verband Deutscher Electrotechniker. Those who propose to read Papers are requested to forward the manuscript before July 20th, and those who propose to take any part whatever in the Congress must send their names in before July 1st. The following subjects are set down for discussion at the Congress:—(*a*) Magnetic Units, (*b*) Photometric Units, (*c*) Transmission and Distribution of Power to Great Distances by means of (1) Direct Currents, (2) Alternate Currents, (*d*) Protection of High-pressure Overhead Electric Lines against Atmospheric Discharges, (*e*) Various Disturbances caused by Electric Traction. The price of a ticket for the Congress, which includes everything set down in the programme (exclusive of excursions), and in addition all publications relating to the proceedings, has been fixed at 20fr. The price of a ticket for ladies accompanied by a member of the Congress is 15fr. Intending participants are requested to secure lodgings beforehand by applying directly, and, if possible, before August 1st, to the Bureau officielle des Logements de l'Exposition, and to mention in their request that they are members of the Congress. All communications with regard to papers, &c., should be addressed to the Bureau du Congrès International des Electriciens, Université, Genève.



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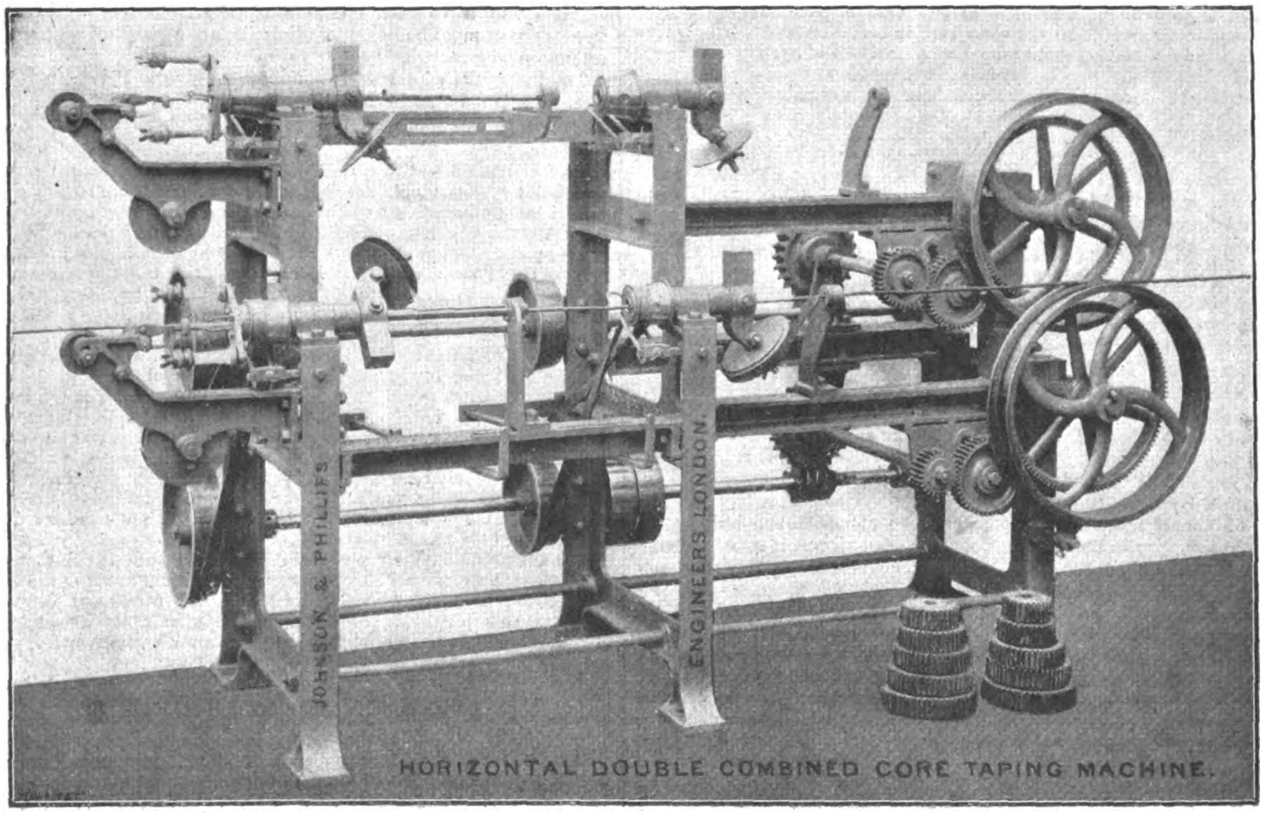
## HORIZONTAL DOUBLE COMBINED CORE TAPING MACHINE.

The first covering of the gutta-percha core of a submarine cable generally consists of a plain tape, brass tape and compounded tape. The machine which we illustrate is for this purpose, and it is arranged for covering two cores simultaneously. In this particular machine the first tape is put on longitudinally, the width of the tape being just equal to the circumference of the core. This tape is carried on a disc at the leading-in end of the machine, and the arrangement for folding it over on to the core is very ingenious. It is first led over a special-shaped casting which throws the edges of the tape back, and it then passes through three small spoon-shaped pieces which act like the thumb and the first and second fingers of the human hand, folding the edges of the tape over on to the core perfectly. As soon as this is effected the tape is bound in position by a soft cotton binding from the two small bobbins shown. The brass tape is then put on from the first disc, and the compounded tape from the second disc, both discs being provided with means of regulating the tension at which the tape is put on the core. The brass tape is led through a slotted tube to ensure it going perfectly flat and to obviate the risk of the edge cutting the gutta-percha core. By means of change wheels the speed of drawing through the core can be regulated and altered to give any desired "lay," and the speed of the heads can also be varied by means of the coned driving pulleys to suit various widths of tapes. Each machine is quite independent of the other as far as the starting and stopping is concerned.

Messrs. Johnson and Phillips, of Charlton, who are the makers of the machine, have given special attention to its design, as it is essential that this first operation in submarine cable making shall be most carefully and efficiently done, otherwise faults may very soon develop in the core after the cable is laid, necessitating enormous expense for repairs. As large numbers of machines for this purpose are used in all important submarine cable manufactories, the double machine which we illustrate must effect a considerable saving in ground space and labour, as, in addition to being a multiple machine, its design is very compact, and it can be operated by one lad.



HORIZONTAL DOUBLE COMBINED CORE TAPING MACHINE.

## LONDON COUNTY COUNCIL.

*The Tramway Question.*

At the weekly meeting of the London County Council, held at the County Hall, Spring Gardens, on Tuesday, the adjourned report of the Highways Committee again came up for discussion. The report, which recommended the Council to decline the offer of the County of London Tramway Syndicate, and to enter into an agreement with the North Metropolitan Tramway Company, has already appeared in *The Electrician*. The Committee, however, in addition, brought up a supplemental report, which stated that since the report was last before the Council further letters had been received from the Syndicate containing modifications of the proposals already made. The Syndicate suggested that its proposals should be restricted to the undertakings of the North Metropolitan and London Street Tramways Companies, and stated that it would be prepared to take a lease of such parts of those lines as and when they might become the property of the Council, at a rent equivalent to the entire net earnings of the respective sections of the lines for the twelve months preceding their lease. Further, they suggested that the length of the lease might be subject to modification, provided that the terms upon which the lines should be leased should also undergo modification. No proposal was made as to the extent of the modification further than that it was to be of such a character as to give reasonable assurance that the capital sunk in substituting electrical traction for animal power would be replaced at the expiry of the lease. Having regard to the fact that in the Committee's opinion the utmost length of any lease should be 14 years, they asked the Syndicate to state the modifications they intended, and received a letter which made it clear that the Syndicate had no modification to propose as regarded a term of 14 years, but was prepared to discuss a tenure of 21 years on the basis of the purchase of the Company's undertakings under the arrangement first proposed by it. The Committee were not prepared to recommend a lease for 21 years, or for any term extending beyond the date when the last portions of the line would in the ordinary course become purchasable by the Council. Having gone exhaustively into the financial proposal of the Syndicate, the report goes on to say that the sum of £75,239 shown as the average rent to be paid by the Syndicate represented what it would be willing to pay on the basis of a 28 years' lease. Although during the second period of 14 years the Council would be receiving the full rent offered by the Syndicate, on the other hand, under the proposed arrangement with the North Metropolitan Company, the Council would then have a free hand and be able to take full advantage of the total profits that could be earned at that date on the lines. It must also be remembered that the rent receivable from the Syndicate would be on the basis of electrical traction, whereas in the case of the North Metropolitan Tramways' offer the figures were on the basis of horse traction, leaving it open to the Council to largely increase the amount by calling on the Company to adopt electrical traction if found to be a success. The proposals of the Syndicate would also be disadvantageous to the Council from the point of view of capital expenditure. In addition to purchasing the lines and buildings of the two Companies the Council would also be compelled to purchase the plant, horses, cars, &c.,

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estimated to cost £210,000, and that would be a dead loss to the Council, as the Syndicate proposed that after the change to electrical traction these should be sold and the proceeds paid to the Syndicate in part payment of its expenditure on the reconstruction of the lines. As against that the Syndicate proposed that the lines as reconstructed should at once become the property of the Council without further expense. The question at issue had been obscured by a suggestion that if the Syndicate's proposals be not accepted the adoption of electrical traction would be postponed for 14 years. Those proposals were based entirely upon the belief that the substitution of electrical traction would make the tramways far more remunerative than they were at present. They had, however, not yet been able to satisfy themselves of the certainty of the success of the proposed system of underground conduit traction in London. There could be little doubt that the trolley or overhead system had met with considerable success in America and elsewhere; but proposals to adopt that system had always been refused by the Council, and the latter had no reason to believe that it would modify its views upon this matter at present. No evidence had been given by the Syndicate that in the limited number of instances where the conduit system had been tried it had been either commercially or practically a success, or that it would be possible to maintain the present low fares if that system were adopted. Should it after trial prove to be a failure, the Council might find itself in possession of a greatly depreciated property as the result of the alteration. The Syndicate, in its letter of May 6th, offered to make an experiment with electrical traction on the Highgate Hill line; but the proposals for the purchase of that line by the Council having fallen through, that experiment could only be made with the consent of the purchaser. Should, however, the Council at any future time be satisfied that the use of electrical traction would be desirable and profitable, its adoption, under terms which were in our opinion exceedingly favourable to the Council, was assured by a special provision inserted in the heads of proposed agreement with the North Metropolitan Company.

In a second paragraph the Committee stated that if future development in the system of traction by electricity should promise a very largely increased return by reason of saving in working expenses and increase in number of passengers, they were of opinion that the bulk of such profit should accrue to the Council and the ratepayers rather than to any private Corporation. In order to more fully secure that object they had considered whether modifications might be made in the special provision relative to electrical traction proposed to be inserted in the heads of agreement with the North Metropolitan Company, and they had now arranged with the representatives of the Company that in lieu of head 3 the following should be substituted:—

"(3) (*k*). Not to use, except with the consent of the Council, in writing, other than animal power upon any of the lines included in the lease, provided that the Company shall and will, at its own expense, whenever called upon by the Council so to do, lay down and equip a length of about a mile of tramway selected by the Council for any system of traction which may be chosen by the Council.

"In the event of the Council deciding to adopt electrical or other mechanical power on the whole or part of the lines included in the lease, the Council or the Company, at the option of the former, shall reconstruct the permanent way, the Council in either case paying the cost; and the Council or the Company, at the option of the former, shall provide the necessary fixed machinery, which shall be maintained by the Company to the satisfaction of the Council during the term of the lease; the equipment shall be provided by the Company to the satisfaction of the Council, and shall be taken over by the Council at avaluation at the end of the term of the lease; and the rent to be paid by the Company shall be as follows:—

"(*a*) The Company shall continue to pay the rent to be reserved in the lease on the lines and depots and other buildings included therein; subject, however, to deduction of the proportion of the rent allocated to such of the depots or other buildings which may have to be disposed of as unsuitable for use in connection with the altered mode of traction or otherwise.

"(*b*) The Company shall pay an additional rent equal to 6½ per cent. per annum upon the cost of reconstructing the lines, and of the acquisition of any necessary lands and buildings, and also upon the amount of any loss on the sale of depots or other buildings disposed of as unsuitable, and the cost of adapting, for the purposes of electrical or other mechanical traction, any of the buildings included in the lease; and also a rent equal to 7½ per cent. per annum upon the cost of the necessary fixed machinery, if provided by the Council.

"(*c*) The Company shall also pay to the Council 75 per cent. of the net revenue of the whole of its undertaking inside and outside the county, after deduction of (1) the rents payable to the Council under the clauses *a* and *b*, and (2) 5 per cent. on (*a*) the capital of the two Companies on June 30, 1895, less the purchase moneys subsequently paid by the Council to either of the Companies in respect of lines or depots; (*b*) the additional capital outlay made by the Company for machinery (if provided by the Company) and equipment, and the loss, if any, on the sale of horse cars.

"The Council shall, if it so desire, appoint an auditor, who shall have full power to examine and report upon the transactions of the Company."

A special report of the Finance Committee was also submitted in accordance with the resolution passed by the Council a fortnight since (and reported in *The Electrician* at the time) instructing them to report on the financial bearings of the Syndicate's proposal. The report stated that inasmuch as the Council had decided not to agree to a lease beyond 14 years, and the Syndicate were not prepared to accept such a term, they recommended that the reference be discharged. With respect to the proposals of the North Metropolitan Tramway Company, they expressed their approval of the Committee's recommendations except with regard to the security offered by the Company, which, however, there was no difficulty in arranging satisfactorily.

Mr. WESTACOTT (Chairman of the Highways Committee) moved the adoption of paragraph 1 of the report declining the proposals of the Syndicate.

This was agreed to without discussion.

Mr. BENN asked the Chairman of the Finance Committee if the Committee had gone into the figures showing the probable revenue of the Council if the Council worked the tramways up to 1910.

Mr. HOARE said that that matter had not been considered in detail by the Committee.

Mr. WESTACOTT then formally moved the adoption of paragraph 2 of the Committee's report, which recommended that the proposals of the North Metropolitan Tramway Company be accepted.

Mr. J. BAKER moved the following amendment, "That the report be referred back to the Highways Committee with instructions to report for the purpose of comparison as to the probable profit to the ratepayers if the Council itself worked such portions of the northern system of tramways as will be within the control of the Council after 1898, information being given upon the basis of horse traction and also electric traction or other approved mechanical means." He said that as a member of the Highways Committee he had taken special and deep interest in the subject ever since the Syndicate had first approached the Council. He felt from the very first that the proposals they had before them were entirely inadequate for the value of the property which was partly in the possession of the ratepayers. He contended that it was the duty of the Council to see that London had not only the very best possible system for the convenience of the general public, but that also in regard to its tramway property the Council should in the interests of the ratepayers receive the largest possible financial consideration they could get. He thought that in his amendment he was asking something that was not unreasonable, his position being that the Council wanted more light and more information. They wanted figures as to what the property was worth, and how it could be worked to the best advantage. Having visited the principal cities in Canada and the United States during the past few years, and observed the great advance that had been made in the tramway service there, he considered it his duty to place before them some information on the subject which he had collected in the last few weeks. On January 1st, 1896, the following was the mileage of electric and other mechanical traction on the Continent of Europe:—Germany, 245·30 miles running and 207·73 under construction; France, 78·37 miles running and 39·00 under construction; Italy, 24·61 miles running and 57·00 under construction; England, 36·38 miles running and 13·53 under construction; Austria, 44·04 miles running; Switzerland, 25·24 miles running and 4·80 under construction; Spain, 17·99 miles running and 11·18 under construction; Algiers, 22·00 miles under construction; Belgium, 15·45 miles running; Norway, 4·66 miles running and 3·10 under construction; Russia, 6·20 miles running; Servia, 6·21 miles running; Bosnia, 3·47 miles running; Roumania, 3·37 miles running; Holland, 1·98 miles running; and Portugal 1·73 miles running. By that it could be seen that England was far behind Germany, France and Italy in the adoption of the recent improvements in tramway traction, and London, which had greater need, and probably greater chances of success than any other city in the world, did not possess a single mile. Of the 866 miles of electric tramway in Europe, over half was in Germany alone, and it was in this country, after thorough trial and proof of economy, that the most rapid extension was going on. The example of the United States and Canada was still more striking. Eight or nine months ago it was stated that there were 10,000 miles of electric tramway in operation in North America. It was now estimated at upwards of 15,000 miles. Hanover had a greater mileage of tramways in proportion to its population than any other city on the Continent. The present company bought up the original one three years ago—then paying 1½ per cent.—and now with 15 miles of electric lines, started 18 months ago, and 34 miles of horse lines, was paying 4 per cent., and so successful had the electric installation been that all the remaining horse lines were to be converted to the electric system next year. Hamburg was the first city in Europe to have the whole of its tramways converted. It formerly employed 2,600 horses. Many of the streets where the trams run were narrower than those in London and quite as busy. That was the largest installation in Europe, and had been a marked success. In Berlin two test lines were being converted and equipped for electric traction, and it was fully expected that very soon electric traction would supersede horses over the whole 125 miles of the system. Milan had a very successfully combined electric light and electric tramway system. The tramways of Rouen had just been transformed from horse to electric traction, the opening of the latest line being on March 22nd last. The frequency of the service in 1895, with horse traction, was such that two round trips per hour per car were made; whereas, in 1896, with electric traction, three round trips per hour per car were accomplished. From February 8, 1895, to March 19, 1895, the receipts from horse car service, with 30 cars in operation, amounted to £2,000; and for the same period in 1896, with 32 electric cars, the receipts amounted to £3,800. During the period dealt with in these comparisons no change in the fares had been made, the first-class fare being 1½d., and the second-class fare 1d. These figures showed in a striking manner that traffic increased with the adoption of electric traction, on account of it being so much quicker and more attractive and popular. It was not surprising, therefore, that a deputation of the Glasgow Corporation, which had recently visited the principal cities on the Continent to inspect their tramway systems, should say:—"Our general observation is to the effect that a practically universal move in the direction of substituting electric power for horses is in progress all over the Continent," and should recommend their own Corporation to adopt the most approved electrical system, and this, notwithstanding the fact that it was but a little more than a year since the same Corporation completely installed their own tramway system with new cars and horses. Nor was it surprising that the enterprising

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Corporation of Birmingham, after making trial of two other modes of mechanical traction, should decide upon an electric system for their city, the contract for which, he believed, had now been entered into. He thought it would be seen from the foregoing that the earning power of a tramway under usual conditions might soon be doubled by the adoption of the improved systems of traction now in the market, as well as immensely augmenting the satisfaction given to the public, and he believed that the possibilities of London in this direction were equal to those of any city in the world. The clauses in the proposed agreement with the North Metropolitan Tramways Company, and the fact that the Company had a comparatively short lease and would naturally be desirous of continuing to use their present plant and continue their present system, were not, in his opinion, at all likely to ensure the improvements that London needed, nor the profit to the ratepayers that that valuable property should yield. He therefore trusted that a true estimate of our tramways might be arrived at before they committed themselves to the entirely inadequate figures that were proposed. In submitting the foregoing considerations, he would urge that the fullest possible inquiry and examination of the various systems in use on both sides of the Atlantic be made, and their value for London ascertained. He was of opinion that by thus holding their hands until those investigations were made, the value of their property, whether worked by a company or by the Council itself, would not depreciate, but quite the reverse, and it must be acknowledged by all that for the greatest city in the world, whose streets presented an ever-increasing difficulty through the congestion of traffic, too much thought and care could not possibly be given to secure for it the best and most advantageous system that could be obtained.

Lord MOUNTMORRES supported the amendment. He said that the report of the Highways Committee would give the Council the reputation of being a somewhat impracticable and unbusinesslike body of men. Sufficient data had not been laid before the Council to justify it pledging itself in such an important matter as that. He thought that it would be fully recognised that horse traction was completely out of date. Throughout the length and breadth of America there was scarcely a horse car running. The underground conduit system in New York and in Washington had been proved to be a success, and was now being laid down in Chicago and Cincinnati. That was a feasible method of traction without doubt, and there was no reason why the underground conduit system should not be as suitable as the overhead trolley system. The difficulty with regard to the underground conduit was that of insulation, but recent methods had been brought into use which would render that insulation as easy as the overhead system.

Mr. BOULNOIS, M.P., said that the arrangement of the Committee with the North Metropolitan Tramways Company was a most advantageous one for the ratepayers, and he strongly opposed any suggestion of the Council itself working the lines.

Mr. BENN contended that by the proposed arrangement the Council would not get enough, considering the value of the property. The Directors of the Company considered that the financial position of the shareholders would be advanced, and, if that were so, it must be at the expense of other persons. Two years ago the Highways Committee reported that by the end of 1893 they would be in a better position to make terms with the Company than now, for at that period an additional 14 miles would fall in, and the Council would practically have a free hand. They were invited to accept the proposals because there were legal difficulties in the way; but they had spent £25,000 in fighting the Company, and to give up to the Company in the last lap of the race would be folly. Two years ago the Council had decided not to extend a lease to the Street Tramways Company beyond 1900, and now the North Metropolitan Company had offered 2½ per cent. for an additional 10 years' lease of the most magnificent tramway system the world had ever seen. With regard to the heads of the agreement as to the substitution of electrical traction, he thought that anyone examining those clauses would see that they were so safeguarded with regard to compensations for disturbance and so on that any prospect of getting electric traction for the next 14 years was purely visionary. He asked the Council to look at Glasgow and to catch the spirit of that great municipality, and show that London would advance at least in line with the great cities of the empire.

Mr. BERESFORD HOPE said he did not think the Council could work the tramways of London to the advantage of the ratepayers. Under the proposed arrangement they were sure of their rent, and would take no risks in enforcing the Company to substitute electrical traction in the future. The electric tram might certainly be cheaper, but it would not be more expeditious in London.

Lord ONSLOW said the Council had not now to consider the question of electric as opposed to horse traction. The agreement provided for the Council calling on the Company to substitute electric traction, and it was after that report had been carried that the Council should consider what traction should be adopted.

Mr. WESTACOTT, replying for the Committee, contended that all the argument had been based on the assumption that the Council could at once take possession of the lines, but that was not so, and it would be two years before they could get a portion of the system under their control if the Company fought; then again in other cities they had the overhead wire system, but that the Council would not accept. By the arrangement they would secure a good system, and at once could begin to get something for the relief of the rates.

The amendment was carried on a division by 61 votes to 56.

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**THE TELEPHONE IN AMERICA.**—The *Financial Times* of the 20th states that the Western Union Telegraph, the Metropolitan Telephone and Telegraph and the American Bell Telephone Companies' interests have jointly incorporated a telephone company, probably to amalgamate the existing companies. The capital of the new Company is reported to be $16,000,000.

# AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June 12, 1896.*

**The St. Louis Tornado.**—On May 27th last a disastrous storm passed over St. Louis, Mo., taking the form of a tornado, and doing much damage to property. The saddest feature of the storm was the loss of over 300 lives in St. Louis city alone. Telegraph, telephone, electric light and electric railway companies suffered great damage to their property, and telegraphic and telephonic communication between St. Louis and the rest of the country was for a time wholly cut off. The power house, car sheds and boiler house of the Union Railroad Company were completely demolished, four men being killed, one of them the chief engineer. The work of restoring the electric wires to their normal condition has necessarily been slow, on account of the great entanglement and breaking down of the poles themselves.

**The Drawbaugh Patents.**—A favourable report was made in the United States Senate on June 3rd on the Bill for the relief of Daniel Drawbaugh. This Bill directs the Commissioner of Patents to issue to Daniel Drawbaugh patents for the inventions of improvements in telephony, described and claimed in pending applications filed by Drawbaugh at various times from 1880 until 1884, notwithstanding that said inventions may have been in use or on sale for more than two years prior to the date of the filing of Drawbaugh's original application of July 26, 1880. A proviso gives all persons having apparatus containing any of these inventions in use at the time of issuing such patent, the right to continue the use of such apparatus without charge or molestation, and no one is to be liable to Mr. Drawbaugh for any manufacture, use or sale of Drawbaugh's inventions prior to the issuance of the patents authorised in the Bill.

**Long Telegraph Circuit.**—The telegraphic circuit over which the Hon. Chauncey Depew's message was sent from the Electrical Exposition building on May 26th, as computed by the Postal Telegraph Cable Company, was 42,872 miles. The routes travelled by the message were as follows: New York to San Francisco, 4,118 miles; San Francisco to Canso, 4,914; Canso to London, 2,823; London to Tokio, 13,677; Tokio to London, 13,677; London to New York, 3,663. The entire distance was covered in 57 minutes.

**Compressed Air Cars.**—The Metropolitan Traction Company of New York city is about to conduct some experiments in the use of compressed air for the propulsion of street cars. Some cars are now being equipped with the apparatus, and the tests will be made on one of the uptown lines. It is stated that the Company is not altogether satisfied with the underground conduit system now in use on some of its uptown branches, and is looking for some other efficient system with a view to its final introduction, if such a system can be found. The Company has gone to great expense, however, in equipping the electric lines, and it hardly seems reasonable that it should have made so great an outlay without being pretty well satisfied as to the actual obtainable results from the electric system. The actual figures covering the cost of operation, &c., have never been given out, and it is a matter of uncertainty in the public mind as to whether the system is really economically operated or not.

**The Niagara Falls Power Company.**—The Niagara Falls Power Company has decided to extend its present power house and wheel pits and instal seven 5,000 H.P. electrical generators. It is stated that the power developed by the new generators will be carried to Buffalo by an overhead cable, and there utilised for electric lighting, electric railways and for manufacturing purposes. The contract for the new dynamos has been let to the Westinghouse Electric and Manufacturing Company of Pittsburgh, and Mr. L. B. Stillwell, the Company's chief engineer, is now engaged in planning the electrical equipment.

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**The New York Rapid Transit Problem.**—The Manhattan Elevated Railway Company has formally presented to the Rapid Transit Commission of this city its plans for providing rapid transit. It proposes to do this by building several extensions, both lateral and longitudinal, and to add third and fourth tracks to the existing lines. Mayor Strong, who was thought to favour the scheme, entered his opposition to it at the meeting of the Commission on Thursday of this week; but as another meeting will be held next Thursday, it is expected that some agreement will be arrived at. The railway company will not exact any conditions from the city for the privileges asked, but will assume all responsibility itself in the way of damage suits by property owners. The proposed improvements would very materially relieve the existing unsatisfactory conditions, and it is thought that they will satisfy the requirements for rapid transit for many years to come. The fact that the underground tunnel scheme has been practically killed by a court decision, has turned public attention in the direction of the elevated railway system, as that now seems to offer the only solution of the problem.

# CORRESPONDENCE.

## PERMEABILITY BRIDGES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the description of "Prof. Ewing's Permeability Bridge" in your issue of May 8th, it may be of interest to your readers to note that a similar arrangement has been in use in the testing department of the General Electric Company for very nearly two years. It was devised in June, 1894, by Mr. Frank Holden, who was at that time in charge of the instrument room, and the necessary apparatus was constructed very shortly afterwards.

Although differing in detail, the underlying principle appears to be identical in the two cases. Thus, in both arrangements the bar to be tested and a standard bar of precisely similar dimensions are slipped into two parallel magnetising coils, and the ends of the bars securely clamped by two yokes of soft iron. The relative permeability of the two bars is then determined by adjusting the number of ampere turns on each until no permanent deflection is observed on the magnetometer needle placed above them. The **B-H** curve of the standard bar is known, and with the help of this and the readings obtained as above, a point on the **B-H** curve of the sample is readily determined by simple calculation. The process is repeated with different values of **H** sufficient to enable the **B-H** curve of the sample to be plotted.

The difference between the two arrangements lies merely in the method of adjusting the ampere turns to obtain a balance. In Prof. Ewing's case, the adjustment is made by varying the number of turns, the current being constant; while in Mr. Holden's device the same result is arrived at by varying the current, the number of turns being constant and the same in each coil.

Omitting the dial switches, which are not required in our case, the other apparatus used is essentially the same as Prof. Ewing's. The entire arrangement is not so neat in general appearance as Prof. Ewing's, but has the advantage of being simpler in construction and less expensive. Although quite roughly constructed, our apparatus answers all practical purposes, and gives reasonably accurate results.—Yours, &c.,

June 3, 1896. P. T. CLULOW, Eng. Dept.

## THE WORSHIP OF THE POWER-FACTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In common with many other engineers, the writer of the article in your columns upon Mr. Langdon-Davies's motor seems to take an altogether exaggerated view about the so-called power-factor of motors. From the importance he attaches to it one would think that it had something to do with the efficiency of the apparatus. He says he is sorry that in my report on the motor I have made no comment on the power-factor, which in this motor I found to be about 0·49 at full load. For my own part, when a motor of so small a size as ¾ H.P. gives an efficiency as good as 90 per cent., I should not mind if the power-factor were still smaller; and I regard it as a piece of superstition to demand that it should be higher. In larger sizes of motors it would naturally be higher. In condensers, the lower the power-factor the better they are. In transformers a high power-factor is of importance only to the supply company, but of none primarily to the consumer. And, even in that case, the importance lies in the circumstance that the transformer may by the very nature of things be running many hours a day on no load. If transformers were only switched on when wanted to run with a good load, the power-factor would be a very unimportant consideration. Now, motors are not left on circuit all day or all night idle; they are run only when wanted, and normally run on a fair load. If, then, by sacrificing the unimportant detail of an ideal power-factor one can gain the practical result of a singularly high efficiency with good starting effort, why grumble? It would be easy enough to go the other way. In order to satisfy the pedantic demand for a high power-factor, let the motor be redesigned to run hot with a low efficiency and bad starting effort. The pedant who worships at the shrine of the power-factor will be satisfied, but the motor will be decidedly worsened. This is not the way to facilitate the progress of alternate-current motors. Even the central-station engineer would hail the prospect of trebling, if he could, his present slender day load by a demand for current for motors, though their power-factor were but half as good as that of the motors in question. Being a practical man, he would rather have the dividend than the high power-factor. He prefers substance to shadow.—Yours, &c.,

SILVANUS P. THOMPSON.

Morland, Chislett-road, West Hampstead, N.W.,
June 23, 1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think the best answer to Prof. Silvanus Thompson's letter will be found in the figures in the table below of a test made by Mr. Langdon-Davies with a small motor giving a little less than ½ B.H.P. at about 2,400 revolutions per minute. It will be seen that an efficiency of 81·4 per cent. is obtainable with a load factor of 70·4 per cent., and an output of 0·422 B.H.P. If this be possible with such a small output, surely better results are possible with a ¾ B.H.P. motor such as that tested by Prof. Thompson.—Yours, &c.,

June 25, 1896. THE WRITER OF THE ARTICLE.

| Brake load (lbs.) | Speed. | B.-power H.P. | B.-power + correction H.P. | Torque (lb. ft.) | Volts. | Amp. | Ampere reading. | Appar'nt power (watts). | Watt-meter reading. | True power (watts). | True power (E.H.P.). | Power factor. | Effici'ncy per cent. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ... | 2,555 | ... | ... | ... | 98·4 | 7·0 | Direct. | 695·8 | Direct. | 127·5 | 0·17 | 0·1833 | ... | Light without brake. |
| 3·5 | 2,400 | 0·418 | 0·618 | 0·889 | 98·75 | 8·2 | — | 810·0 | — | 570·0 | 0·76 | 0·704 | 83·9 | |
| 3·5 | 2,420 | 0·422 | 0·622 | 0·889 | 98·8 | 8·2 | — | 810·0 | — | 570·0 | 0·76 | 0·704 | 81·4 | |
| 3·0 | 2,450 | 0·366 | 0·566 | 0·762 | 98·8 | 8·75 | — | 866·0 | — | 615·0 | 0·82 | 0·71 | 68·8 | |
| 3·0 | 2,480 | 0·371 | 0·571 | 0·762 | 98·9 | 8·8 | — | 870·0 | — | 615·0 | 0·82 | 0·707 | 69·3 | |
| 4·0 | 2,370 | 0·471 | 0·671 | 1·016 | 98·8 | 11·75 | — | 1160·0 | — | 735·0 | 0·98 | 0·634 | 68·1 | |
| 3·0 | 2,472 | 0·37 | 0·57 | 0·762 | 99·5 | 9·4 | — | 936·0 | — | 652·0 | 0·92 | 0·697 | 65·1 | |
| 3·0 | 2,480 | 0·371 | 0·571 | 0·762 | 99·9 | 9·0 | — | 900·0 | — | 645·0 | 0·91 | 0·717 | 66·0 | |
| 3·5 | 2,430 | 0·423 | 0·623 | 0·889 | 99·0 | 9·75 | — | 965·0 | — | 690·0 | 0·97 | 0·715 | 67·4 | |
| ... | 2,500 | ... | ... | ... | 99·5 | 8·4 | — | 835·8 | — | 285·0 | 0·38 | 0·34 | ... | [without weights. With brake coupled light |
| ... | 2,560 | ... | ... | ... | 99·5 | 7·0 | — | 696·5 | — | 132·0 * | 0·18 | 0·188 | ... | Light without brake. |

* The brake absorbs 0·20 H.P. running light. Motor E. 110.

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## THE LANGDON-DAVIES MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following tests may interest you; they refer to motor No. 118 mentioned in your article on my motors in last week's *Electrician*.

The tests shown in Fig. 15 of your last week's issue were made with a stator having 32 *equally-spaced* slots, wound as a four-pole machine having four concentric coils per pole, as in Fig. 7. The rotor had 19 copper bars; the number of copper bars should have been greater to give the best result with such a stator, but I had not the materials to hand wherewith to construct a suitable rotor.

I have since fitted this stator with a rotor having 31 bars, and obtained a starting torque of 1·5 pounds feet, viz., a weight of 9lb. lifted by a cord wound on a 4in. pulley, the weight hanging dead, not touching the ground.

I have not been able as yet to make complete tests of the machine, but I can safely say that this is equal to full load running torque.

I find also that cos $\phi$ (a factor of the power, not to my mind "*the* power" factor) has increased.—Yours, &c.,

W. LANGDON-DAVIES.

57, Comeragh-road, West Kensington, W., June 22, 1896.

## CATHODE RAYS AND X-RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Some experiments I am making on the connection between cathode rays and X-rays have just given me a result which it seems desirable to publish without delay for the benefit of other workers. Having designed a tube with the now usual oblique anti-cathode or "reflector" of platinum to receive the impact of the cathode discharge and generate X-rays, and an interiorly projecting wire of aluminium in the path of the latter rays, I have found that, with a sufficiently high exhaustion, there were produced simultaneously two shadows—an X-ray shadow on a luminescent screen outside the bulb, and a cathode ray (or Crookesian) shadow on the glass wall of the bulb. Both shadows were thrown as from the "reflector" as origin; but while the cathode ray shadow was capable of being deflected both magnetically and electrostatically, the X-ray shadow was not so deflected, even though the wire object within the tube was itself electrified either + or −. A slight shifting of the X-ray shadow was traced to a small change in the apparent origin of the X-rays, as the cathode discharge fell more on one spot or another of the platinum "reflector." At no state of exhaustion did the "reflector" convert all the cathode rays into X-rays.—Yours, &c.,

SILVANUS P. THOMPSON.

June 25, 1896.

# LEGAL INTELLIGENCE.

### Jardine v. King, Mendham and Co. and Miles.

Judgment was delivered in this action on Tuesday last, full particulars of which were given in our last issue. In delivering judgment, Mr. Justice North said that several points had been raised during the progress of the case which he did not think it necessary to consider, as he had come to the conclusion that the defendants' contrivances were not an infringement of the plaintiff's patent. The law of the case was governed by the well-known case of the ticket-punch patent, in which the Court of Appeal had laid down that a similar machine for the accomplishment of the same action would not necessarily be an infringement of the other. He said that automatic time-checks for taking the times at which workmen arrived at their work were well known at the time of the plaintiff's patent. There were numerous differences between the plaintiff's and defendants' machines, and the question was whether they were substantial differences or merely equivalent to imitations. For instance, in the plaintiff's machine the box operated without any electric current except at the moment the current passed and opened the drawer. In the case of the defendants' machine the current was permanent, and the box could only work when the current was on, which it was during the whole time the box was in operation. In the plaintiff's, before the current was on, the checks went into the early compartment, whereas in the defendants', before the current was on, the checks were not received at all; and so on. His Lordship then compared the specifications of both patents, and said that all the plaintiff could claim was his method of operation. From the discrepancies he had pointed out he had come to the conclusion that there were substantial differences between the methods of operation of the plaintiff's and the defendants' machines. He could not say that the defendants' machine was a colourable imitation of the plaintiff's, nor was it equivalent to the plaintiff's process. The action would, therefore, be dismissed, with costs.

Judgment accordingly.

### Electrical Construction Company v. Hurry and Young.

This was an action brought in the Scotch Courts by the Electric Construction Company against Messrs. Hurry and Young, electrical engineers and contractors, of Edinburgh, for the payment of £50. 13s. 5d., the price of a dynamo supplied in September, 1894. The defence to the action was that the machine did not conform to the terms of the contract.

Lord LOW, in giving judgment last week, said he must find for the defendants, as he held the defence was a good one. The defendants had directed the attention of the plaintiffs to the matter, and had called upon them to remove the machine. This had not been done, and the defendants had continued to work the machine until the present time. Under the old Scots law he (Lord Low) thought the defendants would have put themselves into a wrong position by continuing to work the machine after the plaintiffs had been called upon to put it right; but under the Sale of Goods Act, if a purchaser had not expressly or by implication accepted goods, he could retain them and claim damages, or set up the breach of contract in diminution or extinction of the price. He was therefore of opinion that the defendants were entitled to set up the breach of contract in diminution or extinction of the price, and as the expenses incurred exceeded the value of the dynamo, he assoilzied the defendants with expenses.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations.**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

TENDERS INVITED.—The Free Library Committee of the County Borough of Rochdale invite tenders for the electric lighting plant required at the Free Public Library, consisting of gas engine, dynamo, wiring and fittings. Specifications, &c., may be obtained from Mr. S. S. Platt, A.M.I.C.E., Borough Surveyor. Tenders must be sent in to the Deputy Town Clerk (Mr. James Leach), Town Hall, Rochdale, by noon of Tuesday, the 30th. Further particulars appear in our advertisement columns.

——— The Vestry of the parish of St. Mary, Battersea, invite tenders for the supply and erection of boiler house plant, engine house plant, switchboard and connections, accumulators, wiring and fittings, &c, for electrically lighting the municipal buildings and Town Hall. Tenders can be sent in for sections of the work. Specifications, &c., can be obtained of Mr. R. Hammond, Ormond House, Great Trinity-lane, London, E.C., after Monday next, and tenders must be sent in to Mr. W. Marcus Wilkins, Vestry clerk, Municipal-buildings, Lavender-hill, S.W., not later than Tuesday, July 14th, at noon. Further particulars are given in our advertisement columns.

——— The Urban District Council of Ealing require tenders for work in connection with the extension of their electric lighting station at Ealing. Tenders to Mr. Wm. Ruston, Clerk, Public Buildings, Ealing, W., by 4 p.m. on Wednesday, July 1st.

——— The Edinburgh Town Council invite tenders for building work in connection with the proposed additions and alterations to the electricity station. Tenders to the Burgh Engineer, 1, Parliament-square, Edinburgh, by July 13th.

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TENDERS INVITED.—Tenders are being invited by the Spanish Minister for Foreign Affairs for the construction and working of a telephone system in San Juan de Puerto Rica. The copy of the Royal Order inviting tenders may be seen at the Commercial Department of the Foreign Office, Downing-street, S.W., between 11 and 6. Tenders must be sent in to the Ministry at Madrid by August 10th, and must be accompanied by a deposit of $800.

——— The General Direction of French Posts and Telegraphs invite tenders for 25 kilometres of telegraph cable with six pairs of paper-insulated conductors. Tenders to the Direction, 103, Rue de Grenelle, Paris, by July 11th.

TENDER ACCEPTED.—It is stated that the Elektricitäts Aktien-Gesellschaft vormals Schuckert and Co. have received the contract for the erection of a large electricity supply station at Barcelona at an estimated cost of £240,000 (?). Provision will be made for the supply of current for working the local tramways.

TENDERS RECEIVED.—The Leeds City Council received nearly 70 tenders for an electrical installation for working the proposed Roundhay and Kirkstall tramway, on the overhead electric system. Only two firms sent in estimates for the entire work, all the others being for sections of the contract. Should it be found desirable to let the contract in sections, the Highways Committee have, it is stated, practically agreed upon the firms to be entrusted with the supply of engines, dynamos, boilers and the erection of the generating station. The tenders which the Committee have selected for these items amount to about £25,000. The whole of the work is likely to cost between £70,000 and £100,000.

APPOINTMENTS.—Mr. F. W. Shurlock, B.A., B.Sc., has been appointed Principal of the Swindon and North Wilts Technical School. Mr. Shurlock is at present engaged as Lecturer in Mathematics and Physics at the Bristol Merchant Venturers' Technical School.

——— Mr. August Bornemann has been appointed general manager of Ruston, Proctor and Co. (Limited), in place of the late Mr. John Kent. Mr. Bornemann has been in the firm's service during the last 19 years.

APPOINTMENTS VACANT.—The Corporation of Paisley require a resident electrical engineer to design and superintend the laying down of an electric light installation, and to manage the same after completion. Salary, £200 per annum. Applications to the Town Clerks, Messrs. Young and Martin, Paisley, by July 1st.

——— From our advertisement columns it will be seen that an assistant lecturer and demonstrator of physics is required by the Firth College, Sheffield, after Michaelmas next. Salary, £120 per annum, together with certain allowances. Applications to the Registrar by July 9th.

——— A workshop instructor in house wiring and jointing is required by the governing body of the Battersea Polytechnic, London, S.W. Some particulars will be found in our advertisement columns.

——— Under the Swansea Intermediate and Technical Education Scheme applications are invited for (1) lecturer in metallurgy and chemistry, (2) lecturer in physics, and (3) lecturer in engineering. Salary in each case, £200, rising to £250 per annum.

——— The Brighton Town Council require temporary lecturers and instructor in applied electricity and physical science at the Corporation Technical School. Salary £80 per annum for two evenings per week. Applications to the Town Clerk.

LIQUIDATIONS.—Creditors of the Universal Electric Carriage Syndicate (Limited) must send in particulars of their claims to the liquidator (Mr. W. O. Attree), 41, Coleman-street, E.C., by July 1st.

——— We have received a summary of the liquidator's account in the matter of Poole and White (Limited) from September 15, 1895, to March 14th last. The accounts show that there was a balance brought forward from receipts of £165. 2s. 6d. This is partly exhausted as follows: Board of Trade and Court fees, 2s.; costs of solicitor to liquidator, £123. 7s. 4d.; incidental outlay, £3. 11s. 8d.; total, £127. 1s.; balance forward, £38. 1s. 6d. Probability of any dividend for creditors, *nil*. It is somewhat surprising that the creditors in this concern, the whole conduct of which from the commencement of trading was of a most peculiar character, have not, in the light of the result of the action Gaskell *v.* Gosling, arranged to place a clear statement of affairs before counsel in order that, if so advised, steps could be taken to obtain a similar verdict to that in the action referred to. There never was a commercial failure in which investigation on behalf of trade creditors was more necessary than in the bankruptcy of Poole and White (Limited) and its subsequent receivership.

THE "HOLOPHANE" SYSTEM OF DIFFUSION OF LIGHT.—We learn that "Holophane" (Limited) are about to place upon the market a newly-designed set of fittings to be used with the patent diffusing globes associated with their system. The dome of the "Holophane" globe is made with a rim which clamps into the new fitting, and makes it extremely safe, effective and simple. The fitting can be plain or ornamental in character, and is especially adapted for ceiling lights, to supersede chandeliers and spray brackets. "Holophane" globes are also made to fit the regulation electric light fittings supplied by the regular dealers, and the globes are equally suitable for electric light or gas. Where a softened light is required, as for reading and writing, these globes are certainly an improvement on the ordinary clear glass globes. "Holophane" globes and fittings will not be on the market for a few weeks, as the necessity for show rooms and larger offices has required new premises, and these have been taken at 91, 93 and 95, Queen Victoria-street, London, E.C., to which address the Company will shortly remove.

SILICIUM BRONZE WIRE.—The Phosphor Bronze Company issue a useful hanging sheet table of approximate weights and electrical resistances of patent silicium bronze wire, giving information which will be found of service to electrical engineers. The wire is supplied in five classes, varying in conductivity from 100 to about 30 per cent. (for long spans). The information given includes tensile strength, electrical resistance, conductivity, &c, and the explanatory matter accompanying the table shows the uses to which this wire is most generally applied.

"THE JOURNAL."—Part 123 of the *Journal* of the Institution of Electrical Engineers is now ready, price 3s. This part contains the discussion on Mr. Dane Sinclair's Paper on "Telephone Exchanges and their Working," and Mr. W. E. Langdon's Paper on "Railway Telegraphs, with Special Reference to Recent Improvements," and the discussion thereon.

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ABERDEEN.—The Harbour Commissioners have written to the Electric Lighting Committee of the Town Council asking for the terms upon which they would be prepared to supply current for the lighting of the harbour. The matter has been remitted to a sub-committee.

ALDERLEY EDGE.—Notice is given of the intended transfer by the District Council of the Provisional Order to the Alderley and Wilmslow Electric Supply (Limited). The terms of the transfer provide for the payment to the Council of the cost of obtaining the Order and for lighting all streets in the compulsory area electrically. The Council reserve power to purchase the undertaking at any time on six months' notice by paying to the Company all capital expended, less depreciation, and making up a cumulative dividend of 8 per cent. on the capital.

BANGALORE (INDIA).—A scheme for the construction of tramways in this city has been laid before the Municipality by Messrs. Arbuthnot and Co., the Indian agents of the Electric Construction Company. It is proposed to employ electricity as the motive power.

BEDFORD.—The Corporation have received the sanction of the Local Government Board to the borrowing of £17,000 for electric light extension purposes.——The Local Gas Company has been notified that the Corporation will discontinue to use the gas lamps in several streets after January 1st.

BIRMINGHAM.—Negotiations are still in progress between the Public Works Committee and the Canadian Syndicate who are seeking to become lessees of the city tramways. The Committee insist upon a higher rent being paid for the lines, the introduction of halfpenny fares and the abolition of steam traction. The only point remaining to be settled is the mileage of line to be worked on the underground conduit system, and how much of the tramways will be worked on the overhead system. It is reported that the concessionaires have accepted the Committee's terms, and have agreed to employ the underground system on 10 out of the 22 miles of tramways about to be leased. A special meeting of the Committee was held yesterday (Thursday) to finally consider the report to be made to the Council.

BRIGHTON.—The Town Council have decided that in the event of consumers leaving their premises during any half-year the successors in occupation are not entitled to benefit as regards the reduction in the charge for electric current by the amount consumed by their predecessors, nor to count such consumption towards reduction in the event of their taking current at other premises.

DUBLIN.—It is stated that the Dublin United Tramways Company have decided to purchase the undertaking of the Dublin Southern District Tramways for £273,500. The capital of the Dublin United Company is £540,371, with a debenture loan of £75,600. The terms of the purchase will shortly be laid before a meeting of the shareholders.——The Bill promoted by the Dublin Southern District Tramways Company for extending their tramway system in and around Dublin has been rejected by the Select Committee of the House of Commons.

EALING.—A Local Government Board inquiry was held at Ealing on Tuesday into the application of the District Council to borrow £25,000 for electric light extension and other purposes.

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EAST HANNINGFIELD.—Mr. G. W. Clarke's new roller mills and the rectory have been wired and fitted up for the electric light, current for both places being supplied from a Crompton dynamo driven by a Davey-Paxman engine. The plant is stationed at the mills, and current is conveyed to the rectory, a distance of about 600 yards, by means of overhead cables.

ELECTRIC TRACTION IN SOUTH AFRICA.—It is stated that the Syndicate which recently acquired the Cape Town tramways have purchased the Port Elizabeth tramways, and will equip them electrically. It is also announced that electric traction will be introduced on the Johannesburg tramways.

EXETER.—Mr. H. D. Munro, engineer to the Exeter Electric Light Company, has been appointed borough electrical engineer at a salary of £200 per annum, and various other staff appointments have also been made. The Electric Light Committee have made arrangements for installing and repairing electric light fittings in the houses of customers under a system similar to that employed at Leicester. The Council have made all preparations for the transfer of the electricity works on Tuesday next.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from June 17th to June 23rd, with the ports of destination :—

*Argentina*.—Buenos Ayres, £194. *Australasia*—Fremantle, £1,676 (including £1,635 telegraph material); King George's Sound, £13; Sydney, £498; Wellington, £140. *Azores*—Fayal, £15. *Belgium*—Antwerp, £165 (electric fuses); Brussels, £72. *Brazil*—Bahia, £61 (telegraph material); Rio de Janeiro, £177 (telegraph material); Rio Grande do Sul, £102 (telegraph material). *Ceylon*—Colombo, £33. *China*—Shanghai, £120. *Egypt*—Alexandria, £240 (telegraph material). *France*—Boulogne, £70. *Gibraltar*, £76. *Greece*—Syra, £50 (telegraph apparatus). *Holland*—Amsterdam, £120; Flushing, £10. *India*—Bombay, £57; Calcutta, £93; Rangoon, £14. *Japan*—Yokohama, £3,770 (including £270 telegraph material). *Panama*—Santos, £51. *Portugal*—Oporto, £31. *Russia*—St. Petersburg, £171 (including £133 telegraph material). *South Africa*—Cape Town, £128; Durban, £705; East London, £65; Lourenco Marques, £428 (telegraph material); Port Elizabeth, £425. *Spain*—Pasages, £24 (telegraph material). *Sweden*—Stockholm, £844 (including £224 telegraph material).

GLASGOW.—At the last meeting of the City Council it was reported that at May 31st the revenue from the electric lighting department amounted to £23,034, an increase of £5,240 compared with the corresponding period of 1895.——At the meeting of the Electric Lighting Committee on Tuesday it was agreed to recommend the Council to reduce the price of electric current.

HALIFAX.—The Local Government Board have sanctioned the borrowing of £20,000 by the Town Council for electric light extension purposes.

HANLEY.—A deputation of the members of the Incorporated Association of Municipal and County Engineers visited Hanley a few days back and inspected the various town improvements which have been effected during the past ten years under the supervision of the Borough Engineer, Mr. J. Lobley, who was president of the Association in 1886. Mr. Lobley read a Paper dealing with the various improvements effected in the town, including the establishment of the Borough Electricity Works, for which a Provisional Order was obtained in 1891. The Paper contained a description of the public arc and incandescent lighting, and the visitors were much interested in a description of Mr. Lobley's automatic lamp-lighting device. Mr. Lobley expressed his acknowledgement of the assistance rendered by Mr. G. H. Cottam, the electrical engineer to the Corporation, during the early years of the electric lighting undertaking, and to Mr. C. A. Cowell and Mr. C. J. Sutherland, who were last year appointed electrical engineers and joint managers under Mr. Lobley's general directions. The author of the Paper was awarded a cordial vote of thanks on the motion of Mr. Boulnois, of Liverpool. The visitors were subsequently taken a round of inspection, which included a visit to the electric light works, at which several novel methods of dealing with the work at the station, introduced by Mr. Lobley, were shown and described.

HULL.—The Electric Light Committee have just decided to recommend the erection and equipment of another generating station in Sculcoates-lane, at a cost of £40,679, on the high-tension system. For some time past the questions of the extension of the electric light and the adoption of electric traction on the local tramways have been before the Corporation, and under the present scheme provision can be made to supply current for working the trams. A proposal to extend the electric light mains to East Hull at a cost of £9,562 has been postponed.

LIVERPOOL.—A Local Government Board inquiry was held last week at Liverpool into the application of the City Council to borrow, amongst other sums, £5,550 for wiring and fitting up St. George's Hall for the electric light.

MILE END (LONDON).—The Special Electric Lighting Committee have issued a report in which they recommend the Vestry to light the district electrically, and to apply for a Provisional Order.

MITCHELSTOWN (CORK).—The Board of Guardians have decided to light this village electrically, and intend to make an application to vest in the Board the necessary powers under the Electric Lighting Act (1882).

NEWMARKET.—An unsuccessful attempt was made at the last meeting of the District Council to rescind the resolution recently passed in favour of the establishment of electricity supply works, the motion being rejected by eight votes to four.

ROYAL AGRICULTURAL SOCIETY'S MEETING.—The fifty-seventh annual exhibition of this Society was opened on Monday last at Leicester. Amongst the most prominent exhibitors were Messrs. Clayton and Shuttleworth, Crossley Brothers, J. Fowler and Co. (Leeds), E. S. Hindley, Ransomes, Sims and Jefferies, Robey and Co., and W. H. Willcox and Co. The exhibit of Messrs. Clayton and Shuttleworth included both steam and petroleum engines, and a fine example of the long-stroke fixed steam engine, manufactured by this firm, and specially adapted for electric lighting work, being on view. At Messrs. Crossley Brothers' stand gas and oil engines were exhibited, a machine claiming special attention being a 14 H.P. latest type gas engine, specially arranged for direct electric lighting purposes, and to give steady driving without the dynamo being flywheeled. The maximum indication of this machine is given at 48 H.P. The oil engines included new patent portable and horizontal machines of 7 H.P., 6½ H.P. and 3½ H.P. respectively. Messrs. Fowler's exhibit, although chiefly made up of agricultural engines and machinery, included a fine example of the firm's 8 H.P. compound semi-portable engine, specially designed for all kinds of work where steady running is essential. As usual, Mr. E. S. Hindley made a good display of small-power engines and combined engines and boilers. Included in this exhibit was a dynamo and high-speed engine direct-coupled, and a variety of donkey and centrifugal pumps, saw benches, band-saw machines, &c. In addition to a fine assortment of agricultural machinery and apparatus, Messrs. Ransomes, Sims and Jefferies had on show a large variety of steam engines and force-pumps, including a powerful 16 H.P. portable engine for general work. Messrs. Robey and Co.'s exhibit included two good specimens of the "Robey" oil engine of 7 and 8 B H.P. respectively, and a horizontal long stroke fixed steam engine of 8 H.P. fitted with automatic governor and link expansion gear, enabling the engine to maintain a practically constant speed with great variation of load. A medium stroke horizontal fixed engine of 6 H.P. was also shown for which the firm claim that it is well adapted for driving machinery where steadiness of running is an important consideration. Both engines work at 80lb. pressure. An improved "Robey" gas engine was also shown for which the following important advantages are claimed: sensitive governor, positive lubricator, patent igniter, multiple impulse self-starter, pressure-starter, an improved combustion chamber and exhaust silencer, and specially balanced cranks. Messrs. W. H. Willcox and Co. always show well at the Royal Agricultural shows, and their varied exhibits on this occasion included a number of first-class lubricating oils, engine packings, engineers' sundries, boiler mountings, engine fittings, pumps, tools, and many other articles for which the firm have obtained a well earned reputation. The Leicester Show may be termed an undoubted success.

SHEFFIELD.—The tramway question occupies a good deal of attention in civic circles in Sheffield. The Council take possession of the tramways in a few days, and have decided to work the lines. The condition of the rolling stock is therefore being considered by the Tramways Committee. It is proposed to extend the present tramways, and the Corporation intend to promote a Bill in the next session of Parliament. The Council already possess power to introduce electric traction, and it is stated that as soon as the scheme of extensions has been definitely decided upon, this branch of the subject will be considered.

SHIP LIGHTING.—The second-class cruiser "Eclipse," which was recently launched at Portsmouth, has been supplied with a duplicate set of electric light machinery by Messrs. G. E. Belliss and Co., of Ledsam Street Works, Birmingham.

SOUTHAMPTON.—A Local Government Board inquiry was held at Southampton on Tuesday last by Col. J. O. Hasted, R.E., into the application of the Town Council to borrow £50,000 for the purchase of the works and undertaking of the Southampton Electric Light and Power Company and for extensions of the plant and mains. The Town Clerk stated the purchase money amounted to £21,000, which comprised £19,187 capital expenditure to December 31st last, a further amount on capital account to date of agreement, together with a nominal sum for goodwill. The Council intended to apply for a provisional order to extend the area of supply. The consulting engineer, Mr. E. Manville, and Alderman Bone also gave evidence. There was no opposition.

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SWANSEA.—The question of inviting tenders for the electric lighting of the new market led to a lengthy discussion at the last meeting of the Town Council. It had been proposed by the Market Committee to confine the tendering to two local firms—Mr. J. Legg and Mr. J. S. Brown. Protests were made against this proposal by several members, who contended that the tendering should be open, and that the contract should be advertised in the usual way. Ultimately the Committee's recommendation was agreed to.

ST. PANCRAS (LONDON).—The second annual outing of the staff of the Regent's Park electric supply station of the St. Pancras Vestry took place on Saturday, when about 30 of the *employés* journeyed to Hastings, and spent an agreeable day. Mr. T. Cooper, M.A., distributing engineer to the Vestry, presided at the dinner at the Manor Hotel.

SYDNEY (N.S.W.).—A company, called the North Sydney Electric Railway Company (Limited), with a total capital of £350,000 (of which £250,000 will, it is stated, be offered in England), is being promoted for the construction of a railway from the Post Office, Sydney, to Milson's Point. It is proposed to employ electricity as the motive power, and the estimated cost, inclusive of all expenses for tunnel, lifts, land purchase, generating works, plant, rolling stock, and providing a working capital reserve, is put at £350,000. The Bill authorising the railway reached the Select Committee stage in the last session of the New South Wales Parliament, and it is stated that leave will be asked for its reintroduction this session at the earliest possible date.

TELEPHONE TRUNK WIRE EXTENSIONS.—On Monday next telephonic trunk line communication will be established with Cambridge.

UNDERGROUND TELEPHONE WIRES.—The Dundee Town Council have conditionally agreed to allow the National Company to put its wires underground.——A committee of the Leeds Council recommend the Council to give the same Company facilities for putting its wires underground.

WALSALL.—At Wednesday's meeting of the Town Council it was decided to give notice to the South Staffordshire Tramways Company, requiring them to sell to the Council so much of their undertaking as is within the borough.

WEST HAM.—The Corporation have considered and approved the report recently prepared by the Borough Electrical Engineer on the electric lighting question, and which was referred to in our issues of May 22nd and June 19th. Application is to be made to the Local Government Board for sanction to borrow £67,000 for carrying out the recommendations of the report.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

May 26, 1896.

11,387. A. G. HORNE. Glasgow. An improved electrical locking and unlocking railway signal apparatus.

11,391. J. C. REYNOLDS. Wolverhampton. Improvements in cut-outs for electrical uses.

11,417. R. C. BROWN and F. E. HUNTRESS. London. Improved means for electrically connecting the rails or sections of electric railways.*

11,421. J. D. F. ANDREWS. London. Improvements in dynamos and electro-motors and in the gearing of same.

11,429. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED). London. Improvements in and connected with electric brakes for electrically-propelled vehicles. (W. B. Potter, U.S.A.)*

11,441. T. E. ADAMS. London. Improvements in electric arc lamps.*

11,451. W. P. THOMPSON. London. Improvements in apparatus for producing musical sounds by electricity. (G. Breed and C. A. Bragg, U.S.A.)*

11,471. W. L. WISE. London. Improvements in arc lamps for alternating current circuits. (A. B. Fernald and J. H. Hubbell, U.S.A.)*

11,473. J. C. LOVE and J. E. HODGES. London. Improvements in electric railways or tramways.

May 27, 1896.

11,481. T. TOMLINSON. Bray. Improvements in the driving of machinery, vehicles, boats, &c., by electric motors or other high speed motors.

11,517. H. A. BESSEMER. Southampton. Improvements in or relating to the application of electric light to carriage or other lamps.

11,519. R. J. CROWLEY and A. B. HUTCHINGS. Improvements in or relating to induction coils, alternating current motors, transformers, dynamos, and other machines depending upon the principle of electrical induction.

11,520. W. M. KLEES. London. A new electrical signal of the signal house at the railway station.

11,552. C. ADAM. Liverpool. An improved means for switching current, applicable for electric motor cars operated by a mixed supply.*

11,553. J. W. SWAN. London. Improvements in the manufacture and production of filaments for incandescent electric lamps.

May 28, 1896.

11,617. H. BINKO. London. An improved electric alarm for railway trains and other purposes.

11,627. E. J. CLUBBE, A. W. SOUTHEY and THE ELECTRIC MOTIVE POWER COMPANY (LIMITED). London. Improvements in secondary batteries.

11,647. E. THEODORA (LADY FORBES). London. Improvements relating to electric couplings.

May 29, 1896.

11,171. W. L. POOLE, A. STONE and A. ST. V. TURQUAND. London. An improved electrical method of joining metallic and other tubes, pipes, bars, and the like.

11,724. A. E. WOODHOUSE. London. Improvements in the manufacture of electrical hot plates and other apparatus designed for electrical production of heat.

11,730. W. P. THOMPSON. Liverpool. An improved apparatus for producing galvanic or electrolytic depositions. (The Elektra Galvanoplastische Anstalt, H. Teith and A. Floeck, Germany.)

11,732. F. GRUNWALD. Liverpool. An improved plate for storage batteries.

May 30, 1896.

11,779. J. G. LORRAIN. London. Electric arc lamp. (J. McLaughlin, United States.)

11,783. H. H. LAKE. London. Improvements in electric railways. (G. Ferraris and R. Arno, Italy.)

11,800. J. ATHERTON, G. KNIGHT and G. ELLIS. London. Improvements in coin-freed electric meters for the measurement of electricity.

11,801. J. KATZENSTEIN. London. Improvements in sockets or holders for electric incandescent lamps.

11,813. W. A. PRICE. London. Improvements in or relating to electric cables.

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

9,144. BINSWANGER and BALL. Electric soldering apparatus.

9,146. NIEWERCH, H. and R. Arc lamps.

9,372. MIDDLETON and NEALE. Electric oven.

9,433. BURN and TATE. Electrically signalling on locomotives.

9,882. SAFETY TREAD SYNDICATE, (LIMITED), and others. Electric conduits.

10,155. FREADENBERG. Telephone systems.

10,302. SNELL. Laying submarine electric cables.

10,696. COX. Electroplating ships, vats, &c.

11,951. BERDITSCHEWSKY (called Apostoff). Telephonic exchange system.

12,187. HOLDEN. Telephonic apparatus.

12,414. NIBLETT. Electrically lighting vehicles.

12,417. WEISE. Secondary battery plates.

12,683. BERDELL. Telephone transmitters.

12,690. BRAULT and JEANTAUD. Electrically propelled vehicles.

13,014. NEW AND MAYNE. Dynamos and electric motors.

13,619. WETTER (Elektrizitäts Aktien-gesellschaft vorm. Schuckert and Co.) Electric railways and tramways.

20,923. THOMPSON (Higgins). Electric annunciator.

23,250. SCHNEIDER. Electric accumulators.

1896.

1,344. BEAUJEAN. Securing electric insulators, hooks, &c., to walls, girders, &c.

2,501. KROTZ and others. Conveying electricity to railway cars.

3,091. LINDE. Accumulator batteries.

3,627. RUSSELL and others. Telephones.

4,806. WETHERILL. Magnetic separators.

5,171. BAKER. Arc lamps, electroliers, &c.

5,389. JACKSON (Etheridge). Autographic telegraph apparatus.

5,951. DEVONSHIRE (Bassett). Electric cars.

6,048. DEVONSHIRE (Potter). Controllers for electric motors.

6,208. BALLANCE AND HEWSON. Electric switches.

6,487. DEVONSHIRE (Priest). Controllers for electric motors.

6,576. HARDEGEN. Microphones.

7,794. HELLYER. Incandescent electric lamp shade holders.

7,881. DEVONSHIRE (Moody). Electric current transformers.

7,884. DEVONSHIRE (Berg). Electric current power systems.

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# COMPANIES' MEETINGS AND REPORTS.

## Metropolitan Electric Supply Company (Limited).

An extraordinary general meeting of the Company was held at Winchester House, Old Broad-street, on Tuesday, Sir Eyre M. Shaw presiding, "to consider the recommendation of the Board that the capital of the Company be increased to £1,000,000 by the creation of 50,000 new shares of £10 each, and (if thought fit) to pass a resolution in accordance with such recommendation."

The SECRETARY (Mr. E. Cunliffe Owen) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the remarks which I made to you in the course of moving the adoption of the report at the last general meeting will have prepared you for the notice which you have recently received, and upon which this extraordinary meeting is summoned. You will no doubt remember that I then stated that our chief engineer, Mr. Frank Bailey, laid before us some months ago his estimates of our probable requirements up to the year 1900. These estimates refer to the new works which are rendered necessary by reason of the most satisfactory manner in which the demand for electric lighting is being maintained. This increase is not only gratifying in that it is large, but I would specially point out that it does not come by fits and starts, but continuously, as if it were obeying some law of demand upon the maintenance of which we can rely with some confidence, and which has been the main factor in enabling us to make our calculations for the future. In addition to this normal progress, to which we can look forward as practically assured, I ought also to remind you of the reduction in our rates of charge, which we have felt ourselves justified in making to certain classes of our customers. We have every reason to believe that this concession will be a great boon to a large number of customers, especially smaller tradespeople, whom, owing to the regularity of their burning hours, we can supply economically, and to whom we are, therefore, able to offer our lowest current rates. The increase in our lamp density in many portions of our district also warrants our commencing the work of re-arranging our system of supply by the creation of transformer sub-stations. I need hardly point out that from the very commencement of our working, the formation of these sub-stations has been kept in view; but so long as the demand was scattered it would have been impossible to arrange a supply on this system economically. Moreover, the experience which has been gained by other companies in the last few years through the working of these sub-stations has demonstrated that our caution in dealing with this matter was not misplaced. Special appliances, such as large transformers and concentric mains, with the necessary connections, are requisite for the work, and it has taken some time to bring their manufacture to the present state of perfection. We can, therefore, confidently look forward to obtaining the best results with absolute certainty and with a much smaller capital expenditure than would have been the case had we embarked on this undertaking during its experimental stages. In carrying out this development the Directors wish you clearly to understand that the work which has been carried out up to the present time has not only fulfilled its purpose of maintaining our supply during what may be termed the pioneering period of the Company's history, but the methods then adopted now enable us to carry out the new work with the greatest facility, and with the complete utilisation of our past expenditure. It will be at once obvious to you that to carry out these works on the most economical basis, it will be necessary to construct them to meet the demands of the Company as they arise from time to time, and to be in a position to take advantage of the most favourable time for making contracts for new machinery and materials. The resolution which we now ask you to pass authorises the increase of the share capital of the Company to £1,000,0000 by the creation of 50,000 new shares of £10 each; and, for the reason which I have just given you, we ask you to leave it to your Directors to issue such new capital at such times and in such amounts as the exigencies of the Company shall seem to demand. We ask you to leave to the discretion of your Board the best method of placing the various issues on the market, feeling sure that you will credit them with the intention of furthering the best interests of the shareholders. I ought to add that it was only after the fullest consideration and after consultation with those best able to advise us, that we came to the conclusion that in the interests of the Company the capital required could be more advantageously raised by the creation of share capital than by any other method. So few weeks have now elapsed since I last had the pleasure of meeting you, that we have not much additional information to impart as to our present position; but I am happy to inform you that the revenue for the first quarter of the present year amounted to £38,616, as against £31,201 for the corresponding quarter in 1895, or an increase of 23·8 per cent. The number of lamps connected to our system, which, on the date of the last report, viz., March 17th last, was 272,000, now amounts to 335,000. Before I move the resolution I should like to refer to certain letters which we have received from some of our original shareholders, inquiring what benefits they will receive in the new issues. Now, while I am most anxious to assure our original shareholders that the Board fully realise how much is due to them, I feel sure that they will understand that it would be manifestly inexpedient, even if it were possible for me to tell them the precise terms upon which the first or any subsequent issue of this new capital will be made. The conditions under which these issues will be brought out will quite possibly vary to meet the conditions of the market at the time; and I ask, therefore, those gentlemen who have been kind enough to write to us, to accept our assurance that, so far as is conveniently possible, the interests of the shareholders of the existing capital of the Company shall receive their first and best consideration. I now beg to move the resolution before the meeting.

Lord JOHN HAY seconded the motion.

Mr. JOHN NEWTON said he would be the last man to offer criticisms against Directors who had done so much for their shareholders as the Directors of this Company had done; but still, shareholders had certain rights, and to ask them for powers to issue shares at such times and at such price as the Directors thought proper was not showing that confidence in the shareholders which the latter had in the Directors. The issue of capital was a very simple matter, but the question was whether the Board should issue it at par to their own shareholders or at a premium. He asked them to have confidence in the shareholders, and to give them some information that within the next six or twelve months an issue of new shares would be made, and to state the price, in order that they might not be taken by surprise. The shareholders would gladly support them in the issue of new capital, but they would do so more gladly if the issue were made so that they might know that the money was capital and that they would get interest on it.

Mr. BILSON asked if the Directors had considered the question of getting rid of the Founders' shares.

The CHAIRMAN, in reply, said that if their shares really stood at over par he saw no reason why they should attempt to issue them at par to the shareholders or anyone else. If Mr. Newton wished for further details on the interesting point he had raised, the auditor was present and could satisfy him; but the general reply was what he had already said—that he did not think they would be justified in issuing shares at par when they knew that they were valued at much more. With regard to Mr. Bilson's question there were no means known by which they could get rid of the founders, who had a perfect right to their shares. There were no means of extinguishing those shares excepting by holding a general meeting of the Company and altering its organisation.

Mr. NEWTON asked whether the Ordinary shareholders would not have a right to appeal to the Courts if a large premium were taken from them.

The CHAIRMAN, in reply, remarked that Mr. Newton had spoken as if existing shareholders were compelled to take the new shares, but there was no obligation whatever on them to do so. If they adopted Mr. Newton's view and issued the new shares at par to existing shareholders, a great many of them might then throw their shares on the market and lower their price, to the disadvantage of poorer shareholders, who might desire in the following week to sell their shares.

Mr. NEWTON regretted that that was not an answer, and he did not think it was complimentary to the shareholders to make such a reply. If shareholders were unable to take up their shares, there was a very just way of dealing with those shares—by the Directors selling them for the benefit of such shareholders. The shares which were not taken up would be sold for the benefit of the Company.

Mr. JOHN GRIFFITHS, in further reply, stated that Mr. Newton had raised an objection to a course of procedure which was almost universal in every important institution in this country. They would hardly find a railway company, he thought, or any of the great companies whose shares were at a premium, that would dare to issue their stock at par when investors could only acquire them at a very considerable premium in the market. It appeared to him, as advising the Company and the shareholders present, that it was the duty of the Directors to secure some moderate premium on the contemplated issue of new shares. In answer to one of Mr. Newton's criticisms, he would remind that gentleman that if the Directors had thought it right to recommend them to issue debentures, or debenture stock, or preferential stock, or anything that would bear an interest-charge in priority to the shareholders' rights, the same result which Mr. Newton regarded as so improper would arise. The same thing would tend, as he (the speaker) trusted that the proposal before them would tend, to improve the dividend on the stock of the Company and to raise its character as an investment before the public. So far as he might express an opinion on the matter he would suggest that the price of issue should be such as, while bearing a moderate premium, should be a real temptation to the existing shareholders to take up their allotments. They should have a real interest in being themselves subscribers for the new shares. There were, however, many shareholders whose means would not permit them to buy the new shares, however much they might desire to do so. That being the case, he trusted that the price of issue would be such that they could sell their rights of allotment to the new shares for a moderate profit—not an extravagant profit such as would result from an issue of the shares at par. He would ask them to bear in mind that to issue the new shares at par would be practically giving away a large amount of goodwill which the Company had built up, and he felt convinced that the Company would benefit by the new shares being issued at a moderate premium. Of course, the premium would go to the credit of capital account. It would be downright improper, though, he believed, not illegal, to pass such a premium to the credit of profit and loss account. It would go to the credit of the capital and be used as capital for the purposes of the Company, and would, he was sure, tend to improve its value, and therefore tend to improve the value of the Ordinary shares of the Company.

Mr. NEWTON said he was not convinced by what Mr. Griffiths had said, because the premium paid by the shareholders was capital which would be used for the development of the business and for the earning of dividends on that portion of the capital which was not called capital. They would, therefore, pay a higher dividend on the Ordinary shares, and the Founders' shares would come in for a share of profits to which they would really not be entitled. He would therefore move—

"*That this meeting recommend the Directors to make the issues of capital at par to existing shareholders.*"

Theirs was neither a railway company nor a gas company.

The CHAIRMAN said he could not take Mr. Newton's proposal as an amendment, but they could negative the resolution. He put the resolution, and declared the same carried, with one dissentient.

The proceedings then terminated.

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## NEW COMPANIES, STATUTORY RETURNS, &c.

**AUTO-ELECTRO FEED WATER PURIFIER COMPANY (LIMITED).**—This Company was registered on June 16th, with a capital of £10,000, in £5 shares, to acquire from Thomas Clifford-Jones his interest in British Patent No. 7,435 of 1893, in relation to the purification of the feed water of steam boilers, and to manufacture, buy, sell, repair, alter and deal in apparatus and machinery designed for the purification or heating of the feed water of steam or other waters and steam generators. The first Directors are: Thomas B. Cooper, Thomas Clifford-Jones, Edwin Dixon, Rupert E. C. Kettle, Ebenezer K. Mitting and Charles E. Shaw.

**BRITISH ELECTRICAL INDUSTRIES COMPANY (LIMITED).**—This Company was registered on June 18th with a nominal capital of £100, in £1 shares, to purchase or otherwise acquire, take over as going concerns, and carry on any businesses connected with the working of electricity in all its branches, and to carry on the business of establishing and carrying on stores!

**CYCLE AUTOMATIC MANUFACTURING COMPANY (LIMITED).**—This Company has been formed, with a capital of £94,000, in £1 shares, to manufacture by automatic machinery cycles and cycle parts. The Company takes over the cycle business of the South of England Electric Manufacturing Company, of Birmingham and Croydon. The purchase price is £44,000, payable £24,000 in cash, and £20,000 in fully-paid Ordinary shares.

**DENAYROUZE LIGHT SYNDICATE (LIMITED).**—This Company was registered on June 17th, with a capital of £25,000, in £1 shares, to enter into and carry into effect an agreement to be made with Albert Vickers and Basil Zaharoff, and to carry on the business of suppliers of light, heat, electricity and other motive power, electricians, electrical and mechanical engineers, chemists, &c., the first Directors being Albert Vickers, Dillwyn Parrish and John Crossley.

**ELECTRICAL MANUFACTURERS (LIMITED).**—This Company was registered on June 19th, with a capital of £5,000, in £1 shares, to acquire and take over as a going concern the business of and dealer in electrical apparatus now carried on by Henry E. Childs, at 223, Upper Thames-street, London, E.C., and to carry on the business of manufacturers of and dealers in electrical apparatus of every description, electricians, electrical and mechanical engineers and suppliers of electricity. The subscribers and shares taken are:—

| | Shares. |
|---|---|
| Oscar T. Dorme, electrician | 25 |
| Edmund J. Coste, broker | 25 |
| Thomas F. Moss, wire manufacturer | 100 |
| Edward G. Richmond, electrical engineer | 50 |
| H. Findlay, journalist | 50 |
| Edward R. Ward, gentleman | 50 |
| E. Mezzadrey, hotel proprieter | 25 |

The first Directors are Henry E. Childs and Thomas F. Moss.

**METALLURGICAL ENGINEERING COMPANY (LIMITED).**—This Company was registered on June 18th, with a capital of £100,000, in £1 shares, to carry on the business of explorers, prospectors, miners, smelters, steel makers and converters, engineers, tin plate makers, chemists, electricians, electrical engineers, suppliers of electricity, electrical apparatus manufacturers, &c.

**TAYLOR, TUNNICLIFF AND CO (LIMITED).**—This Company has been registered with a capital of £60,000, in £5 shares, to acquire the business of potters and manufacturers of earthenware, and manufacturers of apparatus and appliances for electrical work now carried on at Eastwood Vale, Hanley, Staffs., under the style of Taylor, Tunnicliff and Co.

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**BRITISH ELECTRIC LIGHT COMPANY (LIMITED).**—Notice is given that this company no longer carries on any business.

**BRITISH INSULATED WIRE COMPANY (LIMITED).**—The annual return, made up to March 25th, has just been filed. The nominal capital is £110,000, divided into 300 Founders', 3,950 Preference, 9,450 Ordinary "A" and 8,300 Ordinary "B" shares of £5 each. 298 Founders', 3,720 Preference, 7,152 Ordinary "A" and 8,053 Ordinary "B" shares have been taken up, and shares of the nominal value of £49,110 have been issued as fully paid. The full amount has been called on 79 Founders', 2,745 Preference and 6,577 Ordinary "A," and £47,005 has been paid. In addition £265 has been received in connection with the forfeiture of two Founders', 50 Preference and 52 Ordinary "A" shares.

**DIRECT ELECTRIC GENERATOR SYNDICATE (LIMITED).**—The statutory return, made up to April 30th, has been filed. 45,979 shares have been taken up out of a capital of £100,000 in £1 shares, and 41,799 have been issued as fully paid. The full amount has been called on 4,180 and £3,830 has been paid.

**INDIA-RUBBER, GUTTA-PERCHA AND TELEGRAPH WORKS COMPANY (LIMITED).**—The annual return of this Company, made up to May 10th, was filed on June 10th. The capital is £812,000 in £10 shares; 50,000 of these have been taken up, the full amount called and £500,000 received.

**LIVERPOOL GAS AND ELECTRIC FITTINGS COMPANY (LIMITED).**—The annual return of this Company, made up to May 6th, has been filed. The whole nominal capital of £10,000, in £1 shares, has been subscribed for, and the full amount has been called and paid.

**WINDERMERE AND DISTRICT ELECTRICITY SUPPLY COMPANY (LIMITED).**—The annual return of this Company, made up to May 27th, has been filed. The nominal capital is £50,000, in £5 shares, and 307 of these have been taken up. £1 per share has been called on seven shares and nothing on the others, and £7 has been paid.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31d. per oz. (June 25th). Consols (2¾ per cent.) 113—113¼ for money, 113$\frac{1}{16}$—113$\frac{3}{16}$ for account; 2½ per cent. 106¾—107 (June 25th). Stock Exchange Settling Days: Consols, July 1st; Stocks and Shares Continuation Days, July 13th; Ticket Day, July 14th; Pay Day, July 15th; Mining Share Carry-over Days, July 11th.

**ANGLO-PORTUGUESE TELEPHONE COMPANY (LIMITED).**—Coupons No. 17 of the First Mortgage and No. 12 of the Second Mortgage Debentures of this Company will be paid, less income tax, by Parr's Banking Company and the Alliance Bank (Limited) on and after the 1st prox.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).**—The coupons on this Company's Second Issue of Five per Cent. Debentures, payable on the 30th inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, London, E.C. Coupons to be left three days for examination.

**BRIGHTON AND ROTTINGDEAN SEASHORE ELECTRIC TRAMROAD COMPANY (LIMITED).**—The annual meeting of this Company was recently held at Brighton. The Chairman (Mr. E. C. Bleackley), in moving the adoption of the report, gave particulars of the progress that had been made during the year, and stated that the line, with the exception of a small section, had been completed. The passenger car had been delivered, the poles for the overhead wires were being erected, and the machinery was ready for delivery. Power to increase the share capital of the Company by £8,000, and the Debenture loan by £2,000, had been obtained. The application for extension of time to construct the line had also been granted. The Directors anticipate being able to open the line by the end of July.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended June 21st were £836, against £794 in the corresponding week of 1895, an increase of £42. The total receipts for the half-year amount to £23,178, against £23,093 for the corresponding period of 1895, an increase of £85.

**EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).**—The coupon on this Company's Five per Cent. Australian Government Subsidy Debentures, due July 1st, will be paid on and after that date at Messrs. Barclay, Bevan and Co's. Bank, 54, Lombard-street, London, E.C. Coupons must be left three clear days for examination.

**EVERED AND COMPANY (LIMITED).**—During the week this Company invited subscriptions for 3,504 £10 shares at a premium of £5. The authorised capital of the Company is £200,000, in £10 shares. The subscribed capital is £164,960, and the paid-up capital £135,704, made up as follows:—£6,744 fully-paid shares, 9,752 shares, with £7 per share paid. The assets of the Company have been valued at £227,903 by Messrs. Chatteris, Nichols and Co., chartered accountants, of London. The average net profits for the past ten years amounted to £13,762, or more than 10s. on the paid-up capital. The prospectus states that owing to the great increase of business the Directors consider it necessary to make the present issue, which is the balance of the authorised capital of the Company.

**"HINTS TO SMALL INVESTORS."**—Under this heading the *Statist*, a leading financial organ, in its issue of the 20th inst. devotes considerable space to a discussion of the merits of the £1 fully-paid share of the Oriental Telephone and Electric Company and of the Ordinary and Preference stocks of the Anglo-American Telegraph Company as investments for small capitalists. The journal points out that the dividend prospects of both undertakings have an extremely favourable outlook, and especially with regard to Anglo-Americans, calls special attention to the market argument that those stocks have not shared in the general appreciation that has taken place in submarine cable securities.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 21st inst. amounted to £1,221. The amount for the corresponding week last year was £1,245, decrease £24.

**THOMAS PARKER (LIMITED).**—The annual report of the Directors of this Company states that the balance standing to the credit of the profit and loss account amounts to £2,505. 11s. 10d., out of which it is proposed to pay a dividend at the rate of 5 per cent. per annum, amounting to £2,387. 19s., and to carry forward the balance of £417. 12s. 10d. The Directors state that they did not think it necessary to write off anything in regard to the capital assets of the Company, as the buildings, plant, machinery and tools are all new, but one-third of the preliminary expenses and half of the amount at which the patterns' account stood on April 30, 1895, have been written off.

**RAND CENTRAL ELECTRIC WORKS (LIMITED).**—At a Board meeting of this Company on Tuesday last it was decided to make a final call of 5s. per share.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange Committee appointed yesterday (Thursday) a special settling day in £76,770 Four and a-Half per Cent. Second Debenture Stock of the Brush Electrical Engineering Company (Limited), and have ordered the same to be quoted in the Official List.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the week ending June 19th, after deducting 17 per cent of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,900.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half-month ended 15th inst. are £2,448, against £2,121 in the corresponding period of 1895.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, June 17. | | Price Wednesday, June 24. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending June 20. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 47 | 49 | 47 | 49 | 5 2 0 | Jan., Apr., July, Oct. | 48½ | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 92 | 93 | 92 | 93 | 5 1 6 | " " " | 92¾ | 91½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 8¾ | 9¼ | 9 | 9½ | .. | .. .. | 9½ | 8½ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 | 104 | 101 | 105 | 3 17 8 | January and July .. | 101½ | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10 | 11 | 10 | 11 | .. | .. .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15 | 15½ | 15 | 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15½ | 15½ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 113 | 117 | 113 | 117 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | $1½ | Commercial Cable Capital Stock | 160 | 170 | 160 | 170 | 4 3 6 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 | 13 | 12½ | 13½ | 5 18 6 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 19½ | 20½ | 19½ | 20½ | 4 17 7 | .. .. | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 4 | 5 | 3½ | 4½ | 4 8 11 | April and October .. | 4 | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 | 10½ | 10 | 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% | 110% | 108% | 111% | 4 2 9 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ | 10 | 9½ | 10½ | 4 3 0 | Jan., Apr., July, Oct. | 10 | 9½ |
| 400,000 | 10 | 2/6 | Eastern | 17 | 17½ | 17 | 17½ | 3 14 4 | " " | 17⅞ | 17½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ | 18¾ | 18½ | 18¾ | 3 4 0 | " " | 18⅞ | 18⅞ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 | 134 | 131 | 134 | 2 19 11 | May and November | 131½ | 131½ |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 | 109 | 106 | 109 | 4 13 3 | February & August | .. | .. |
| 250,000 | 10 | 6/6 | Eastern Extension | 17½ | 18 | 17½ | 18 | 3 17 9 | Jan., Apr., July, Oct. | 17⅞ | 17⅞ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 132 | 135 | 132 | 135 | 3 0 2 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900 | 101 | 105 | 101 | 105 | 4 17 4 | January and July . | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb., 1900 | 101 | 105 | 101 | 105 | 4 17 4 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 | 108 | 105 | 108 | 3 14 11 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 110% | 113% | 110% | 113% | 3 11 1 | May and November | .. | .. |
| 130,237 | 10 | 2/6 | Globe Telegraph and Trust | 10½ | 11 | 10½ | 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅛ | 10½ |
| 130,042 | 10 | 6% | Do 6 per Cent. Preference | 17 | 17½ | 17 | 17½ | 3 8 7 | " " | 17⅜ | .. |
| 150,000 | 10 | 10/0 | Great Northern | 23½ | 24½ | 23½ | 24½ | 4 1 8 | Jan., April, and July | 24½ | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1933 issue | 104 | 107 | 104 | 107 | 4 14 7 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 52 | 55 | 52 | 55 | 4 10 11 | May and November | 54 | 53½ |
| 37,548 | 10 | .. | London Platino-Brazilian | .. | .. | .. | .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 110 | 1 3 | 110 | 113 | 5 7 7 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 | 111 | 108 | 111 | 3 13 3 | .. .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 6½ | 7½ | 6½ | 7½ | 5 8 1 | April and October .. | 7⅞ | .. |
| 8,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 135 | 140 | 135 | 140 | 4 5 9 | " " | 138 | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 7 | 8 | 7 | 8 | .. | January and July . | .. | .. |
| £233,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 103 | 106 | 103 | 106 | 4 15 8 | March & September | 104 | .. |
| 80,000 | 10 | 2/0 | West Coast of America | 1 | 2 | 1 | 2 | .. | January and July . | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 102 | 107 | 102 | 107 | 7 15 4 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1 | 1½ | 1 | 1½ | .. | .. .. | .. | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11¼ | 11¾ | 11½ | 11¾ | 5 2 2 | May and November | 11⅜ | 11⅜ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ | 10½ | 9½ | 10½ | 5 14 3 | .. .. | .. | .. |
| £30,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 109 | 112 | 109 | 112 | 4 11 1 | June and December | .. | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian | 9½ | 9¾ | 9 | 9½ | 4 12 4 | May and November | 9⅛ | 9⅛ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6½ | 7½ | 6½ | 7½ | 5 3 8 | — | 7 | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ | 3 | 2½ | 3 | .. | — | 2⅛ | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 105 | 109 | 105 | 109 | 5 12 2 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 105 | 109 | 105 | 109 | 5 12 2 | " " | — | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 | 115 | 110 | 115 | 6 2 3 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 | 105 | 102 | 105 | 5 15 11 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3 | 3½ | 3½ | 3¾ | .. | — | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/8 | 1/8 | 1/8 | 1/8 | .. | May and November | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | 1/8 | 1/4 | 1/8 | 1/4 | .. | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7⅞ | 7¾ | 7⅞ | 7¾ | 3 9 10 | June and December | 7¾ | 7½ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 16 | 18 | 17 | 19 | 3 3 2 | " " | 18½ | — |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16½ | 17½ | 16½ | 17½ | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6¾ | 7 | 6¾ | 7 | 3 11 5 | — | 6⅛ | .. |
| 1,100,000 | Stock | 3½% | Do. Debenture Stock, 3½% (red.) | 107 | 110 | 107 | 110 | 3 4 6 | January and July .. | 103½ | 103½ |
| 58,000 | 5 | 3/0 | United River Plate | 3½ | 4 | 3½ | 4 | .. | " " | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 100 | 105 | 100 | 105 | 4 17 1 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ | 15½ | 14½ | 15½ | 3 4 6 | — | 15½ | .. |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ | 17 | 16½ | 17 | 3 10 7 | — | 17 | 13⅜ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 | 138 | 134 | 138 | 3 13 8 | June and December | 137 | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. | .. | .. | .. | .. | — | .. | — |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 8½ | 8¾ | 8½ | 8¾ | .. | — | .. | .. |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. | .. | .. | .. | .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8½ | 9½ | 8½ | 9½ | .. | — | .. | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ | 13½ | 12½ | 13½ | 4 8 11 | — | 13 | 12½ |
| 8,322 | £5 | .. | House-to-House Electric | .. | .. | .. | .. | .. | — | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. | .. | .. | .. | .. | — | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. | .. | .. | .. | .. | January and July .. | .. | .. |
| 45,000 | £5 | 3/0 | Liverpool Electric Supply (fully paid) | 8 | 8½ | 8 | 8½ | 3 12 9 | — | .. | — |
| 111,000 | 5 | .. | London Electric Supply | .. | .. | .. | .. | .. | — | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13½ | 14½ | 12 | 14 | 2 17 2 | — | 13 | 13½ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 | 123 | 120 | 123 | 3 14 5 | June and December | .. | — |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9½ | 9¾ | 9½ | 9¾ | .. | — | 9½ | .. |
| .. | .. | .. | Rand Electric | ⅜ | ½ prem. | ⅜ | ½ prem. | .. | — | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 11 | 11½ | 11½ | 11¾ | .. | — | 10 | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 9½ | 10½ | 9½ | 10½ | 3 3 7 | — | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 9½ | 10½ | 10 | 10½ | 2 19 6 | — | 10½ | 9½ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1½ | 1⅝ | 1½ | 1⅝ | 5 8 8 | — | .. | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1½ | 1⅝ | 1½ | 1⅝ | 6 17 2 | — | 1⅝ | 1⅜ |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 | 114 | 111 | 114 | 4 0 0 | March & September | — | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 | 2½ | 2 | 2½ | .. | January and July | .. | .. |
| 88,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1½ | 1⅝ | 1½ | 2 | 7 10 5 | February & August | .. | .. |
| £1 0,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 105 | 108 | 105 | 108 | 4 5 1 | January and July .. | .. | .. |
| £ 1,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | — | — | .. | .. | .. | — | — | — |
| 110,000 | 2 | .. | Electric Construction | 1½ | 1½ | 1½ | 1⅝ | .. | — | .. | .. |
| 12,845 | 2 | 2 9⅞ | Do. 7 per Cent. Cumulative Pref. | 2½ | 3 | 2½ | 3 | 4 13 4 | September | 2⅛ | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ½ | ¾ | ½ | ¾ | .. | — | .. | .. |
| 22,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. | .. | .. | .. | .. | — | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23 | 24 | 23 | 24 | 4 3 4 | February & August | 23¾ | 23½ |
| £2 0,000 | 100 | .. | * Do. 4 per Cent. Debentures | 105 | 107 | 105 | 108 | 5 14 1 | March & September | 106½ | 105 |
| 15,995 | £10 | .. | International Okonite Ordinary | .. | .. | .. | .. | .. | .. | — | — |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. | .. | .. | .. | .. | December and June | — | — |
| 80,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ½ | ⅝ | ½ | ⅝ | .. | .. | .. | .. |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 | 41 | 38 | 41 | 4 7 10 | March and July | .. | .. |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 104 | 107 | 104 | 107 | 4 5 3 | January and July | — | — |
| 37,514 | £5 | — | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. | .. | .. | .. | .. | — | — | — |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 16½ | 17½ | 17 | 18 | 4 8 11 | March & September | 17½ | 17 |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 17 | 18 | 17 | 18 | 3 17 9 | " " | 17⅞ | 17⅞ |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 | 114 | 109 | 114 | 4 0 0 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | | | |
| £330,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 42 | 44 | 42 | 44 | 2 16 10 | January and July .. | 44 | 43½ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ | 15½ | 14½ | 15½ | 3 6 5 | " " | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 135 | 137 | 135 | 137 | 2 18 5 | May and November | 137 | .. |
| 87,500 | £10 | 3½% | Liverpool Overhead Railway | 14 | 14½ | 13⅛ | 14⅛ | 2 2 8 | — | — | — |
| 10,000 | 10 | 5% | Do. 5% Preference | 17½ | 17⅞ | 17½ | 17⅞ | 2 16 10 | — | — | — |
| 125,000 | Stock | 4% | Do. 4% Debenture | 114½ | 116½ | 114½ | 116½ | 3 10 10 | January and July .. | — | — |

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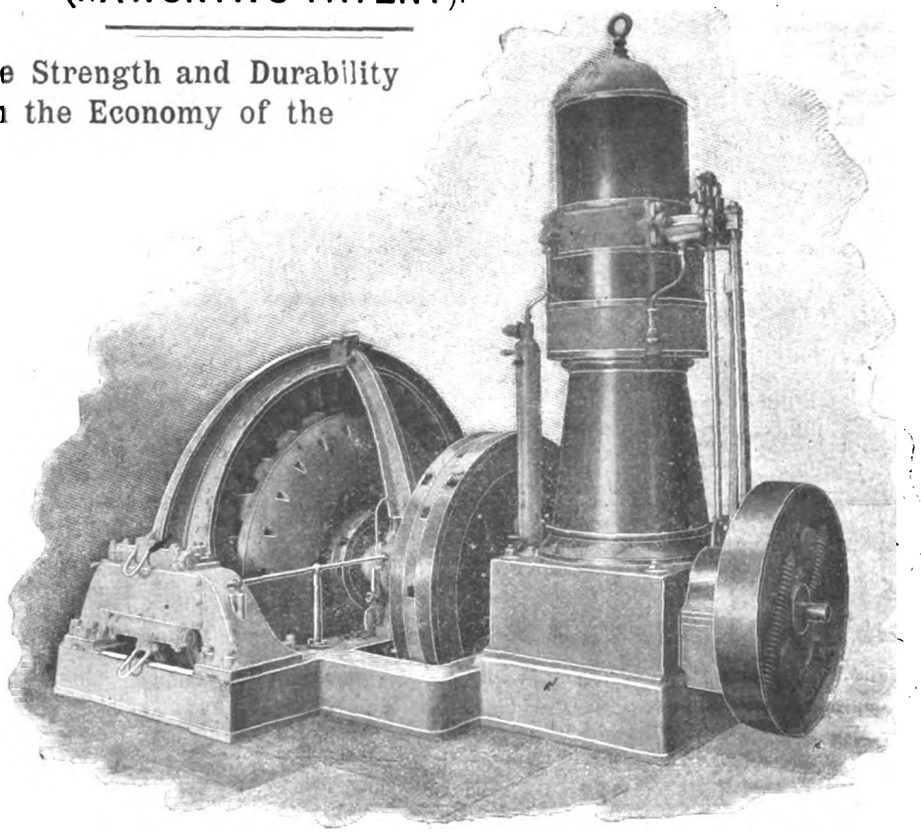

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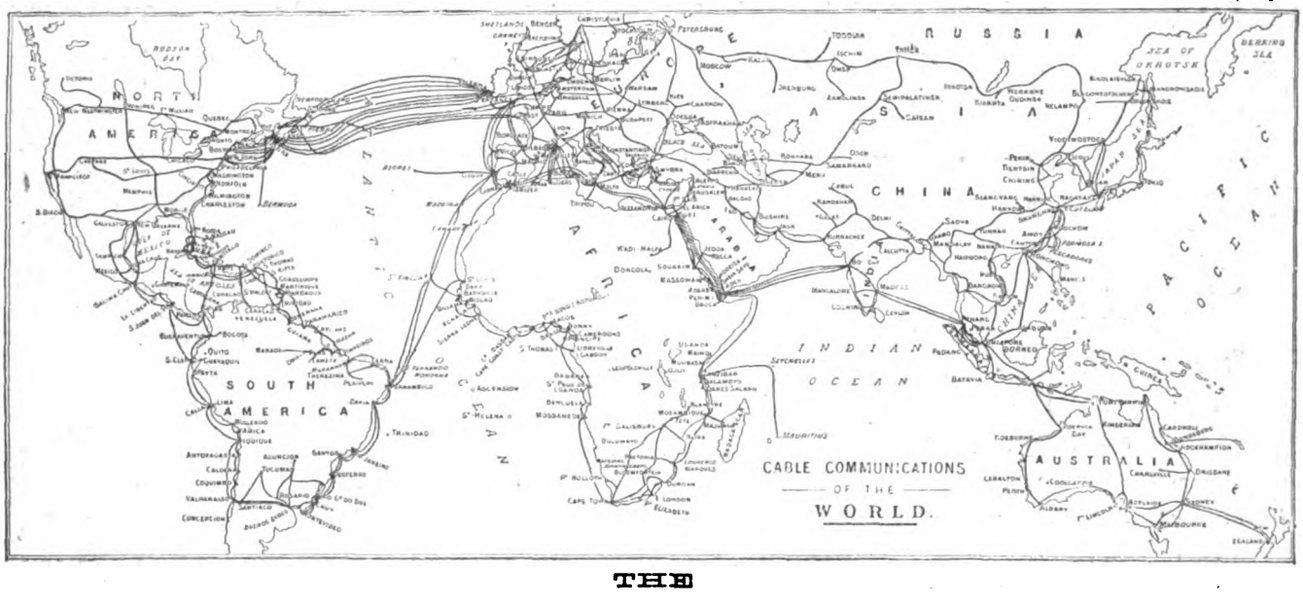


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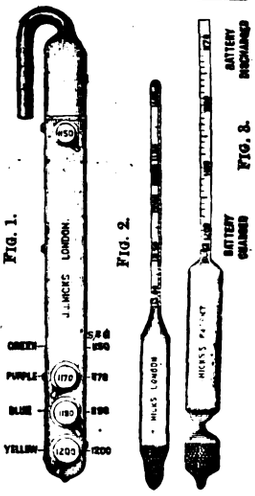


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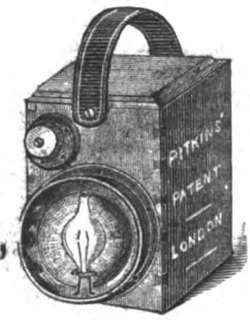

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"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY, LIMITED,
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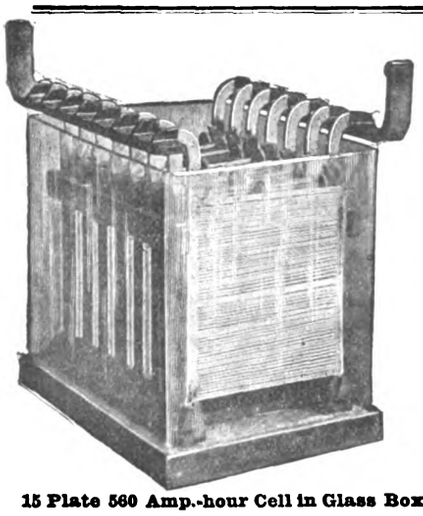

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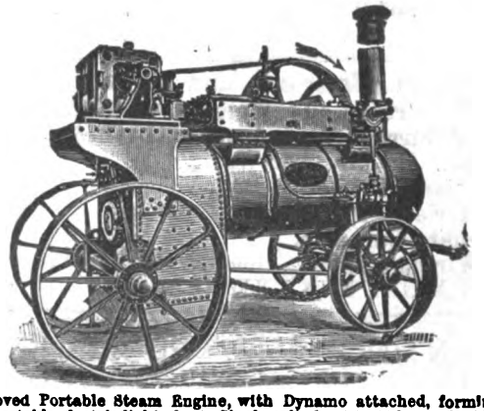

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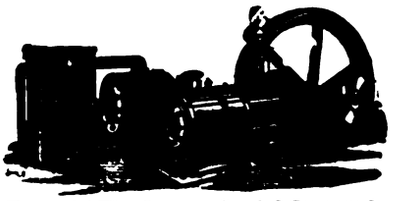

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 946. [Vol. XXXVII. No. 10.] FRIDAY, JULY 3, 1896. PRICE SIXPENCE.

## NOTES.

THE Report of the Electric Lighting Department of the Manchester Corporation for the year ended March 31st last should prove pleasant reading to the ratepayers of Cottonopolis; their commercial investments are large and by no means uniformly profitable. Upon a total capital expenditure of a quarter of a million sterling, a clear profit of £11,138, or 4½ per cent., has been earned, after transferring £3,492 to Renewals Account, paying £5,149 as interest on loans, and allocating £4,262 to the Sinking Fund. The net profits of the past *two* years' working have amounted to £16,638; and out of this total £7,000 has been appropriated for the relief of the rates, and some £8,500 has been placed to the credit of a Contingent Fund.

IT has been contended by certain municipalities that in municipal electric light undertakings there is no need to allow for depreciation, since the Sinking Fund appropriations are a complete equivalent. Of course a municipality which is regularly reducing its capital commitments does not require to set aside as much for depreciation as a company; but, unless the capital is being paid off as fast as the plant, &c., is wearing out, something should most certainly be set aside. Manchester with its plethoric surplus has naturally been able to do this, and, when it is generally done, municipal undertakings will be on a thoroughly sound financial basis. That there is nothing extravagant in our contention can be seen by the fact that, notwithstanding the transference of £3,492 to a Renewals Account, in addition to the £4,262 paid into the Sinking Fund, the two sums together do not amount to more than 3 per cent. on buildings, 7 per cent. on machinery and 3 per cent. on mains.

THE financial results of the Manchester municipal electrical undertaking are all the more creditable to those responsible for its everyday working, seeing that quite an abnormal amount of money (37 per cent. of the total capital expenditure) is locked up in land and buildings. Doubtless this is due in a large measure to a desire to provide betimes for extensions, but it is none the less a heavy burden on a three-year-old concern. Another good feature of the Manchester accounts is the formation of a Contingent Fund. That a municipal business shall genuinely pay its way is all that can be expected of it, that it should provide for extensions out of past earnings is all that could be desired.

IN the opinion of the *Journal of Gas Lighting*, Mr. ARTHUR WRIGHT was quite wrong in supposing that the electric light department of a municipal administration ever suffers to the advantage of the gas department. "It is notoriously otherwise," says our contemporary, "the electric lighting, being youngest born, is always favoured at the expense of the gas undertaking." This is a somewhat sweeping statement. Without invidiously mentioning names, we may say that we have seen such a thing as an important municipality, the owners of a well-to-do gas works, defeating the intention of a company to obtain a Provisional Order by hastily undertaking a little electric lighting themselves, and then starving the new concern in every possible way. The electric light department, for instance, has been made to purchase coke from the Corporation gas works at a ridiculously high price, though the fuel is utterly unsuited to the particular type of boiler adopted; while the consumers have been stemmed back by high prices and by preposterously high rentals for meters, and even for house transformers.

THE temptation to frail human nature, even though enshrined in an alderman or a councillor, is a very obvious one. Naturally a municipality with a thriving gas concern cannot contemplate its possible decay with equanimity. Naturally also they sometimes believe that the rivalry of the electric light can be rendered less formidable if they have control over the "new illuminant." A well-managed gas concern has in reality very little to fear, even from the most enterprising electrical undertaking; in all but the very smallest towns there is plenty of room for both, and a healthy rivalry between the two systems of light and power will conduce to the improvement of each. Progress on these lines, however, is not, it must be admitted, quite so comfortable a process as might be. Hence the danger, no imaginary one, as the facts just recited prove, of a Gas Committee charged with the care of an electrical infant, repressing the exuberant vitality of the unwelcome little stranger as far as they dare. In many instances, as at Manchester, for example, Gas Committees have taken a broad view of their duty, and have consulted the best interests of both undertakings committed to their charge, by developing each to the fullest possible extent. On the whole, there is not much to complain of on either side, but enlightened policies are not usually predominant on this sublunary sphere, and it were a safer plan to place our municipal fathers beyond reach of temptation, and to confide the administration of two such dissimilar undertakings as a gas

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and an electric supply to two totally separate committees; their emulation will tend to maintain both concerns in a state of healthy growth, fear of the ratepayers will tend to prevent the extravagance of a cut-throat competition.

THOSE who had searchings of heart as to the advisability of erecting the Clark or any cell into a legal standard will not have their doubts lessened by Mr. HIBBERT'S announcement that he has succeeded in devising a cell giving exactly 1 volt, and having a temperature coefficient of only 0·0002. Moreover, the HIBBERT standard, while somewhat more difficult to prepare, has proved to be quite as constant as, and to have a more rapid recovery after accidental short circuit than, the legal standard. A cell giving exactly unit pressure, and having a negligible temperature coefficient, has manifest advantages as a standard over one giving 1·434 volt and with a temperature coefficient of about 0·00077 per degree Centigrade.

WHETHER or no the curious behaviour of the electric arc, when the current is suddenly increased, affects the question of its negative resistance, it is impossible not to feel deeply interested in the experiments in which Mrs. AYRTON detected it. These experiments are described by Prof. AYRTON in our correspondence columns this week. It seems that when the current is suddenly increased in an arc, between cored positive and solid negative carbons, there is first produced a sudden rise of potential difference to a higher value than its new steady value. This is followed by a very rapid fall in potential difference to far below its new steady value, which again is followed by a gradual rise to the new steady value. Accompanying these changes, the negative carbon grows suddenly much brighter than usual, and the area of its incandescence increases; after which, the brightness and area of glow diminish to the new normal conditions.

THERE is, we think, an alternative explanation to that advanced by Mrs. AYRTON. The rapid fall in the potential difference between the carbons, which follows the first abnormal rise, may indeed, as she points out, be caused by the large additions to the column of vapour, produced by the vaporisation of the shower of heated carbon particles from the positive carbon. On the other hand, the overheating of the negative carbon tip by this shower would very much diminish the difference of temperature between the two carbons. This would necessarily diminish any back electromotive force arising from thermo-electric causes; and if, as has been suspected and seems reasonable, such thermo-electric effects exist between the carbons and the arc, their sudden momentary decrease would result in a corresponding change in the potential difference. Then, as the temperature of the negative tip regained its normal value, the steady potential difference would be restored. At any rate, from whatever cause arising, this curious thermal "hunting" in the arc, which closely resembles the "hunting" of a badly-governed engine when suddenly varied in load, furnishes an interesting addition to our knowledge of the phenomena of the arc.

IN order to avoid the danger arising from the dangling of live trolley wires when a break occurs in the wire, several inventions have been brought out from time to time in America, the main idea being to cause the hangers to release the broken section of trolley wire and let it drop to the ground. In both the Hutchins and the Fletcher "safety" hangers the trolley wire is cut at the supports, and the ends are provided with claw pieces which, so long as the wire remains unbroken, are locked to the support, but which are released directly the wire is broken. The end sought is undoubtedly commendable, namely, to protect traffic from the menace of live wire ends dangling to the ground; but it is doubtful if the extra safety introduced by these detachable hangers justifies the extra expense and high line-resistance involved in cutting the trolley wire at each support.

**Howard Lectures.**—It has been arranged by the Society of Arts that the next course of Howard lectures shall be delivered by Prof. Ewing.

**Electric Tanning.**—Demonstrations of the Groth system of tanning by electricity have recently been made in Kansas City, U.S.A., which annually despatches 1,200,000 raw hides.

**Municipal Purchase.**—The Liverpool Corporation, on Wednesday, July 1st, took over the business of the Liverpool Electric Supply Company, paying £400,000 for the privilege.

**Obituary.**—We regret having to report the death, on the 23rd ult., of Mr. Chas. H. Phillips, late of the Eastern Telegraph Company and the Lea Telegraph Works, Hackney Wick. Mr. Phillips was well known in cable circles.

**Institution of Civil Engineers.**—Mr. James Forrest has relinquished the secretaryship of the Institution of Civil Engineers, and Dr. J. H. T. Tudsbery, M. Inst. C.E., has been appointed his successor.

**Newport (Mon.).**—The Board of Trade has appointed Mr. Hugh Erat Harrison, Principal of the Electrical Standardising, Testing and Training Institution, electric inspector to the Corporation of Newport (Mon.).

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique | Dec. 19, 1895. |
| Monte Alegre—Santarem | May 5, 1896. |
| Cadiz—Teneriffe | June 6, 1896. |
| Jamaica—Colon | June 10, 1896. |

**Lightning Fatalities.**—During a storm which burst over Charlottenburg and the neighbourhood on Wednesday, three persons were struck by lightning in the cemetery at the west end of the town and killed. Five others were injured, but it is expected that they will recover.

**Electric Traction in Brussels.**—The electric tramways at present in operation in Brussels are all on the overhead-conductor system. The Société des Tramways Bruxellois is, however, about to experiment with a conduit system on its line between Schaerbeek and the Bois de la Cambre.

**South Kensington Museum.**—Among the more important recent acquisitions of the Science Museum are a model Dowson gas plant, a Laval steam turbine, models of several systems of forced draught, Mr. Vernon Boys' radiomicrometer, and a Kelvin apparatus for the harmonic analysis of tidal observations.

**Electric Traction for Glasgow.**—A meeting of the sub-committee on mechanical traction in connection with the Tramways Committee of Glasgow Corporation was held on Tuesday last. The reports by the two deputations which visited Hamburg were fully considered, and it was unanimously agreed to recommend the Tramways Committee to fit up at the earliest possible date the overhead system of electric traction for tramcars along the route from Dennistoun in the extreme east to Kelvinside in the west of the city.

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**Patent Statistics in the United States.**—In the 25 years from 1871 to 1895 inclusive, the total number of United States patents rose from 98,460 to 531,619. Of the latter number electric generation claims 3,117, electric railways 2,019, electric lighting 3,622, electric power 1,183, electric signalling 1,934, telegraphy 3,205, and telephony 2,459. During the last 25 years 25 persons have been granted more than 100 patents each, or an aggregate of 4,894:—Mr. Edison received the highest number, 711; Prof. Elihu Thomson, 394; Mr. Edward Weston, 274; Mr. C. J. Van Depoele, 244; and Mr. George Westinghouse, jun., 217.

**Colardeau X-Ray Tube.**—At a recent meeting of the Société Française de Physique, M. Colardeau described a new form of Crookes' tube devised by him for X-ray work. M. Colardeau uses a cylindrical tube only 6mm. to 7mm. in diameter, containing a concave cathode (4mm. to 7mm. radius of curvature). The anti-cathode is inclined at an angle of 45deg. to the axis of and 7mm. to 8mm. from the cathode. Just opposite the focussing electrode the wall of the tube is expanded into a small hemispherical bulb, the glass being 0·1mm. thick. M. Colardeau usually employs a small induction coil with this tube.

**Utilisation of the Lachine Rapids.**—The extensive fall of water known as Lachine Rapids, on the St. Lawrence River above Montreal, are about to be utilised for driving electrical plant to the extent of some 15,000 H.P. The machinery house is being erected on a strong dam which has been built across the river, and will have a machinery room 1,000 feet in length. Twelve "Victor" turbines are being set, and these will drive twelve polyphase generators, built by the General Electric Company of America. The power is to be transmitted to Montreal, where it will be used for lighting, traction and general purposes.

**Electricity v. Gas at Tunbridge Wells.**—The Engineer of the Tunbridge Wells Electric Lighting Works having sent out a circular to consumers, asking for a return of the number of electric lamps used and gas burners replaced, as well as the comparative gas and electric light bills for the quarter, the Gas Company, says the *Journal of Gas Lighting*, have issued a counter-circular, pointing out that the action of the borough authorities in putting forward such a request is unfair and misleading in the form of return; and consumers are, therefore, requested not to fill in the paper sent to them, but a form enclosed by the Company. This issue of the two circulars has created some amusement in the town.

**Direct-Connected Railway Generators.**—Though in this country only slow progress is made in the employment of direct-driven generators for traction work, on the Continent this form of plant has found great favour for some time past. The latest instance of this practice is afforded by the new power station of the Società Generale Italiana di Elettricita Sistema Edison of Milan, which is to be equipped with three 1,000 H.P. three-phase generators coupled direct to steam engines. The generators will be of the Brown type, and are already in course of construction. Besides working various tramways from this station, some current will be also supplied for lighting purposes.

**Death from Electric Shock.**—While the overhead conductors of an electric supply station at Limburg were hanging close to the ground for repair, two men came in contact with them, and were killed. The usual pressure on the wires is between 700 and 800 volts, and the judge, at the action subsequently brought against the engineer of the Company, remarked that he (the engineer) could not have anticipated fatality at that pressure, and the defendant was, therefore, discharged. The court of appeal to which the action was carried held, however, that though the defendant was not guilty of manslaughter, he was guilty of culpable negligence, and was therefore fined £30, or 40 days' imprisonment.

**Institution of Electrical Engineers.**—We would remind our readers that a Special General Meeting of Members only will be held on Monday next, at 4:15 p.m., at the offices of the Institution, to confirm the resolutions passed at the special general meeting held on the 15th ult. Notice is also given that a Special General Meeting of Members and Associates will be held at 4:30 on the same day for the purpose of receiving the statement of receipts and expenditure and balance sheet for the year ending December 31, 1895, as amended, and for considering the following proposal in reference to the building fund, and for passing such resolutions as may be thought fit in relation thereto, viz.:—That the building fund, which is now but a subdivision of the funds of the Institution, shall be made a permanent "building fund," and that the interest accruing from such fund or the investments thereof be added to the fund from time to time.

**Electric Lighting Provisional Orders.**—In the Report just issued by the Board of Trade respecting the applications for Electric Lighting Provisional Orders made during the past twelve months it is stated that 39 Orders were asked for and 31 granted, 24 to Local Authorities and 7 to Companies. At the present moment there are no less than 240 Orders in force in the United Kingdom; of these 167 belong to Local Authorities and 73 to Companies. The last batch of Orders granted relate to Allerton (C.), Ashton-on-Mersey (C.), Bath (L.A.), Bray (L.A.), Colwyn Bay (L.A.), Cork (L.A.), Cowes (L.A.), Devonport (L.A.), Folkestone (L.A.), Gloucester (L.A.), Godalming (L.A.). Great Berkhamstead (C.), Great Crosby (C.), Huddersfield (L.A.), Keswick (L.A.), Kettering (L.A.), King's Lynn (L.A.), Kingsdown (L.A.), Liverpool (L.A.), Battersea (L.A.), Camberwell (C.), St. Saviour's, Southwark (C.), Manchester (L.A.), Margate (L.A.), Merthyr Tydfil (C.), Middleton (L.A.), Pembroke (L.A.), Queenstown (L.A.), Rathmines (L.A), Sale (L.A.), and Wells (L.A.).

**Board of Trade Regulations.**—Revised regulations for the purposes of Section 4 of the Electric Lighting Act, 1888, are now under consideration by the Board of Trade, and will shortly be issued. Section 4 of the Act of 1888 relates, we may mention, to unauthorised electric light undertakers, *i.e.*, those not working under any Special Act, Provisional Order, or Licence. By this Section the Board of Trade is empowered to serve a notice upon the owners of non-statutory electric supply concerns, requiring them to comply with "such regulations for the protection of the public safety and of the electric lines and works of the Postmaster-General, and of other electric lines and works lawfully placed in any position and used for telegraphic communication," as may be prescribed; and in case of non-compliance with its regulations the Board of Trade may insist on the removal of the offending wire or wires. To be within the ambit of this Section the "electric line" must "have been laid down, or erected in, over, along, across, or under any street, for the purpose of supplying electricity . . . . or in such a manner as not to be entirely enclosed within any building or buildings."

**American View of Electric Underground Railways.**—"Underground rapid transit in New York City," says the *Street Railway Review*, of Chicago, "is at last buried. Its emaciated remains have been dead a long time, and now the appellate division of the supreme court has furnished the shroud in a decision which settles the scheme for one generation at least. We have always maintained the scheme was impractical on account of its enormous expense, which contemplated the outlay of several hundred million dollars, and the greatly superior transportation to be had on the surface or by double decking the present L roads. Its promoters have made a prodigious fight and spent several hundred thousand dollars, but conditions present and prospective were all against it, and now it is no more. It was a wonder that the people ever voted to authorise the 50 millions asked for construction, and that the Legislature and Governor sanctioned the outlay; for the amount named would have to be multiplied several times to bring the work to completion. A comparison of the statements of the City and South London (underground) and the Liverpool Overhead, both electrically operated, ought to convince any sane person that underground transportation, even in densely populated New York, is not a commercially successful venture."

**Northampton Institute, Clerkenwell.**—We are pleased to note that this new addition to the educational and social institutes of the Metropolis was partially opened in quite an informal manner for the use of members on Saturday, the 27th ult., at 3 p.m. Owing to difficulties encountered some

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two or three years since in acquiring the site, on account of leaseholders whose leases had not expired, the educational site of the Institute is not yet ready for occupation, but it is hoped that it will be available at the commencement of the educational year in October. The part opened on Saturday consists of the various social rooms, library and reading room, refreshment room, gymnasium and the large hall, but the latter can only, for the present, be used by members, and will not be available for public meetings until the proper licences can be obtained at the Licensing Sessions in October. We may add that the buildings are situated in St. John-street-road, Clerkenwell, and that they cover 1¼ acres of ground, generously given by the Marquis of Northampton; hence the name of the Institute. The money for erection and equipment has been found by the City Parochial Charities, the Skinners' Company, the Saddlers' Company, and certain grants will be available from the London County Council towards equipment only. The total capital expenditure on buildings and equipment will probably not fall short of £70,000. At Saturday's opening there were present Mr. Chas. Dorman (Chairman of the Governing Body), Lieut.-Gen. Laurie, M.P., Mr. L. B. Sebastian, Mr. Herbert Wix, Rev. J. H. Rose, M.A., Dr. Garnett and Miss Pycroft of the Technical Education Board, Principal Dr. R. Mullineux Walmsley, Mr. Sidney Axford, the Lady Superintendent Miss Wheeler, and others. There was a large attendance of members and visitors, and everything passed off very successfully.

**Verband Deutscher Elektrotechniker.**—The fourth annual meeting of this society of German electrical engineers was held at Berlin last week, and was, according to the *Elektrotechnische Zeitschrift*, a great success. Among the guests at the grand dinner was Li-Hung-Chang, the viceroy of China. The annual report of the Verband shows an increase in the membership of 102, bringing the total up to 1,645. The finances are in a satisfactory condition, and in the technical department several successes have been obtained. The Verband has been consulted by the Imperial Government with regard to the proposed law relating to the standardising of electricity meters. Several municipalities have also consulted the Verband in electrical matters. The committee on low-pressure wiring rules reports the completion of the same, and has now been charged with the drawing up of similar rules relating to high-pressure installations (an abstract of the low-pressure wiring rules was published in *The Electrician* of January 24, 1896, page 408). The £15 prize offered by the Verband for the best design of an uninterchangeable fuse (see *The Electrician* of November 15, 1895, page 71) was won by the motto, "Einfach und Praktisch." On opening the envelope it was found that the inventor was Mr. A. Rittershaussen, of Amsterdam. The glow-lamp question was also under discussion at the Berlin meeting, and a committee consisting of manufacturers, supply station engineers and others, has been appointed to investigate the matter. The election of officers for the ensuing year resulted as follows: President, Herr Stübben of Cologne; Members of Council, Herren Budde, Slaby, Naglo, Jordan of Bremen and Jordan of Berlin. Eisenach has been selected for next year's meeting. Amongst the Papers read was one on the transmission of power-plant at Rheinfelden (Switzerland). This plant is of considerable interest on account of the high pressure used (16,000 volts) and the various devices employed.

**Action of Electric Currents on Mine-Surveying Instruments.** In view of the rapid increase in the number of electric railways in the Westphalian coalfield, and in the use of electric power underground, the question of the action of electric currents on magnetic mine-surveying instruments is of great interest, and Herr W. Lenz has conducted a series of experiments, which were described in a recent issue of *Glückauf*. A point, underground, was selected at a horizontal distance of some 100 yards from the rails of the Bochum-Herne electric railway, and 434 metres below it. There, by means of a Fennel magnetometer with quartz fibre suspension, a series of observations of variation were made based on a fixed line. The magnetometer was previously compared for a long period with the apparatus in the Bochum Town Park, and the two instruments were found to coincide almost exactly. The first observation, in September, 1895, was made by day, the second by night, when the line was free from current, and the last again by day. While the curve of the day results exhibited great irregularities, that of the night results was perfectly regular and in accord with the magnetic records. The irregularities in quite small intervals of time amounted from 2·7 minutes to 5·4 minutes. As at first it was thought that the deviation might be ascribed to the safety lamps employed, a third observation was made in the morning, the lighting being effected by a stearine candle. The results were exactly the same as on the first day. As the observations were made at a comparatively large distance from other workings, and as the shaft was 200 yards away, it is evident that magnetic observations can, under such conditions, be only satisfactorily conducted during the night in the absence of the magnetic current. Another source of error is the safety lamp. Composed of various metals, the lamp in a hot condition sets up thermo-electric currents which act on the magnetic needle. In order to obtain information on this point, the author placed six mine surveyors' safety lamps free from iron, one at a time, first in a cold condition then heated, at a pole of a sensitive magnetometer. Of the six lamps examined, two, when cold, had no action on the needle, whilst all acted on it when hot. The deviations observed amounted to from 30 seconds to 160 seconds. A new benzine lamp that had not been previously used, caused a deviation of as much as five minutes of arc. The deviation increased with the temperature of the lamp. A quite new aluminium safety lamp caused the same deviation when cold as when hot.

**Electric Traction for Birmingham.**—The Public Works Committee of the Birmingham Corporation have just issued a lengthy report with regard to an application made on behalf of Mr. William McKenzie, of Toronto, and Mr. James Ross, of Montreal, asking for the consent of the Corporation to an assignment to them and to a company being formed, of the lease now held by the Birmingham Central Tramways, the lease to be subsequently surrendered and a further lease for a term of 21 years to be granted to the new company. After prolonged negotiations the basis of an agreement has been arrived at, and the Public Works Committee have warmly recommended the acceptance of the scheme, pointing out that it will result in an increase of the revenue, received by the Corporation from the tramways, from about £700 per annum to about £5,000 per annum. Furthermore, steam traction will be immediately abolished, and some approved method of electric traction adopted. Halfpenny fares will be introduced and long distance fares will be reduced, and there will also be a reduction in the working hours of the men, and the complete municipalisation of the tramways will only be postponed by about 10 years. The main point of difference between the representatives of Messrs. McKenzie and Ross and the Public Works Committee was with regard to the sixth head of agreement, which originally ran as follows:—"On termination of the lease the whole of the lines in the city, whether constructed by Corporation or constructed or purchased by Syndicate, to become the absolute property of the Corporation, together with all posts, wires, cables and all other appliances used in connection with the tramways, except rolling stock. The Syndicate also to transfer all licences, and to allow the Corporation the use of all patents granted to or belonging to Syndicate." The representatives of the applicants stated that their clients were perfectly ready to yield up the permanent way at the expiry of the lease, but they did not consider they should be asked to forfeit *all* the assets acquired by the expenditure of their own capital in return for a further lease of 10 years only. After considerable discussion, the Public Works Committee added the following proviso to the sixth head of agreement:—"Provided that if the Corporation require the Syndicate to lay more than 8 miles of single line of underground electric conduit out of the existing 24 or 25 miles of tramways leased to the Central Company, the Corporation will, at the expiration of the lease, pay the then value of so much of such underground conduit as shall be in excess of such 8 miles, less the estimated value at that time of the corresponding length of tramway, if constructed on the overhead trolley system." With this concession the applicants had to be content, and the proposal now awaits confirmation by the Corporation of Birmingham.

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## ELECTRIC AND MAGNETIC RESEARCH AT LOW TEMPERATURES.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S., M.R.I.

During the last four years much time has been spent by Prof. Dewar and by me in the prosecution of a joint research on the principal electric and magnetic properties of metals at very low temperatures. Some reference has already been made in previous discourses by Prof. Dewar to portions of this work,† but the special object of the present lecture is to extend these descriptions and put you in possession of the latest results in this department of the low temperature investigations. It will be convenient to discuss the several divisions of it in the order in which they have engaged our attention.

One hundred and sixty-seven years ago, Stephen Gray, pensioner of the Charterhouse, in conjunction with his friend, Granvile Wheler, stretched a pack-thread 300ft. long over silk supports, and demonstrated that an electrification of the thread at one end spread instantly over the whole mass; but that if metal wires replaced the silk no electrification of the thread was possible. This experiment undoubtedly formed the starting point for the first definite recognition of the necessity for a classification of bodies into insulators and conductors, a distinction which Gray's brilliant contemporary, Dufay, extended and confirmed, and for which he and Desaguiliers coined these familiar terms.‡ Gray's contributions to knowledge as an epoch-making discoverer have received less notice from scientific historians than their real value deserves. It is less easy to state who first noticed that the powers of conduction and insulation were greatly affected by temperature. Cavendish, in 1776, however, was perfectly familiar with the fact that warm solutions of salt conduct electricity better than cold,‖ and made measurements of the relative resistances of an iron wire and a salt solution, marvellously accurate when we consider that his means of measurement was the comparison of electric shocks taken through the bodies to be examined.

Not until after the invention of the battery and galvanometer was it clearly proved that differences exist between the conducting powers of metals; but by Davy, Becquerel, Ohm, Pouillet, Fechner and others all the fundamental facts were ascertained, and the classical researches of Wheatstone, and later of Matthiessen, gave us the accurate laws and constants of electrical conduction. By these investigators it was shown that in the case of electric conduction through metallic wires of uniform sectional area their total resistance was proportional to the length, inversely as the cross-section, and also proportional to a specific constant for each material, called its *resistivity*. Moreover, it was found that this resistivity was considerably affected by temperature, generally being increased in metals by rise of temperature and decreased for carbon, electrolytic liquids and many badly conducting bodies.

Although much knowledge of the behaviour of pure metals and alloys in regard to electric conduction has thus been accumulated, we considered that it would be of great scientific interest to examine with care the changes occurring in the conductivity of these bodies or reciprocally in their resistivity when cooled to temperatures of 200deg. or more below the centigrade zero by the aid of liquid oxygen and liquid air.¶ Knowing the great influence of very small quantities of impurity on this quality, our first attention was directed to obtaining samples of alloys and metals in a state of great chemical purity, in giving to wires drawn from them a suitable form, and in devising a convenient support or holder by which the electrical resistance of the wire might be measured when immersed in liquid oxygen or liquid air either in quiet ebullition in an open vessel or under reduced pressure in a closed one. It will be unnecessary to dwell on the difficulties surrounding the preparation of these accurately-drawn metallic wires of pure metals. Suffice it to say that our obligations to Mr. George Matthey, Mr. Edward Matthey, Mr. J. W. Swan and other friends, were very great with respect to this portion of the work. The final outcome of all failures was the production of a resistance coil of the following form:—Two thick wires of high conductivity copper about 3mm. or 4mm. thick were bent as shown in Fig. 1, and wrapped round the lower part with a cylindrical sheath of thin vulcanised fibre laced to them by a silk thread. On this sheath, which generally had the form of an oval cylinder, a paraffined silk cord was spirally wound so as to leave a helical groove. In this groove was coiled the resistance wire, of known length and section, and its ends were attached by solder to the ends of the thick copper leads. The wire was wound a little loosely in the groove so as to allow for the great contraction

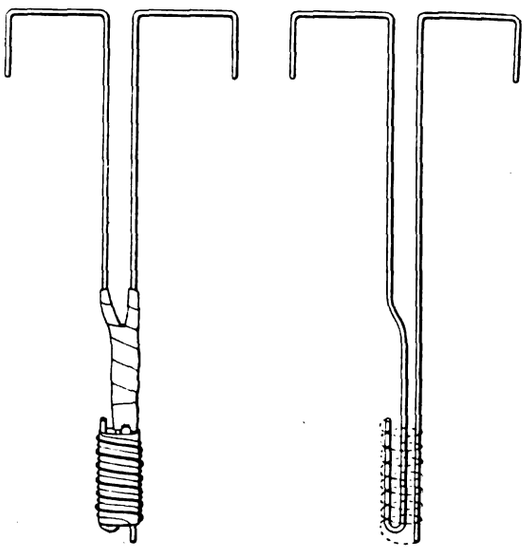

FIG. 1.—Resistance Coil for Low Temperature Research.

which takes place in cooling, and yet the wire was exposed so as to take up instantly the temperature of the bath, whilst at the same time the mass of material to be cooled down was rendered as small as possible. The length of wire employed was generally about 1 or 2 metres, and the diameter from about one-twelfth to half a millimetre (0·003in. to 0·02in.). These mean diameters were measured by the microscope micrometer at about 50 to 100 places for each metre length of the wire. Having thus prepared a great collection of resistance coils of pure metals and alloys, each in the form of a wire of known length and mean diameter, the next operation was the measurement of their resistance at definite temperatures.

All our resistance measurements have been reduced to express them in terms of the International ohm as defined by the Board of Trade Committee and obtained by reference to standard coils carefully standardised for us at Cambridge. By this means the whole of our wires were measured at five definite temperatures, viz., at about 200°C., at the temperature of boiling water 100°C., at the temperature of melting ice 0°C., at the temperature of solid carbonic acid melting in ether, which gives a temperature of about −78°C., and at the temperature of liquid oxygen boiling under a pressure of 760mm., which gives a temperature of about −182°C.

In this last case the coils were immersed in liquid oxygen contained in suitable vacuum jacketed vessels. In this con-

* A Friday evening discourse delivered at the Royal Institution, June 5, 1896, Lord Kelvin in the Chair.

† "Scientific Uses of Liquid Air," a Friday evening discourse by Prof. J. Dewar, LL.D., F.R.S., delivered at the Royal Institution January 19, 1894. See *The Electrician*, Vol. XXXV., p. 361.

‡ *See* "The Intellectual Rise in Electricity." By Park Benjamin. Stephen Gray's Papers on this subject communicated to the Royal Society are as follows: — *Phil. Transactions*, 1720, Vol. XXXI., p. 104; 1731, Vol. XXXVII., p. 18; 1732, Vol. XXXVII., p. 285; 1735, Vol. XXXIX., p. 16; 1736, Vol. XXXIX., p. 400. *See* also Dufay, *Phil. Trans.*, 1733, No. 431, p. 258.

‖ *See* the "Electrical Researches of Cavendish," edited by Clerk Maxwell, p. 324.

¶ Almost the only experimental work previously done in this subject seems to have been that of Cailletet and Bouty (*Journal de Physique*, July, 1885) on the resistance of metals at −100°C., using ethylene as a refrigerating agent, and a research by Wroblewski on the resistance of copper at very low temperatures (*Comptes Rendus*, 1885., Vol. CI., p. 161).

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nection I should like to express with due emphasis the opinion that none of this low temperature research would have been possible at all without the assistance of Prof. Dewar's most valuable invention, the glass vacuum jacketed silvered vessel. For much of this work it has been necessary to employ many litres of liquid oxygen and air at a time, and to be able to keep it for hours in a state of perfect quiescence and absolutely constant temperature, and in no way could this have been done without this beautiful and scientific device.

Before describing the results of these experiments it may be interesting to exhibit a few of the principal facts. The most striking of them is the very great reduction in electrical resistance or increase in conductivity experienced by all the pure

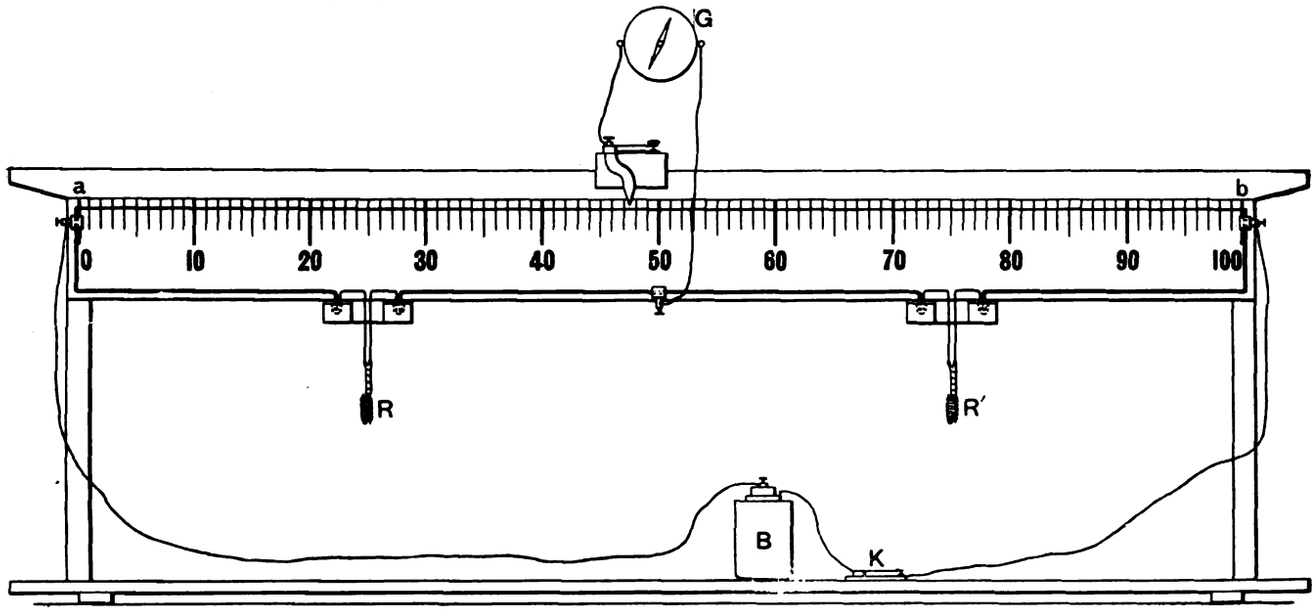


Fig. 2.– Slide-Wire Bridge.

metals when cooled in liquid air. We may, for instance, compare on this large slide-wire bridge (*see* Fig. 2) the resistances of two similar iron coils, when one is placed in boiling liquid air and the other in boiling water. The resistances, instead of being in the ratio of 1 to 1, are now found to be in the ratio of 1 to 12. Again, if we take two wires, one of pure iron and one of pure copper of exactly equal length and equal section, we find that at ordinary temperatures (15°C.) the iron wire has about six times the resistance of the copper; but if we cool down the iron wire in liquid air to – 186°C., still keeping the copper coil at the ordinary temperatures (15°C.), we now find that the iron coil has actually become a much better conductor (about 30 per cent. better) than the copper.* On the other hand, if we examine the behaviour of a coil of German silver, which is a copper-zinc-nickel alloy, or of a platinum-silver coil, we find that the cooling through 200deg. has but a small effect upon its electrical resistance. We thus see that whilst pure metals have their electrical resistance immensely decreased by cooling to the temperature of liquid air, alloys generally do not experience anything like so great a change. A word or two must next be said on the manner in which we have represented graphically all the results of our experiments. We desired to delineate lines on a chart so as to express the change in specific resistance of all our metals and alloys in terms of temperature; and the question then arises, How was this temperature measured? You already know that an ordinary thermometer, whether mercury, alcohol or air, would be useless to measure temperature at temperature which even air liquifies under ordinary pressure.

The employment of the constant-pressure hydrogen thermometer with reduced pressure would have given us temperature readings very approximately those of the absolute thermodynamic scale, but the experimental difficulties of its use would have been enormous. We preferred to use the platinum resistance thermometer, and to express our temperatures in platinum degrees as follows:—Our experience has shown us that a pure soft annealed platinum wire may be cooled as often as necessary to the lowest attainable temperatures and yet will always have the same resistance when measured again at other constant temperatures. Availing ourselves of this fact we have used in all this work a low temperature platinum thermometer made in the following way:—A well-annealed platinum wire is made into a resistance coil, as already described. Its resistance is carefully measured at the temperature of boiling water, 100°C., and melting ice, 0°C. From these measurements we construct a scale of temperature as follows: A horizontal line (*see* Fig. 3) is taken, on which to mark off temperature, and any two points are taken on this line, and divided into one hundred equal parts. At these extreme points perpendiculars are set up proportional to the resistance of the platinum wire at 0°C. and at 100deg. respectively, and through the tops of these perpendiculars a sloping straight line is drawn until it cuts the axis of temperature. The graduation of the horizontal line is continued in both directions on the same scale as the sub-division of the line between the points marked 0 and 100. To measure

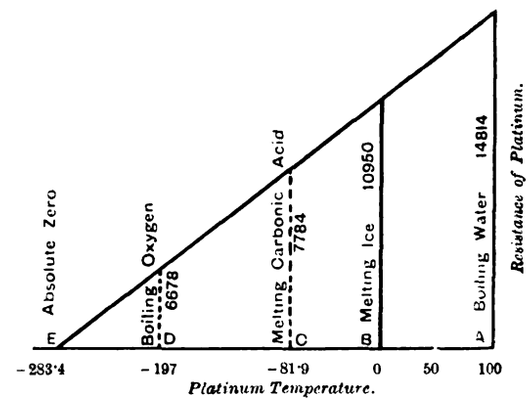


Fig. 3.—Method of erecting a Scale of Temperature.

and define any other temperature—say, for instance, the boiling point of liquid oxygen under a pressure of 760mm.—we have simply to measure the resistance of the platinum wire in the oxygen. We then look out on the chart the ordinate which has the same numerical value as the resistance of the wire in the oxygen, and at the foot of that ordinate we find a number—(viz. – 197), which is the temperature of the liquid oxygen on this platinum scale.

Two questions then arise: First, Do all annealed platinum wires give, when used in this way, the same numerical values

* The exact resistances of the coils used for the experiment were as follows:—Iron at 16°C. = 7·003 ohms and reduces to 0·711 ohms at – 186°C. Copper at 16deg. = 1·169 ohms, reduces to 0·2033 at – 186°C.

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for definite and identical temperatures? The answer to this is, Nearly, but not quite. In the case of two thermometers much used by us the difference was about half a degree at −100°C., the boiling point of liquid ethylene. Into this matter it is not possible here to enter more fully; suffice it to say that we have invariably referred our temperature measurements to one standard thermometer. The second question is equally important. It is, What is the relation of the scale of temperature so defined to the absolute thermodynamic scale, or, what is very nearly the same thing, to the scale of temperature defined by a constant-pressure hydrogen thermometer? If the air thermometer and platinum thermometer readings are made to agree at 0°C. and 100°C., then a temperature which would be called 50deg. on the centigrade scale would be denoted by 50·4 nearly on the platinum thermometer scale, and corresponding to −78deg. on the centigrade scale, which is the temperature of carbonic acid melting in ether, the platinum temperature by our standard is −8·19deg.; and corresponding to −182°C., which is very nearly the centigrade temperature of liquid oxygen boiling at the normal pressure of 760mm., the platinum temperature by the same standard is −197deg. The conversion of these numbers representing low temperatures in platinum degrees into the numbers representing the corresponding absolute thermodynamic temperatures is a work we have reserved for a future research,* but meanwhile it may be said that there is no method of measuring low temperatures which is so easy of application and so accurate as that depending on the use of a platinum thermometer. All our work has been ultimately referred to one standard platinum thermometer which we call $P_1$. A suggestion may here be made. There is no reason why the Board of Trade electrical laboratory should not possess a standard platinum thermometer defining officially platinum temperatures or absolute temperatures for all time, and with which other platinum thermometers could be easily and very accurately compared.

Having thus defined our scale of temperature we proceeded to embody the whole of our results in a chart (*see* Fig. 4) in which vertical distances represent resistivity, or specific resistance, or the resistance in absolute measure per cubic centimetre of the various metals, and horizontal distances represent platinum temperatures. The curves indicate the manner in which the specific resistance varies with temperature for each substance. The first thing which strikes one on looking at such a chart is that the lines for the pure metals all converge downwards in such a manner as to indicate that their electrical resistance would vanish at the absolute zero of temperature, but that no such convergence is indicated in the case of alloys. We have found that the slightest impurity in a metal changes the position of this resistance line. In the next place the order of conductivity is different at low temperatures to that at ordinary temperatures. At 15°C. pure silver is the best conductor, but at −200deg. pure copper is better than silver, and the position of mercury is, of course, very different. Again, the lines of some metals are very much curved. The principal magnetic metals, iron and nickel, have lines which are very concave upwards, and this is a characteristic apparently of many magnetic alloys. The mean temperature coefficient of these magnetic metals between 0°C. and 100°C. is much larger than that of other metals, and the percentage decrease in resistance in cooling them from +200°C. to −200°C. is greater than is the case of any other metal. It is worth noting in passing that these magnetic metals, iron and nickel, have smaller atomic volumes than any other metal, and that generally speaking the worst conductors amongst the metals are those that have the large atomic volumes and large valency.

Next turning to alloys, we may make mention of a few general facts with regard to their resistance. If to one pure metal we add a small quantity of any other metal the result is always to raise the resistance line almost parallel to that of the predominant constituent. Thus the line of the alloy consisting of 6 per cent. of copper with 94 per cent. of aluminium is parallel to the aluminium line, but higher up. Three per cent. of aluminium added to 97 per cent. of copper yields an alloy with a resistance line parallel to that of copper, also higher up. When two pure metals are alloyed together in various proportions there is generally some proportion in which the resultant alloy has a maximum resistivity, and, except in the case of alloys of zinc, tin, lead and cadmium with each other, the resistivity of the alloy is greater than that of either of its constituent metals. In the case of many well-known alloys the proportions which give high, if not the highest, resistivity are those which correspond to definite and possible chemical combinations of the metals with each other, as, for instance, in the well-known platinum-

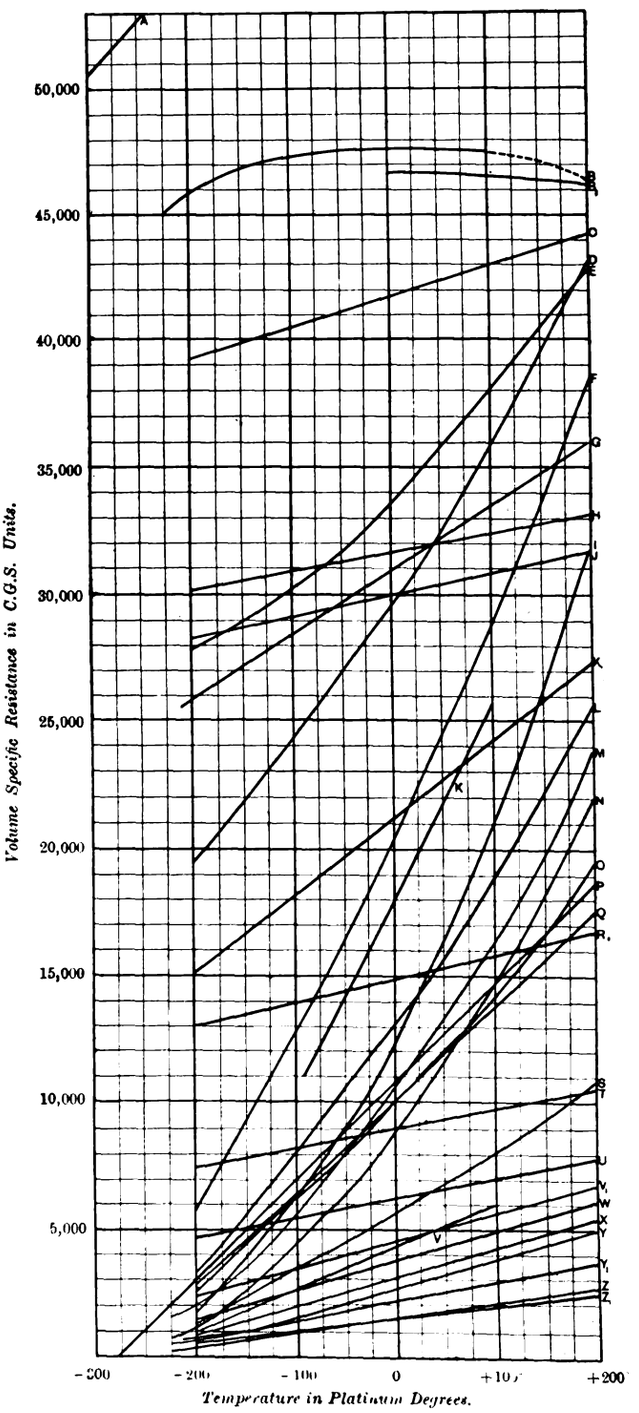


FIG. 4.—Resistance-Temperature Chart.

A, Manganese Steel, Full Scale. B, Manganin. $B_1$, Manganin after annealing at 200°C. C, Platinoid. D, Nickel Steel. E, Manganese Steel, Half Scale. F, Lead. G, Platinum Iridium. H, Platinum Silver. I, German Silver. J, Nickel. K, Thallium. $K_1$, Platinum Rhodium. L, Tin. M, Iron. N, Iron. O, Cadmium. P, Platinum. Q, Palladium. R, Cu 87·0 per cent., Ni 6·5 per cent, Al 6·5 per cent. S, Zinc. T, Cu 97 per cent., Al 3 per cent. U, Au 90 per cent., Ag 10 per cent. V, Magnesium. $V_1$, Ag 6 per cent. W, Al per cent., Ti per cent., X, Al 94 per cent., Cu 6 per cent. Y, Aluminium. $Y_1$, Gold. Z, Copper. $Z_1$, Silver.

* Callendar has shown that over a wide range of temperature from 0°C. to 700°C. the difference between the platinum temperature and the air thermometer temperature is a parabolic function of the absolute temperature.

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silver alloy in proportion 33 to 66, which corresponds in proportion with the combination $PtAg_4$; the iron-nickel alloy in proportion of 80 to 20, which corresponds with the combination $NiFe_4$; the platinum-iridium alloy 80 to 20, which corresponds with the combination $IrPt_4$; and the copper-manganese alloy 70 to 30, which corresponds with the compound $Cu_2Mn$. All of which are, as far as valency is concerned, possible compounds. It is, however, found that very high resistivity generally involves in alloys a want of tenacity and ductility, and when we reach such limits as 100 microhms per cubic centimetre we begin to find the solid alloys becoming less useful on account of this deterioration of their useful mechanical quality.

We have especially studied the electrical resistance at low temperatures of a large series of steel alloys containing varying proportions of nickel, aluminium, chromium, tungsten and manganese in them. The diagram (*see* Fig. 5) shows

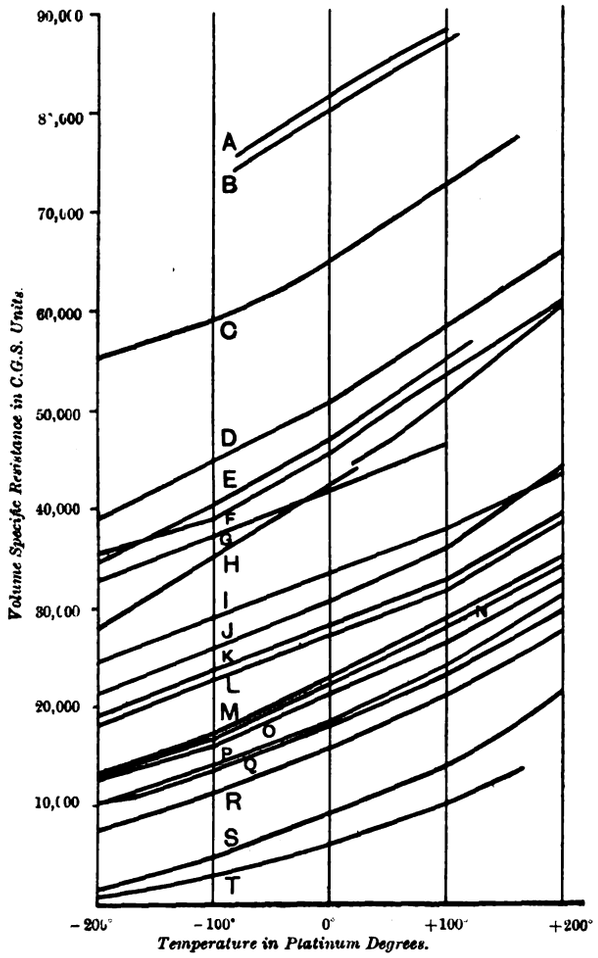


FIG. 5.—Diagram Showing Resistance of Steel Alloys between +200° C. and −200° C.

A, Nickel-Steel, 19·64 per cent., non-magnetic. B, Nickel-Steel, 29·0 per cent., non-magnetic. C, Manganese-Steel, 12 per cent., non-magnetic. D, Manganese Steel, 12·0 per cent. (thin), magnetic. E, Nickel-Steel, 19·64 per cent., magnetic. F, Nickel Steel, 29 per cent., magnetic. G, Silicon-Steel, 2·67 per cent. H, Manganese Steel, 12·0 per cent. (thick), magnetic. I, Aluminium-Steel, 0·72 per cent. J, Chromium-Steel, 1·18 per cent. K Aluminium-Steel, 1·60 per cent. L, Aluminium-Steel, 1·16 per cent. M, Nickel-Steel, 3·82 per cent. N, Nickel-Steel, 7·65 per cent. O, Chromium Steel, 9·18 per cent. P, Chromium-Steel, 5·44 per cent. Q, Chromium-Steel, 0·29 per cent. R, Nickel-Steel, 0·94 per cent. S, Iron. T, Electrolytic Nickel.

the results of these resistance measurements over a range of temperature from −200deg. to +200deg. In this diagram the resistance line of pure iron is also drawn, and we see that the effect of adding the other elements of the alloy is always to shift up the resistance line nearly parallel to itself, so that the resistance lines of all the iron alloys are nearly parallel to that of the iron line, only the absolute value of all the ordinates is increased. This is equivalent to saying that the effect of the added material is to increase the specific resistance, but not to alter the slope or form of the resistance curve. Amongst these steel alloys there are two or three that are very interesting. A nickel steel alloy containing 19 per cent. of nickel, sent to us by Mr. R. A. Hadfield, exhibits some very extraordinary properties. Nickel steel alloys with large percentages of nickel can, as Dr. Hopkinson has shown,* exist over wide limits of temperature in two different physical states, in one of which they are strongly magnetic and in the other of which they are feebly magnetic, and they pass from the non-magnetic to the feebly magnetic on cooling to low temperatures. Take, for instance, a sample of the 19 per cent. nickel steel in the non-magnetic condition. If it is cooled in liquid air we can make it pass instantly into a magnetic condition. In the first state it is fairly ductile and plastic, but in the second state it is very hard and brittle. Moreover, its electrical resistance is permanently altered on undergoing this change. In the non-magnetic state it has a high resistivity of about 81,500 C.G.S. units per cubic centimetre at 0°C., but on cooling in liquid air and becoming magnetic it is found to have decreased to about 47,200 C.G.S. units when taken at 0°C. It is perhaps more correct to say that this alloy can exist in an infinity of different physical states, because we have found that the lower it is cooled in temperature the lower its resistivity can be made to be when measured again at ordinary temperatures. On heating up the alloy again to a bright red heat it goes back into the non-magnetic ductile state. The chart (Fig. 6) shows how the electrical resistance varies between the limits of −200°C. and 100°C. when the alloy is taken through a cycle of temperature, beginning at 100°C. in its non-magnetic state.

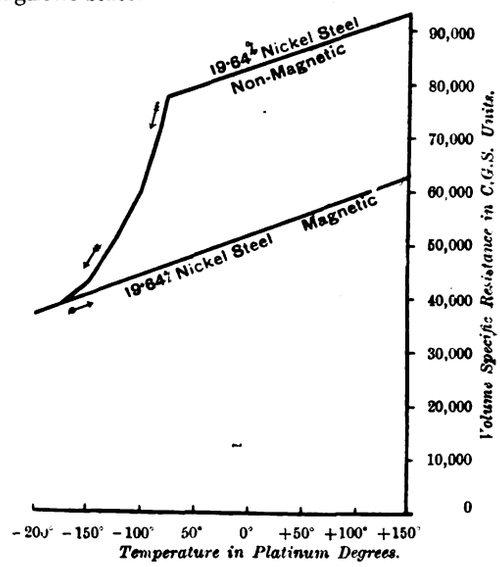


FIG. 6.—Magnetic Condition and Electrical Resistance of a Nickel-Steel Alloy at different temperatures.

The 29 per cent. nickel steel exhibits the same characteristics in a less marked degree. A close study of this interesting material shows that there is room for much valuable work upon it yet.

A manganese steel brought to notice by Mr. R. A. Hadfield, having about 12 per cent. of manganese in it, is also capable of existing in two states, a magnetic and a practically non-magnetic variety. The magnetic variety, which is much more brittle, is, however, in this case formed by the prolonged slow heating of the non-magnetic variety out of contact with air. In the non-magnetic condition the material has a very high specific resistance at 0°C., about 65,700 C.G.S. units per cubic centimetre, but the magnetic variety has a much lower specific resistance, viz., about 51,400 C.G.S. units at 0°C. In all these cases it is interesting to note that the change of the alloy into the magnetic variety is accompanied by a decrease in resistivity or increase in conductivity, and in an increase in brittleness. We have tried cooling this non-magnetic variety of manganese steel in liquid air, but have not been able in that way to make any change in its condition as regards magnetic susceptibility.

There is a particular alloy of copper 84 per cent., manganese 12 per cent. and nickel 4 per cent., called manganin, which at

* See *Proceedings* Royal Society, 1890, Vol. XLVII., p. 138.

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ordinary temperature exhibits but little change of resistance with change of temperature. On taking the curve of its resistance over wide ranges of temperature we find that its curve is very concave downwards, and the vertex of the curve lies at about 16°C. Hence at ordinary temperatures small changes of temperature make no change in its resistance, but above this point its temperature coefficient is negative and below it it is positive. All alloys in which a negative temperature coefficient has been observed are probably instances of the same mode of variation of resistance. It may be noted in passing that the element manganese when present in an alloy seems to have a great tendency to produce high resistivity and small temperature coefficient.

Returning then to the pure metals we may ask what is the meaning of the fact that in their case the resistance lines all converge so as to indicate that the electrical resistance would vanish at the absolute zero of temperature. We know that the passage, as we call it, of an electric current through a conductor heats it, and that by Joule's law the rate of production of heat in the conductor is proportional to the square of the current strength and to the total resistance of the conductor. Suppose we take two wires, say, of iron and an aluminium-copper-nickel alloy of the same size and length. These wires at 100°C. have the same resistance. A unit current flowing through them will therefore generate heat in them both at the same rate. Cool them both down, however, to the temperature of liquid air. In the case of iron the

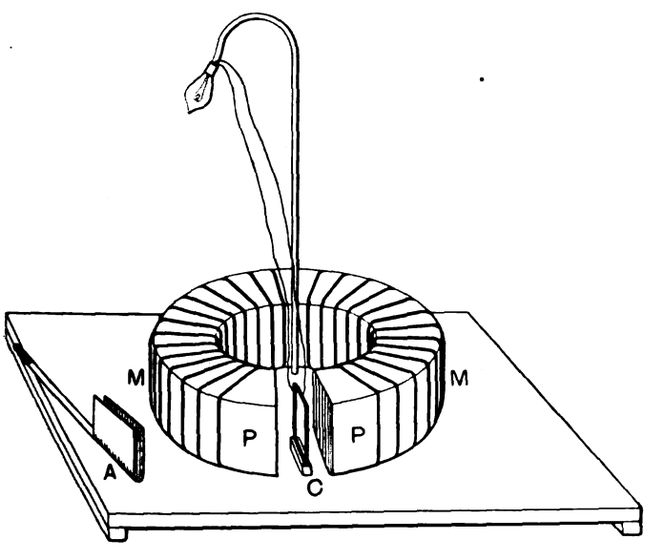


FIG. 7.—Experiment showing Increased Electromagnetic Screening Effect of Metals at Low-Temperature.

resistance is reduced to one-fifteenth of its value at 100°C., in the other case it is only reduced by about 12 per cent. Hence at the low temperature the alloy dissipates energy when traversed by the same current nearly 13 times as rapidly as the iron. It is a logical deduction from all we know to conclude that if we could reach the absolute zero of temperature the pure metal would not dissipate the energy of the current at all. Imagine two iron wires then stretched through space from the earth to the moon, and kept everywhere at the absolute zero of temperature. We could transmit any amount of electrical energy along them without dissipating any of it as heat in the wires.

As another consequence of this fact any pure metal cooled to the absolute zero of temperature would become a perfect screen for electromagnetic radiation, and would be perfectly impenetrable to electro-magnetic induction. We can show this increase in the power of electromagnetic screening by metals when cooled in the following way. A suitable coil of wire is placed between the poles of an alternating current magnet and a small incandescent lamp connected with the coil (*see* Fig. 7). When the magnet is excited it induces currents in the coil and the lamp glows up. A cap of aluminium is made of such a size as to drop easily over the coil. This aluminium is not of sufficient thickness or conductivity to screen off the induction when it is warm. If, however, we cool the aluminium cap in liquid air and then drop it over the coil the lamp for one instant goes out, but it brightens up again as the metal cap instantly warms up. This shows us, however, that if the cap were at the absolute zero of temperature it would, however thin, be a complete screen for the induction. In fact, these experiments furnish us with a new definition of what we mean by the absolute zero of temperature. It is the temperature at which perfectly pure metals cease to have any electrical resistance.

*(To be continued.)*

## THE HOPKINSON THREE-WIRE PATENT.

As most engineers and managers of electric supply undertakings are already aware, application has been made to the Privy Council for an extension of Dr. John Hopkinson's three-wire patent No. 3,576, of July 27, 1882 (for an abstract of this patent see *The Electrician*, Nov. 4, 1892, p. 7); and, as it is rapidly nearing the end of its natural existence, arrangements have been made for hearing counsel for and against the petition, on Wednesday, July 15th. The title of this patent *after* the amendment of June 22, 1891, is "IMPROVEMENTS IN DISTRIBUTING ELECTRICITY AND IN APPARATUS TO BE EMPLOYED FOR THAT PURPOSE." The claims, originally four in number, were, by the amendment above referred to, reduced to two, which run as follows:—

> First. The employment of a differentially wound indicating or regulating apparatus so connected to the conducting wires from a generator of electricity to a distant place as to indicate that the difference of potential between the two conductors leading to such distant place deviates from an assigned value at that distant place, or to regulate the electricity producing machinery in such wise as to maintain a constant difference of potential at a distance from the place of supply or generation of the current substantially as hereinbefore described with reference to Figs. 1 and 2 of the accompanying drawings.
>
> Second. In a system of electric distribution or supply, the employment of three (or more) conductors in combination with two (or more) dynamo machines in series substantially as hereinbefore described with reference to Fig. 5 of the accompanying drawings, whether the middle conductor be continuous or be replaced by an earth return as set forth.

In the petitioners' pleadings it is stated that Dr. Hopkinson obtained a patent for this invention in Germany dated February 22, 1883, which patent expires on February 22, 1898, but that he has not obtained patents in any other country, although he communicated the invention protected by the first claim to the Westinghouse Electric Company, of America, which Company patented the said invention and paid Dr. John Hopkinson the sum of £500. In further clauses it is stated that in April, 1889, the Westinghouse Company acquired an equitable interest in the patent; that prior to the year 1879 electric lighting was practically only carried out by means of arcs arranged on the series system, a method not applicable for domestic lighting; and that in the year 1879 a new method of utilising electric current for the purpose of lighting was invented by Edison and others, which method was known as the incandescent system, the lamps being arranged in parallel. The objections to the plain parallel system and the difficulties of the parallel-series system are then alluded to, and we then come to the more important clauses of the petition, which are set forth below in full.

18. The subject matter of the petitioners' said letters patent consists in an entirely novel method of distributing the electric current through the main conductors to the electric lamps, or other devices, requiring to be supplied with an electric current. By means of the said invention an enormous saving in the cost of the copper necessary for the construction of the main conductors of an electric circuit has been effected, such saving amounting, in the case of the licensees hereinafter referred to, to a saving in the prime cost of conductors of over £220,000. The said invention also automatically maintains constant the brilliancy of the lamps in a circuit, no matter how large or how small are the number of lamps alight in the circuit.

22. In practically working the three-wire system, the directions of the currents, generated by the two sources of electricity, are so arranged that normally (viz., when an equal number of lamps are in use in each circuit) no current will be flowing in the small central wire. In the event of any of the lamps in either circuit being put out, the central wire serves to conduct the excess of one current over the other, which would, prior to the use of the three-wire system, have had to pass through some of the

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lamps, affecting their brilliancy. By this means, therefore, their destruction is avoided, and their constant brilliancy is maintained.

24. Immediately after the grant of the patent to the petitioner, Dr. Hopkinson, he used every endeavour to procure the adoption of his invention, but the electric lighting industry was at that time so much in its infancy, and central lighting electric installations (where long main conductors are required, and to which the invention is chiefly applicable) were so hampered by the provisions of the Legislature, that for the first eight years of the life of the patent there was practically no opportunity for the application of your petitioners' invention, and they submit that this gives a strong reason for granting to your petitioners an extension of the term of their patent.

25. Prior to the year 1889, when the equitable interest in the said letters patent was vested in the petitioning Company, as hereinbefore appears, your petitioner, Dr. John Hopkinson, despite great efforts, had only succeeded in granting three licences in this country, and had received the gross sum of £300 only for royalties, from which sum after deducting expenses, a net sum of about £200 only remained as profit derived from the patent up to that date.

26. During the same period, as in the preceding paragraph mentioned, your petitioner, Dr. John Hopkinson, had for his German patent received a net sum of about £150.

27. Subsequently to the date of the said agreements, under which the said equitable interests were acquired by the petitioning Company, your petitioner, Dr. John Hopkinson, has received in shares and cash a net sum of £19,400 as the purchase price of the English and German patents, making, with the sums of £200 and £150 hereinbefore mentioned, a net profit of £19,750 in respect of both the English and German patents.

28. At the date of the said agreements the electric lighting industry was beginning to develop, but the industry was in the hands of wealthy companies, who then and subsequently repudiated the rights of your petitioners to any monopoly of the system of electrical distribution which has been known as, and is herein referred to as, the three-wire system.

29. Your petitioners submit that, in the face of the great opposition to the claims of your petitioner, Dr. John Hopkinson, to any patent rights in the three-wire system, and the certainty that, when the electric lighting companies commenced to lay their cables on the three-wire system, such rights could only be enforced after long and protracted litigation, it was essential for the proper development of the three-wire system that the interest in the patent should be vested in a company having the means to carry on the litigation, and the means to develop the invention; and the petitioning Company submit that, at the present day, it is a meritorious action on the part of public companies to take up and assist inventors in developing inventions of great public utility; and that it is reasonable that if, through circumstances over which they have no control, they have not been able to obtain a sufficient remuneration for the moneys expended by them in developing the invention, their merit in undertaking the development of the patent should be recognised by an extension of the term of the patent, sufficient to enable them to obtain such reasonable remuneration.

30. Immediately after the petitioning Company had obtained an interest in the said patent they used their best endeavours to procure the adoption of the said three-wire system; and finding, in the year 1892, that an electric lighting company, known as the St. James's and Pall Mall Electric Lighting Company, were using the three-wire system for the purpose of electric lighting, they commenced proceedings against the said Company for infringement of the said patent. In the result, after a trial extending over a long period, Mr. Justice Romer decided that the said letters patent were valid and had been infringed.

31. Subsequently to the date of the said judgment, a large number of electric lighting companies have been incorporated throughout the country, and several of these companies and several municipal corporations have adopted the patented three-wire system, and are using the same for the purposes of central-station electric lighting. The petitioning Company have granted a considerable number of licences for the use of their patent, the licences granted by the petitioning Company including licences to the Midland Railway Company in connection with their Derby station; F. H. Royce and Company, Hulme, Manchester; London and India Docks Joint Committee; St. James's and Pall Mall Electric Lighting Company (Limited); Westminster Electric Supply Corporation (Limited); Kensington and Knightsbridge Electric Lighting Company (Limited); Notting Hill Electric Lighting Company (Limited); Charing Cross Electric Supply Corporation (Limited); Crompton and Co. (Limited); the Corporations of Blackburn, Bradford, Brighton, Burnley, Dewsbury, Glasgow, Halifax, Hull, Lancaster, Manchester, Nottingham and Taunton; the Dundee Gas Commissioners; Liverpool Electric Supply Company (Limited); St. Pancras Vestry; Richmond Electric Light and Power Company (Limited); B. Verity and Sons, Manchester; Trustees to the Town Harbour of Whitehaven; Norwich Electricity Company (Limited); the Hove Electric Light Company (Limited); Southampton Electric Light and Power Company; and the National Electric Company (Limited), of Preston.

32. The petitioning Company, as appears from their accounts, have up to the end of the year 1895 received in royalties the gross sum of £21,393, which, after deducting the expenses incurred by them in the purchase of the said patent rights, and in and upon the payment of renewal fees and legal and other expenses in connection with the said patent, leaves them, up to the present time, a net loss of £7,247, not allowing any deduction for interest on capital moneys expended, as hereinafter mentioned.

33. At the present time an enormous development of the electric lighting industry is taking place throughout the country, and a great development is taking place in the use of electricity for the purposes of traction and transmission of power, for which purposes the three-wire system can be applied with advantage. The said invention has been applied not only with three wires, but also with five wires and four dynamos, in which case a still further saving in the cost of the main conductors is secured.

34. The petitioning Company submit that, in addition to the purchase money and expenses set out in their accounts, they are entitled to add to their expenses interest upon the capital moneys expended by them in the purchase and maintenance of the said patent, during the period that the said patent was unremunerative to them. As appears from the accounts filed by the petitioners, after debiting the company with interest at the rate of 5 per cent. upon the capital moneys expended by them in the purchase and maintenance of the English and German patents, and crediting the Company with interest at the rate of 5 per cent. upon all moneys received by them as royalties in respect of the use of the said patent as and when received, there is a loss to the petitioning Company of about £1,818, which they submit should be set off against the gross royalties received by them from the said patents.

35. The German patent owned by the petitioning Company has not, though the best endeavours have been made by the petitioning Company to extend the use of the same in Germany, produced much profit to the petitioning Company. The total net receipts from the German patent amount to the sum of £224; and the petitioning Company submit that the fact that the German patent, granted in respect of the said invention, will expire on the 22nd day of February, 1898, should not be taken into consideration as affecting in any way an extension of the term of the English letters patent, upon the ground that the said invention does not place the British public at any disadvantage as compared to foreign countries. The said patent relates to a system of using electrical currents, and does not place British manufacturers in any position prejudicially affecting them in relation to foreign manufacturers.

36. Your petitioners humbly submit that, under the circumstances of the case, an exclusive right of using and vending the said invention for the further period of seven years will not sufficiently reimburse and remunerate your petitioners.

*Statement by Objectors.*

The following objections to the extension of the patent have been lodged by the Corporations of Glasgow, Hull, Bradford, Dundee, and the National Electric Supply Company (Limited), of Preston:—

1. The petitioner, the said John Hopkinson, the inventor and patentee, has already received full and adequate remuneration in respect of the said alleged invention.

2. If the said John Hopkinson has failed to receive adequate remuneration for the said alleged invention, he has failed to do so in consequence of his own negligence.

3. The alleged invention, as claimed in the letters patent, is not the only method of distributing or supplying electricity by means of a three-wire or five-wire system.

4. The petitioners, the Westinghouse Electric Company (Limited), are a public company, who acquired the said letters patent as a trading speculation and for the purpose of trading, and not with the view of assisting the inventor; and even if the last-named petitioners had not received adequate remuneration in respect of the said alleged invention, that affords no ground on which an extension of the term of the said letters patent ought to be granted.

5. The petitioners, the Westinghouse Electric Company (Limited), have already received full and adequate remuneration for the said alleged invention, or if they have not done so, their failure is due to negligence and refusal to grant licences on reasonable terms.

6. If the petitioners had exacted royalties for, or made arrangements with, all users, in the same manner or of the same nature as they had exacted from, or made with the objectors, they would have realised a very much larger profit than they have made.

7. The objectors and others accepted licences under the said letters patent, and paid large sums by way of royalty in respect thereof, on the faith that the term of the said patent would expire on the 27th July, 1896.

8. The alleged invention is not of such special or exclusive merit or public utility as to be a sufficient justification for any extension of the term granted by the said letters patent.

9. The petitioners have granted licences and are proposing to grant licences to work the patent, if it be extended, upon such conditions as to place the objectors and other public bodies on less favourable terms than trading companies or corporations.

10. The allegations contained in the said petition are incapable of proof.

## THE DIRECT-COUPLED GENERATOR AT STOCKWELL POWER STATION.

The direct-coupled generator now forming part of the equipment of the Stockwell power station of the City and South London Railway, to which reference several times has been made in these columns, consists of a Siemens compound-wound dynamo, coupled to a two-crank compound non-condensing Willans engine. This plant is required to take a portion of the duty during the evening hours, when it runs in parallel with one of the original Mather and Platt belt-driven generators. It is erected on the floor of the gangway between two of these original sets, and to see so compact a plant nestled between the larger and more imposing-looking sets is an interesting and instructive sight. The new set has roughly

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half the capacity of the older sets, and normally develops 250 amperes at 500 volts. It runs at a normal speed of 350 revolutions per minute, and, though subjected to extremely great variations of load at frequent intervals, the fluctuation of speed is very small. A view of the complete set is shown in Fig. 1, which has been prepared from a photograph taken behind the link belting of one of the belt-driven sets (as is seen by the belt crossing the field of view). Figs. 2 and 3 give respectively a longitudinal and partly sectional elevation of the plant, and an elevation of the automatic cut-off valve gear.

Messrs. Siemens Bros. and Co. have retained the usual pattern of their ordinary $\left(\frac{\text{H B 21}}{36}\right)$ compound-wound continuous-current generator in the type of dynamo which they have supplied for this railway plant. The dynamo is of the vertical, under-type, two-pole, single-magnet type, with a drum-wound bar armature. The armature is 21in. in diameter, and the pole face is 36in. The series windings are provided with a hand switch, whereby they may be cut out of circuit on occasion.

of steam will be cut off, and expansion will commence. The steam ports in the piston-rod are slots cut spirally, so that their upper and lower edges are parallel with the spiral lower edges of the sleeve-ports. By means of a mechanism actuated by the governor, this sleeve is rotated horizontally in either direction. If the load rises it is rotated in such a direction that the ports in the piston-rod will receive steam later, as they will not be covered by the solid part of the sleeve until they have fallen below a lower part of the spiral edge of the sleeve-ports. If, on the other hand, the load falls, the sleeve will be rotated in the opposite direction, and the steam ports meeting earlier the spiral edges of the sleeve-ports will cut off steam earlier.

It would, of course, be impossible to obtain satisfactory results without the use of supplementary power to move this regulator sleeve; and the governor in this engine is made to actuate a small steam thrust-piston, contained within a supplementary cylinder mounted on the upper part of the front of the engine. This supplementary valve gear is shown in Figs. 1 and 3. One end of this cylinder is constantly in communication with the steam-chest, while the other can be connected either to the steam-pipe on the boiler side of the

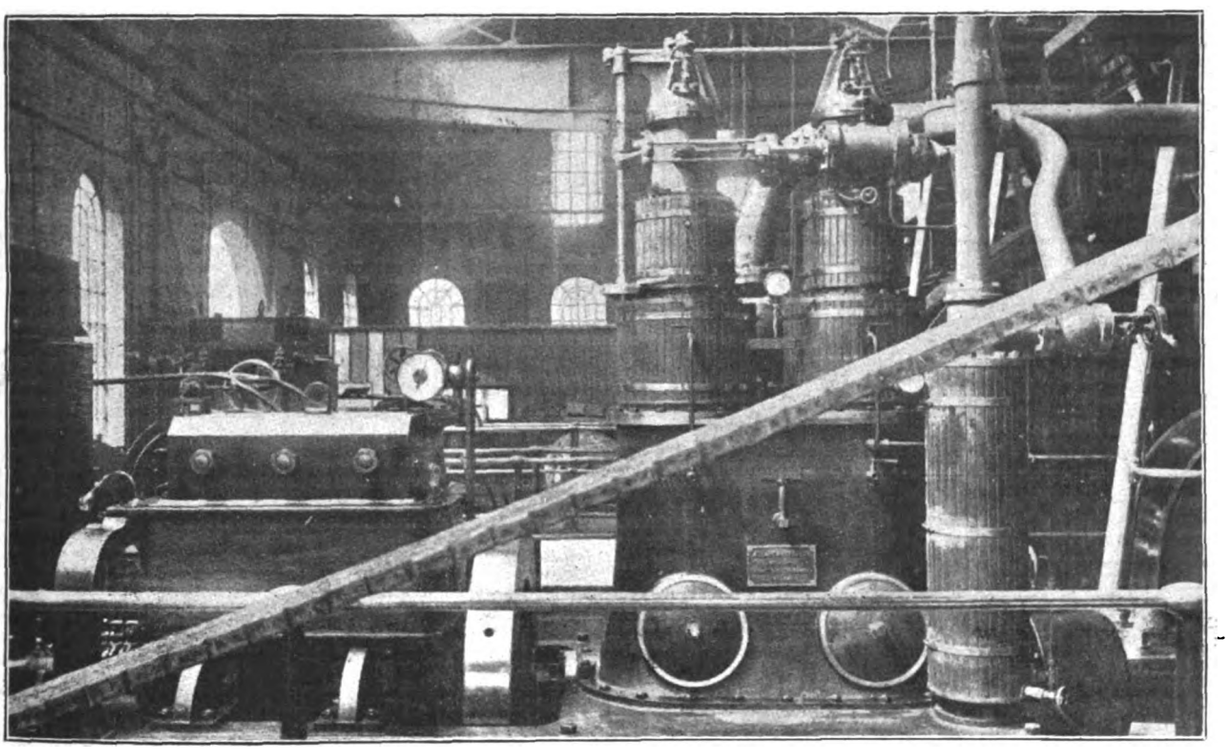

Fig 1.—General view of the Willans-Siemens Direct-Coupled Railway Generator at the Stockwell Station of the City and South London Railway.

The engine supplied by Messrs. Willans and Robinson is of the usual IIS type, and develops a normal power of 180 B.H.P. when supplied with steam at 130lb., and running at 350 revolutions per minute. It is built, however, to develop, on occasion and for short intervals, considerably greater power than this; and to this end it is provided with Messrs. Willans and Robinson's ingenious automatic cut-off valve gear, some description of which we give below. The diameter of the high-pressure cylinders is 14in., and of the low-pressure cylinders 20in.; the diameters of the hollow piston rods are 4in. above the high-pressure piston and 5½in. above the low-pressure piston. The stroke is 9in.

In Fig. 2 the vertical section through the cylinders of one half of the engine enables the internal design of the cut-off valves to be seen. It will be noticed that around the upper part of the hollow piston-rod, in which the steam ports are cut, there is a long sleeve, in which are a number of ports with spirally cut lower edges. This sleeve is interposed between the ports in the moving piston-rod and the steam dome, so that immediately the steam ports in the piston-rod have fallen below the spiral edge of the ports in the sleeve the admission

throttle valve, which is retained as in fixed expansion engines, or to the exhaust, by means of a three-way valve, the usual connection being to the steam-pipe. When load is removed from the engine the speed increases momentarily, the throttle valve closes, the pressure in the steam-chest falls, and the piston in the auxiliary cylinder is moved by the predominating pressure in the end connected to the steam-pipe, and cut-off is made earlier. When load is put upon the engine, the speed falls momentarily, and the throttle valve opens; in opening it moves the three-way valve, which closes the communication between the auxiliary cylinder and the steam-pipe, and opens it to exhaust. The pressure in the steam-chest which is in communication with the other end of the auxiliary cylinder, has, meanwhile, risen to the full steam-pipe pressure, the piston is forced back and cut-off is made later. This form of gear is both powerful and prompt, and appears to be thoroughly well adapted to hold in check the extremely sudden and heavy variations in load to which a railway generating plant is subjected. In the Stockwell plant the cut-off is automatically varied from 0 up to ⅝ full stroke.

As we have previously announced, this generating set

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rejoices in the distinction of being the first direct-coupled electric railway plant in the United Kingdom. Since it was erected there has been started a railway power station at Hartlepool, which is equipped completely with Willans direct-coupled generating sets. Our thanks are due to Messrs. Willans and Robinson and to Messrs. Siemens Bros. and Co. for the assistance they have kindly given to us in the preparation of this article. We hope to see this type of plant increase and multiply in the land, as direct-coupled electric light plants have done in the past and are still doing.

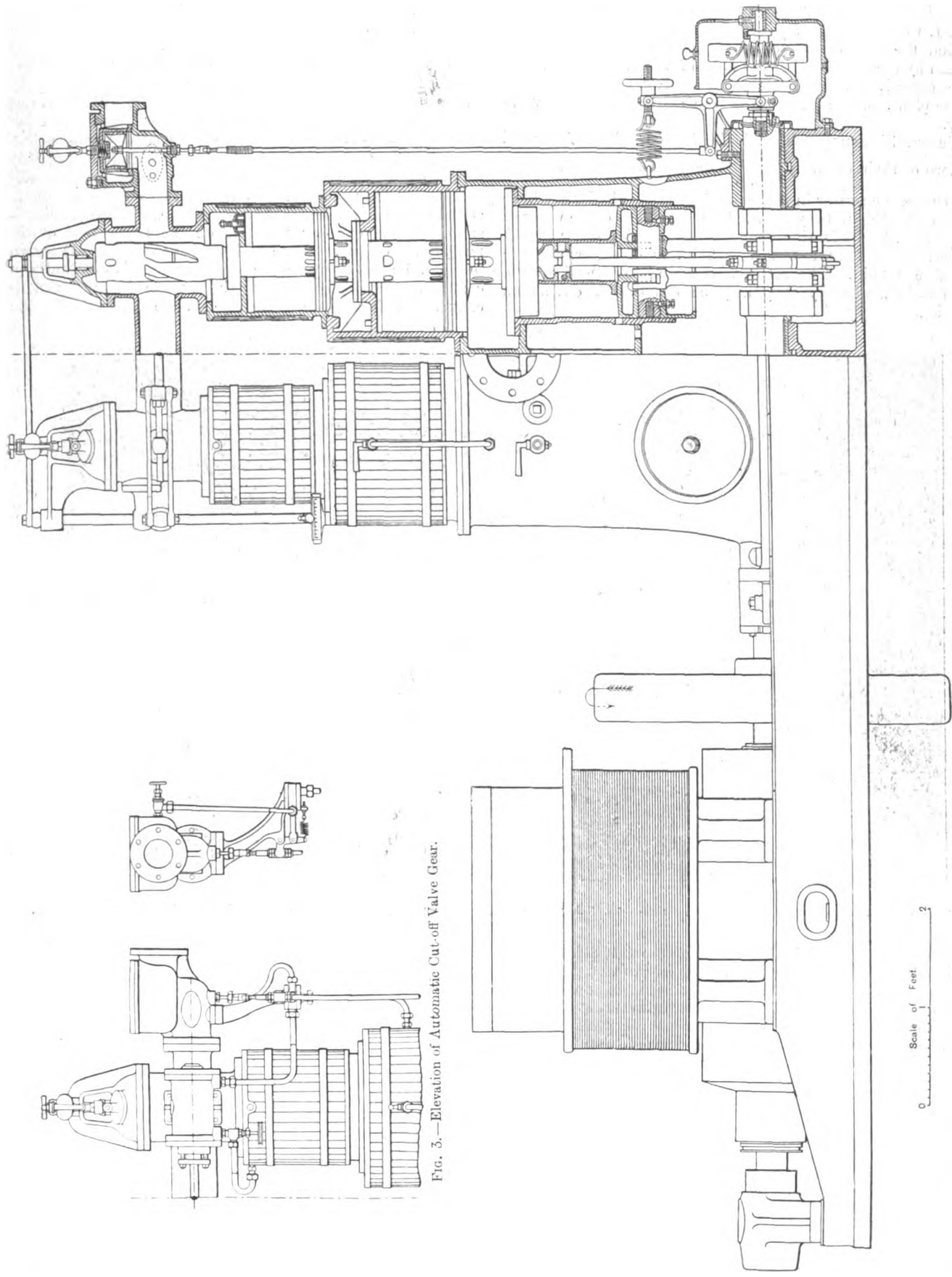


Fig. 2.—Elevation, partly in section, of the Willans-Siemens Direct-Coupled Railway Generator Plant at the Stockwell Station of the City and South London Railway.



Fig. 3.—Elevation of Automatic Cut-off Valve Gear.

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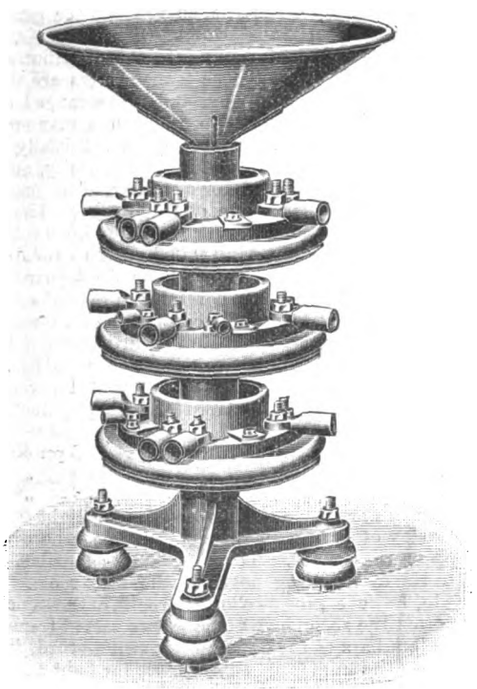
## THE WORDINGHAM PILLAR DISTRIBUTOR.

To secure equality of pressure it is desirable to inter-connect a distributing network at as many points as possible. The great drawback to such inter-connection is, however, the difficulty of localising a fault should one occur, and with a view to providing for this it is essential that all linking points should be capable of rapid disconnection. This is by no means easy to provide for in a neat and convenient manner when there are many cables meeting in one point, and the difficulty is very largely increased when the distribution is effected on the five-wire system, since the number of cables is largely augmented. The necessity for some convenient apparatus for this purpose has led Mr. C. H. Wordingham (Municipal Electrical Engineer at Manchester) to devise the apparatus illustrated in this issue.

A central hollow cast-iron column standing on three oil insulators is fixed in the junction box. From this column project at five different levels three cast-iron lugs 120deg. apart, cast in one with the column. Five cast-iron plates, each having three slots separated from one another by 120deg., and three recesses on the under side placed between the slots, are provided. One of these plates is slipped over the pillar, the slots allowing it to pass the lugs until the bottom three lugs are reached. The plate is then turned through an angle till the recesses are opposite the lugs. The plate is then dropped down, and takes a firm seat. On the plate are placed two flat rubber rings which serve



as a bed for a porcelain insulator of the form shown. This insulator is large enough to slip past the cast-iron lugs. Three slate wedges covered with india-rubber strip are placed between the insulator and the pillar, so that the insulator is firmly fixed. A substantial ring of gunmetal is now placed on the insulator; this ring is prevented from slipping about by means of four small brass pieces secured by bolts and rendered adjustable by means of slots. This ring has studs and tapped holes which admit of a large number of lugs into which cables are sweated, being affixed to it by means of nuts and bolts. A second cast-iron plate is now slid down the pillar and fixed on the next three lugs from the bottom, and an insulator and ring placed on it as before described. Three more cast-iron plates, each with its insulator and ring, are then fixed on the remaining lugs. A large funnel is slipped on to the top of the pillar. This serves to collect any water that may drip into the junction box, and so prevents it from falling on the apparatus; the water runs down the funnel through the interior of the column.

The illustration shows a three-ring distributor complete without any cables attached. Such a pillar distributor is capable of dealing with a very large number of cables. Each ring can readily have six $\frac{1}{2}$ sq. in. cables and six smaller ones attached to it, that is to say, the pillar as a whole will deal with 70 cables. A considerable number of these distributors have been introduced into the Manchester network. It is quite easy to disconnect the five cables which pass down a street in as many minutes, and, in case of a fault, portions of the network from which a large supply is being taken can be broken with perfect safety. On one occasion as much as 1,700 amperes at 200 volts was successfully disconnected on one of these pillars.

Messrs. W. T. Glover & Co. have the sole right of manufacturing the Wordingham "Pillar Distributors."

## ELECTRIC PLANT AT THE MONTMORENCY FALLS IN CANADA.*

BY C. C. CHESNEY.

The Falls of Montmorency, situated eight miles below the far-famed and historic city of Quebec, are the scene of one of the most interesting and successful electric transmissions of power in America. The cataract is the chief natural attraction in that vicinity, and while not possessing the magnitude of Niagara, there is yet something of the same grandeur and magnificence in the wild rush of its waters, and the same deafening roar that stuns for a moment the mind of the most stolid beholder. From a height of more than 275ft. the waters fall perpendicularly over the face of the rock, forming, in succession, furious cascades and seething pools in the ravine below, and rushing off to meet the waters of the majestic St. Lawrence.

It is the especial object of this article to call the attention of those interested in the general development of water powers, and especially of those who may have occasion to investigate the problem of the transmission and distribution of power by alternate currents of electricity, to the method and apparatus there used, in the belief that it is an object lesson, not only of scientific interest, but of general practical value.

It is but a few years ago that a company, organised in Quebec, constructed a dam across a narrow gorge in the Montmorency river at a point 1,500ft. above the face of the Falls, with the object of utilising some of the power for manufacturing. A cotton mill was built at the foot of the bluffs, and, shortly after, a small arc station was erected for the purpose of doing arc lighting in the city of Quebec.

In the year 1889 the present Montmorency Electric Power Company established, in connection with the arc plant, a small incandescent plant of about 100 H.P. capacity, using 2,000-volt alternate current machines, built by the Royal Electric Company of Montreal, and transmitting the current to Quebec with a loss of over 50 per cent. This very unsatisfactory and uneconomical plan was continued until the summer of 1894, when a change of management brought to the service of the Company the well-tried experience and engineering ability of Mr. Frank H. Badger, jun., as general manger, and Mr. Louis Burran, as electrician, to whose intelligent work and attention to the practical details the final success of this plant is largely due.

Acting under the advice and direction of these gentlemen, the Company increased the capacity of the old dam to a minimum of about 12,000 H.P. A short tunnel was run through the solid rock, connecting the dam to the wooden flume, which continues along the face of the adamantine bluffs for a distance of 1,500ft. to the gate house on the brow of the hill. The construction of this flume was a task of considerable magnitude, involving the exercise of much engineering skill. From the gate house, on the brow of the hill, a steel-riveted tube, having a diameter of 72in. and a length of 1,100ft., is carried down a steep incline to the power house, where the pipe-line terminates in a large steel receiver which supplies the water to the turbines.

Owing to the extremely high head and the great velocity at which the wheels must necessarily run, they were required to be very simple, stronger and more compact than is the general rule. The wheels adopted are the "Little Giant" turbines, manufactured by J. C. Wilson and Co., of Picton, Ontario. The noticeable feature of these wheels, besides their simplicity, is the almost entire absence of lateral or end thrust, so frequently found in the ordinary types. They have two sets of buckets, keyed on the same shaft, and the buckets are so formed that whatever end thrust there may be from the one set is counteracted by that of the other. The particular size installed at the Montmorency Falls has a capacity of 700 H.P. and runs at a speed of 600 revolutions per minute. The "Little Giant" turbine is comparatively little known outside the Dominion of Canada, but some idea of its simple and compact nature can be gained from the fact that this 700 H.P. wheel is only 21in. in diameter and has an extreme length not exceeding 2ft.

The generating station is a two-story structure, built of native stone, and is 150ft. long by 50ft. wide. It is situated in a picturesque and convenient spot between the hills and the Quebec, Montmorency and Charlevoix Railroad. The first floor of the building is devoted entirely to the turbines and the necessary gate mechanism. Along one side of the room the numerous wheels are arranged in a row, from which the belts proceed at an angle of 45 degrees to the dynamos on the floor above. The water is taken

* Abstract from *Cassier's Magazine*.



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from the receiver in this same room and is discharged partly into the tail race which empties into the St. Lawrence river, and partly into the 40-inch steel pipe which supplies water to the wheels in the mills of the Montmorency Cotton Manufacturing Company. The second floor in the dynamo-room. It is a large, well ventilated and well lighted space, having practically the same dimensions as the building. To the practised eye of the engineer, it is at once apparent that the design and construction here have been carried out in accordance with the best engineering skill. It is unfortunate that electric lighting stations, as a rule, have been hurriedly constructed with any sort of material that happened to be near at hand, and equipped with that apparatus which was offered at the lowest price, regardless of quality. This room is, therefore, of more than usual interest, since in its equipment, or that proposed for future developments, every necessary improvement has been introduced which in any way promised to increase the reliability and efficiency of the plant, and to reduce the cost of operation.

The problem in electrical engineering which was presented to the Montmorency Electric Power Company is typical of the problems presented to all enterprises for the utilisation of a waterfall by the transmission and distribution by electricity of its energy to distant points. The prime requisites in any such system for power transmission and distribution are, necessarily, simplicity and reliability. The simplicity and reliability of the single-phase alternating system are well known to all electricians and the electrical public in general. This system has been proven and tried in numerous cases where it has been the sole dependence of the larger enterprises, and where the practicability of transmitting power in bulk by this system has been demonstrated beyond question. It lacks, however, range and flexibility; it lacks a motor which commercially answers the requirements of power distribution; and it lacks the ability to be readily converted into direct currents for railroad and electrolytic work.

In the multiphase systems, however, which have been developed within the last few years by the various electrical companies, are to be found all these requirements. Coupled with the simplicity and reliability of the single-phase systems, are to be found range and flexibility. The induction motor forms the missing element for commercial power work, and extends its range far beyond that ever realised by the direct-current motor. When we now add the two-phase or three-phase rotary transformers we have a system, ideal not only for long-distance transmission purposes, but ideal for general central station work, whether the energy be primarily furnished by steam or water power.

Naturally, then, in order to obtain the most complete and commercial results from the power at its disposal, the system adopted by the Montmorency Electric Power Company is a multiphase system. The particular multiphase system is the "S.K.C." (Stanley-Kelly-Chesney) two-phase system as applied by the Stanley Electric Manufacturing Company, of Pittsfield, Mass., U.S.A. The generators are situated on the north side of the dynamo room. The foundations are of solid masonry, through which are run a number of tie rods which hold an insulating cap to the solid bed rock of granite. The insulating cap consists of 10in. by 12in. timbers which have been boiled in paraffin in order to completely remove all moisture. The bed-plates of the machines are held in place by lag screws set into the paraffined timber. Each generator delivers alternating currents, differing in phase by 90deg., to two independent circuits at an electromotive force of from 5,200 to 5,700 volts. By means of rheostats in the fields of the generators the electromotive force can be varied between these limits to meet the requirements of the circuits.

The frequency is 66 periods per second—that is, the current is reversed approximately 8,000 times a minute. The generators are what are commonly known as 8,000-alternation machines. This frequency was selected as being one of the standard frequencies advocated by the engineers of the Stanley Electric Manufacturing Company, and in preference to 133 periods per second (16,000 alternations); for, while the loss in the core of the transformers was increased from 2 to 30 per cent., and the regulation of the generators from a total of 2 per cent. to a total of 3 per cent., the self-inductive drop in the transmission lines was such an important factor that the lower frequency was considered preferable, as giving, on the whole, a better regulating and more economical system.

The currents delivered by the generators are carried by heavily-insulated cables to the switchboard, where the attendant, by suitable switches, may connect the generators to the transmission lines. Two separate pole lines have been constructed to Quebec. One follows the route of the Quebec, Montmorency and Charlevoix Railroad, carrying two transmission lines, each having a capacity of 500 kilowatts; the other follows the old Beauport road, carrying one transmission line of a capacity of 500 kilowatts, and provision for an extra line. All the lines are entirely overhead, and are entirely supported on wooden poles, with the exception that at the crossing of the Charles River they are carried across the river on iron poles 125ft. high.

Triple petticoat porcelain insulators were used, and were made especially for this plant by a Canadian manufacturer, differing, however, but slightly from the design now in common use for high-voltage work. The line wire is No. 0, B. and S. bare copper. The drop, due to the ohmic resistance of the wire, is 8 per cent., which is increased by the self-induction to 10 per cent. On the extreme ends of the top cross-arms of each pole line are strung galvanised iron wires, which are grounded at every third or fourth pole. These iron wires, together with lightning arresters, placed at each end of the transmission lines, give a complete and safe protection from all lightning storms. So perfect has been this protection that a discharge in either the generating station or sub-station is practically unknown.

The transmission lines enter the city of Quebec in that portion known as St. Rochs, and the sub-station is located in the centre of the industrial district, where power is needed for the tanneries and shoe factories for which the city is noted. The sub-station is 90ft. long by 65ft. wide, and is two stories high, built of brick with a stone front. The building consists of a store-room on the second floor, the offices of the company in the front, on the first floor, with the room containing the distributing switchboard immediately in the rear. The transformer house is a part of the same building, but only one story high. The transmission lines enter the sub-station through the cupola to the high-potential receiving switchboard, which contains special high-voltage switches. These switches are mounted on marble and are fitted with special self-enclosing boxes, which are intended to cut off any possible arc that may be formed on opening the 5,000-volt circuits.

From the transmission lines the current of the generators is carried to the step-down transformers, where the electromotive force of transmission is transformed into the distributing electromotive force of 2,000 volts. These transformers are the regular indoor type of the Stanley Company, and are arranged on a rack, in two tiers, five wide and two deep, in such a manner that the air has free circulation, or that they may be artificially ventilated if it be so desired. They are of 50-kilowatt capacity, and are connected in pairs. Each is wound for a primary electromotive force of 2,500 volts and a secondary one of 1,000 volts. The primaries of each pair are connected in series for receiving 5,000 volts, and the secondaries in series for delivering 2,000 volts to the distributing system. This arrangement gives an additional safeguard by lessening the voltage on any particular coil, and in case of a burn-out in any one transformer, the other will carry the load for a time until the relay transformer can be cut in. The insulation of each transformer was tested with 10,000 volts. The regulation of each transformer from no load to full load is about 1 per cent. The average efficiencies of the entire transformer equipment, as shown by the shop tests, are:—

| | | |
|---|---|---|
| Efficiency, full load | 97·8 | per cent. |
| „ half load | 97·9 | „ |
| „ quarter load | 97·0 | „ |

The transformers are divided into two sets of eight transformers each, with a relay of two transformers, which can be cut in or out without stopping the service. Three secondary distributing circuits are carried to the distributing board in the next room. Provision has been made, however, for two more circuits of the same capacity. The current from the secondaries of the two sets of transformers is carried to the 'bus bars of the distributing switchboard, from which it is furnished to the numerous city circuits for light and power.

The generators are the S.K.C. inductor type of two-phase machines, running at 286 revolutions per minute. Each generator has a capacity, at 5,700 effective volts, of 100 amperes. They are the largest inductor machines that have ever been built, and are the first and only practical machines that have ever been constructed for such a high initial electromotive force. The armature is stationary, consisting of two sets of laminated iron rings, connected by steel rods 4in. in diameter. On the inner surface of each laminated armature ring are 56 grooves for receiving the armature coils. The weight of this portion of the machine is 42,580lb. The field or exciting coil is circular, 94in. in diameter, and wound on two copper bobbins, each 4¼in. wide, with a copper strip 4in. wide and 0·026in. thick. It is insulated between the layers with a special oilcloth which is practically indestructible at temperatures under 150°C.

There are, in all, 56 armature coils, 28 for each phase. The coils are small and were wound in a lathe. Each coil was carefully insulated to stand 15,000 volts before placing it in the armature. The insulation of the completed armature was tested, finally, with 12,000 volts. The inductor, the only moving portion of the machine, is a steel casting, 43in. long and 84in. in diameter, upon the periphery of which are two sets of polar projections of iron lamine, 14 at each end. The weight of the inductor, including the shaft, is 28,470lb. The net weight of the completed machine is, approximately, 100,000lb.

In the operation of alternating-current motors, and also of transformers, it is now generally recognised as important that the currents and magnetic fluxes should vary sinusoidally, for the more

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nearly such a condition is approached the less are the losses and idle currents. A first step toward obtaining these conditions is the making of the impressed electromotive force of the generator sinusoidal. The flux between a field-pole and the opposite iron of the armature distributes itself, so that it is, at every point, inversely proportional to the reluctance of the gap at that point, or inversely proportional to the distance from the field pole to the armature iron; that is, the electromotive force at any instant is inversely as the clearance. In order, then, to obtain an electromotive force following the sine law, the pole faces of the inductors of these generators, as well as the pole faces of the inductors of all generators manufactured by the Stanley Electric Manufacturing Company, are so shaped that their curvature may be expressed by a formula which was derived by Mr. Kelly, of the Stanley Company, and is contained in a United States patent issued to him.

In the design of the inductor machine it has been found by the writer that any deviation from this law, or the use of any other than a sinusoidal electromotive force, has resulted in increased losses in transformers and unsatisfactory running of motors. In one instance the output of a 20 H.P. motor was reduced 25 per cent. on a machine with a distorted wave, and the condensers, which were intended to balance the lagging currents of the motor, were absolutely useless for that purpose.

A novel feature has been introduced for the first time in these generators. The entire distributing system has been arranged to be run in parallel, and, in order to do this, the generators must be kept in phase. There are some objections, however, to paralleling 5,000-volt machines through their principal circuits—also do difficulties occur in paralleling long transmission lines. A defect arising in any wire of one line, such as a ground or leak, affects all the wires in all the lines, so that if at any other point another ground occurs, the generators between the two grounded points are all short-circuited. To overcome this difficulty the mains from the different machines are kept separate, and the secondaries of the step-down transformers are connected in parallel with the supply mains.

In consequence, unless the line from one generator has two weak points, there is no leakage, and, at any rate, the leakage due to two weak points can affect directly only one generator. In order to keep the generators in phase under these conditions, a separate and distinct synchronising winding gives an electromotive force of 120 volts and has a synchronising capacity of about 100 kilowatts. This, together with the effect that can be obtained through the paralleled secondaries of the step-down transformers is sufficient to give perfect parallel running. The load can be readily shifted from one generator to the other by varying the quantity of water supplied to the turbines.

The exciters are two slow-speed, direct-current machines of 12-kilowatt capacity, each of sufficient capacity to excite the fields of the three alternators.

Some of the electrical data of these machines are interesting, as showing the improvement in dynamo design and the possibilities of the inductor type of machine. From the shop tests we have the following:—

| | |
|---|---|
| Maximum loss in field | 4,000 watts. |
| Loss in armature iron, friction and windage | 20,000 „ |
| „ armature copper | 7,000 „ |

From these we calculate the efficiencies:—

| | |
|---|---|
| Full load | 95·1 per cent. |
| Half load | 92·3 „ |
| Quarter load | 87·0 „ |

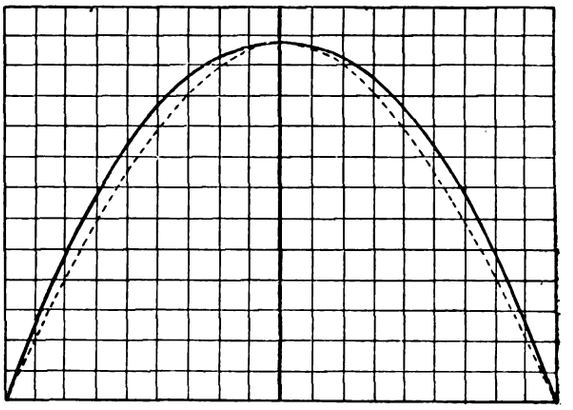
The rise of temperature after a run of 24 hours, with full load, is as follows:—

| | |
|---|---|
| Field coil | 12° C. |
| Armature iron | 21° C. |
| Inductor iron | 7° C. |
| Armature coils | 26° C. |
| Bearings | 21° C. |

The regulation, that is, the variation of the electromotive force from no load to full load, with same speed and same field excitation, was 3½ per cent. With full load on one phase and no load on the other, the percentage difference of electromotive force was 3½ per cent.

Both the generator and distributing switchboards are built of marble, supported upon wooden frames, and the panel method of construction is followed throughout. Each slab of marble was tested for metallic streaks, with a pressure of 12,000 volts. The generator board consists of three sections, of three panels each. The lower panel of the left-hand section carries the two rheostats for controlling the fields of two of the generators. They are mounted on the back of the board, and only the handles and the heads of the supporting bolts show. The middle panel carries four machine switches with self-enclosing arc cut-offs, two for each generator, and one of these for each phase. These connect directly to two of the four-wire transmission lines. It is never intended to open these switches under load, except in the case of great emergency, when the automatic cut-offs will take care of any discharge from the line, or any tendency to arc. When a generator is to be taken out of work, the load, if it is running in parallel with another, is shifted to the other by gradually cutting off the supply of water to its turbine; after that the switch can be opened without difficulty. If the generators are running independently the load is first transferred at the sub-station before opening the switch.

The upper panel contains four ammeters, two for each transmission line, and four voltmeters, with high-potential station voltmeter transformers placed directly at the back. The right-hand section is exactly the same as the left, with the exception that it is, at present, equipped for only one generator and transmission circuit. The lower panel of the middle section carries three four-pole, single-throw switches for connecting the synchronising winding of the generators in parallel. The synchronising lamps are shown just above. The middle panel is the exciter panel, carrying the necessary switches for paralleling the two exciters, and for charging the field of any generator from any exciter if the exciters are running independently. The upper panel contains three direct-current ammeters for the fields of the generators, and also four alternating-current voltmeters, with voltmeter transformer at the back, connecting to the 2,000-volt potential lines which return from the sub-station. The distributing board was originally designed for parallel running only; but it was afterwards learned that on rare occasions ice accumulates in the turbine feed pipes, which affects the speed of the wheels and makes parallel running an impossibility. In consequence, the original design was changed to permit either independent or parallel running of the generators. The two sections on the left of the board are organised for lighting alone, and to permit the transfer of any two-wire circuit upon any of the possible four sets of step-down transformers. This is accomplished by a series of three double-throw, double-pole switches. At the extreme top of this section are the automatic circuit-breakers. The two sections on the right of the board are organised for light and power, and




Full line = curve of E.M.F. Dotted line = sine curve.

E.M.F. Curve of the Generators at Montmorency.

differ from those on the left only in that the four-pole double-throw switches are substituted for the two-pole double-throw. The two centre sections are the same in design. The upper panels contain the voltmeters and ammeters for the various circuits. The middle panels carry four-pole double-throw switches, and are connected to the secondaries of the step-down transformers in such a manner that, if the switches are thrown up, three sets of two-phase secondaries are connected to three separate sets of 'bus bars; if they are thrown down, all the secondaries of each phase are connected in parallel. The lower panel carries the ground detectors of the ordinary transforming type. The whole switchboard is 26ft. long and 11ft. high.

All the motors now in use by the Montmorency Electric Power Company are the S.K.C. induction motors. They vary in size from 1 H.P. to 30 H.P., and do all kinds of work, running the tools of carpenter and machine shops, driving the saws and wood-planers of planing mills, and handling the freight elevators in various mills and in wholesale warehouses with perfect satisfaction. It is now well understood that the magnetising current of an induction motor lags behind the applied electromotive force, and that a lagging current in practice involves considerable loss and expense by necessitating the use of larger conductors and generating apparatus, while it seriously interferes with the proper regulation of the generators, and increases the normal drop of the line. In the S.K.C. motor the magnetising current is furnished by condensers; the motor then takes current in proportion to the load. Two condensers are connected in multiple with the fields of the motor, and each has a capacity in amperes at the working voltage practically equal to the no-load current of each field of the motor. If there is no distortion of the current wave the apparent energy taken by an induction motor with condensers is equal to the real energy.



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## POSITIVE EVIDENCE AND NEGATIVE RESISTANCE.

It may be taken as an axiom that of all possible explanations of any phenomenon or set of phenomena that one is most probably correct which is the simplest, and, at the same time, covers the whole range of known facts regarding the matter in question. An obvious corollary to this axiom is, that an explanation involving radical changes in fundamental ideas should not be accepted unless every other hypothesis has been proved to be false. For example, any hypothesis which involved a reconstruction of orthodox ideas in regard to the conservation of energy or of matter would stand no chance of acceptance unless it were found to cover completely a range of phenomena which proved to be inexplicable according to those orthodox ideas. Thus the fundamental notions of science—the cream and essence of the evidence of ages of experiment and observation—afford a test or standard against which the *a priori* probability or improbability of any new notion may be checked. If these same foundation ideas seem to be violated, or if the canons of logical thought appear to obstruct the way, it behoves true disciples of science to look carefully afresh into the evidence before them, ere they accept so radical a departure from orthodoxy. On the other hand, it is not by any means certain evidence of the falsity of an hypothesis that it seems to contradict the so-called principles of science, even when the contradiction is proved right up to the hilt. In the history of science there are many instances of fundamental ideas having to be reconstructed upon the evidence of newly discovered, or newly interpreted, phenomena. Indeed, it is literally strewn with examples of this species of revolution. It was thus that COPERNICUS and GALILEO compelled the revision of ideas regarding the order of the solar system; in like manner did HUTTON and LYELL upset the crude geology of the cataclysmists and pave the way for the modern theory of geologic evolution; the abolition of the older notions of caloric and phlogiston, and their replacement by the more completely scientific conceptions of thermal energy and of chemical force, afford further examples; while in our own special field of electromagnetic science, the

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changes in fundamental ideas which are associated with the names of AMPÈRE, WEBER, FARADAY, MAXWELL, HELMHOLTZ, EWING and HEAVISIDE furnish sufficient warning that science is not only progressing but often completely cancels old ideas in giving birth to new ones.

A not unimportant controversy, with the initial stages of which our readers must by now have become familiar, has been set on foot by the interpretation put by Messrs. FRITH and RODGERS upon some researches they have made on the resistance of the alternate-current arc. According to their view of the evidence afforded by their oft-repeated and carefully made experiments, the resistance of the arc between solid—*i.e.*, uncored—carbons is, in certain conditions, of negative value. This startling and revolutionary interpretation has received the assent of no less an authority than Prof. AYRTON, who, throughout the controversy, has stoutly defended it. The latest phase in the discussion of the question occurred at the last meeting of the Physical Society, when Prof. SILVANUS THOMPSON attempted to show that not only does the notion of negative electrical resistance conflict with orthodox views of electrical phenomena, but that it also violates the canons of logical thought, and is, in fact, a *reductio ad absurdum*. The evidence which Prof. THOMPSON educes stands quite apart from the phenomena of the electric arc; it is, indeed, a discussion of the question on the most general and universal grounds. If his conclusions are correct, then not only is negative electrical resistance impossible in the electric arc, but it is impossible anywhere or in any circumstance. In its present stage the controversy resolves itself, therefore, into two questions—firstly, as to the inherent impossibility of negative electrical resistance in any circumstance whatsoever; secondly, as to the value of the notion of negative resistance, assuming that it is admissible, as an explanation of certain phenomena of the electric arc. We will deal with these two sides of the matter in the order in which they have been stated. Before doing so, however, we cannot refrain from expressing our appreciation of the service which Prof. THOMPSON has rendered, by the way in which he has emphasised the radical nature of the change in our ideas which must result from an acceptance of the explanation put forward by Prof. AYRTON and his students. Whether or no negative resistance is possible, its acceptance as a physical fact involves such a complete overthrowing of our previous notions of electrical resistance that we do well to scan the arena of science to see what consequences it will involve. It is not merely the difficulty in explaining certain phenomena of the electric arc in any other way, that will justify the novel concept; it must be shown to be possible on general grounds.

Applying the ordinary statement of OHM's law, viz., $C = E/R$, Prof. THOMPSON has asserted that to make the resistance, R, negative results in an absurdity, since it involves a negative current flowing under a positive electromotive force, or a positive current flowing under a negative electromotive force. The reasoning here is marred by the fallacy that while these results would only be produced by making the *whole* resistance negative, the upholders of the new notion only assert that a *portion* of the circuit is of negative resistance, and that at least an equal amount of positive resistance in the circuit is absolutely necessary. Let us make this clear by an illustration. A stranger to the idea of back-electromotive force might assert that it is logically impossible and absurd, since, in the equation $C = E/R$, if E were made negative there would be either a positive current flowing through a negative resistance or a negative current flowing through a positive resistance, and in any case the current could not flow against the electromotive force. This stranger might triumphantly proclaim the physical impossibility of back electromotive force. But he would be wrong, and the reason of his error would be that he had forgotten that to have a *back* electromotive force, *per se*, you must also have a greater adjuvant electromotive force in series with it. A back electromotive force all by itself *is* an impossibility, as everyone will admit. But there is more direct evidence than this. In his Paper Prof. THOMPSON has lucidly explained the fundamental identity, on the MAXWELLIAN theory, of electrical resistance and a distributed back electromotive force proportional to the current. He has also admitted the physical possibility of a distributed adjuvant electromotive force, and he furnishes a very convincing and familiar example of it in the electromagnetic induction of an electromotive force in a length of wire conductor. There is no particular *locus* of the total induced electromotive force; it is distributed all along the conductor, so far as this is under induction. We have, therefore, these two facts admitted: that an adjuvant distributed electromotive force is physically possible, and that a distributed electromotive force is fundamentally the same thing as a resistance. There is only one possible inference, viz., the absolute identity of negative electrical resistance and adjuvant distributed electromotive force; and since the latter is possible, and, in certain circumstances, actually occurs, so may the former also occur. Let us again appeal to illustration to aid our ideas. Suppose that we were perfect strangers to magnetic phenomena, and only familiar with the electric current chemically and in its OHM's law relations; further, suppose that we had a coil of wire through which, unknown to us, a powerful magnetic induction flowed, the flux of magnetic lines undergoing continual decrease. Then, from a cause not understood by us, there would always be an adjuvant distributed electromotive force generated in the coil, so that if we were to use it in the circuit of some electro-chemical measuring apparatus, we should be astonished to find that the coil behaved as if it had a negative electrical resistance. And not until we were able to account for the phenomenon on electromagnetic grounds, should we be able to explain it any other way than on the hypothesis of negative resistance.

Having shown that conditions equivalent to a negative electrical resistance may occur in a portion, though not the whole, of an electric circuit, our next inquiry must be as to the admissibility of this novel idea into the explanation of the behaviour of the alternate-current arc. Remembering that we should always try the simpler explanations before accepting complex or revolutionary ones, we naturally cast our eyes over the past history of the question. What has already been done in the matter of attempting to explain the behaviour of the electric arc? Much has been done; and when we turn from one discarded hypothesis to the one which superseded it, and pass again almost endlessly to other and later rejected theories, finding each in turn capable of explaining only a limited number of facts, but utterly incapable of covering the whole ground of observed phenomena, we find ourselves becoming more and more prepared to believe that the true explanation will only be found in some theory which involves a radical change in our ideas. It is, naturally, when we discover older ideas repeatedly proving themselves inadequate, that our hearts soften, and our minds incline, towards ideas more revolutionary; and it is a comfort when, on testing these radical changes in our ideas, we can find that they are neither illogical nor in conflict with the basic principles of electrical science. Yet, though thus initially inclined to expect a somewhat startling consequence in the true explanation of some of the more puzzling phenomena of the arc, we

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hesitate to accept finally the conclusions to which Prof. AYRTON and Messrs. FRITH and RODGERS would lead us. To us they do not appear inherently impossible; indeed, in the light of the experimental evidence upon which they are based, they seem to possess a high degree of probability. But the matter is too new, too little developed, too restricted to one line of research, for us to believe as yet that, however logically thinkable, negative resistance is the true explanation of the electric arc phenomena under discussion.

## OBITUARY.

### PROF. STOLETOW.

The death is announced of Prof. Alexander G. Stoletow, the well-known Professor of Physics in the University of Moscow. Stoletow was born in 1839, and was educated at the Universities of Moscow, Heidelberg, Gottingen and Berlin, working from 1862-65 in the laboratories of Kirchoff and Weber. He was appointed lecturer in physics in the University of Moscow as far back as 1866, becoming professor in 1873. Prof. Stoletow was a member of the first Electrical Congress held in Paris in 1881, and was a member of the jury of the Paris Electrical Exhibition held in the same year; he was also Vice-President of the 1889 Electrical Congress.

Prof. Stoletow's chief electrical Papers are: "On the General Problem of Electrostatics"; "On the Magnetisation Function of Soft Iron," which contained the first explanation of the susceptibility curve; "On a Determination of Maxwell's $v$" by the method of repeated discharge of an air-condenser of known dimensions; "On Contact Electricity"; "On Kohlrausch's Measurements of the Mercury Unit of Resistance"; "On Actino-Electrical Phenomena," a series of Papers on the dispersion of electricity under the action of ultra-violet radiations; and "Ether and Electricity," an address at the meeting of Russian naturalists in 1890.

## THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 214.*)

*Method* 1 (*Murray's Loop Method*).—The loop is connected up to a resistance box or Wheatstone's bridge as shown in the Figs. 18A, 18B and 18C. Fig. 18A shows the lozenge-shaped diagram, which may also be considered as a stretched wire bridge, the point A being the sliding contact. Fig. 18B shows how a Post Office pattern bridge is to be connected up for the test, and Fig. 18C shows the connections to a stretched wire bridge with two sliding contacts.

The wires leading from the instrument to the cable (which often go by the name of "leads") should be as short as practicable. They must be considered as part of the loop, and their equivalent lengths must be reckoned in when calculating the equivalent length of the loop. If, for instance, the fault is in a piece of 19/16 cable, one uses, say, one yard of 16-gauge wire to connect up with at each side of the instrument, and considers the equivalent length of the loop increased by 19 yards at each end. There is a slight error in this if the temperature of the leads is much different from the temperature of the cable, for instance, when the test is made in the engine room. For every degree Fahrenheit difference between the estimated temperatures of the cable and the leads, 0·22 per cent. should be added in the calculations to the equivalent length of the leads. Mostly this length to be added is only a few yards, and the above correction is accurate enough if not altogether negligible. The actual temperature of the cable can only be estimated, but an approximation near enough is the temperature in a surface box, or in a cellar which does not receive artificial warmth. To make an absolutely accurate allowance for this difference of temperature (which should be done, if possible, when the leads are long and the temperature difference is large), the resistance L of the complete loop, including leads, must first be measured, and then the resistances ($m$ and $c$) of each of the leads. Then the equivalent lengths to be allowed for the leads, in calculating the length of the loop and the position of the fault are $\frac{l}{L-m-c}m$ and $\frac{l}{L-m-c}c$ respectively, where $l$ is the equivalent length of the rest of the loop.

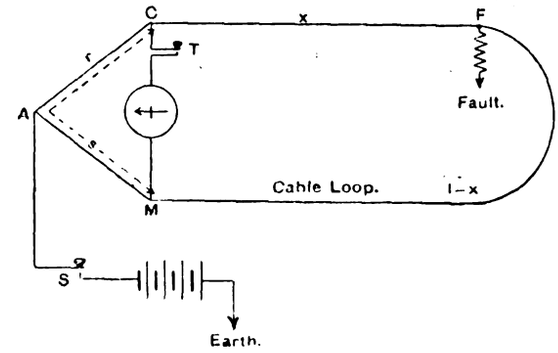


FIG. 18A.

The length and size of the wires leading to the battery and galvanometer are immaterial, as the values of their resistances do not affect the result of the test. The more sensitive the galvanometer the more accurate is the test. The battery may be a few accumulator cells or a primary battery. If the latter a few Leclanché cells or dry cells do very well. If the fault is of high resistance, many cells in series must be taken, so as to force sufficient current through it. If the resistance of the fault is somewhere about 1,000 ohms or more, there is no harm in using 50 accumulators (or more) or a dynamo. When an accumulator or dynamo is employed for this purpose, a fine fuse should be placed in the battery circuit, to save the bridge coils or the stretched wire from being overheated if the fault breaks down during the test. It is also advisable

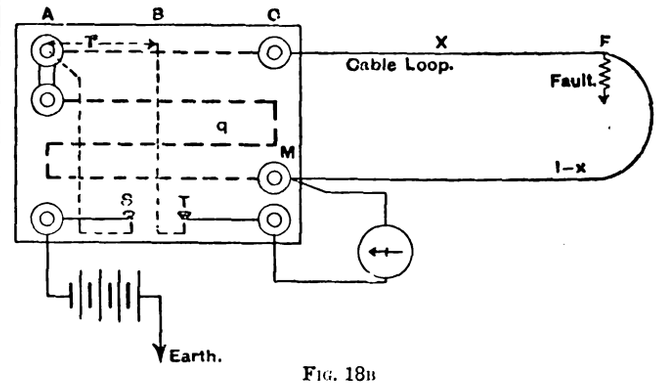


FIG. 18B

to have a low resistance (*e.g.*, a bank of lamps) between the dynamo terminal and earth, instead of earthing the machine directly.

When the test is made with a Post Office pattern bridge, it will be noticed on referring to the diagram (Fig. 18B) that the battery and galvanometer keys are not as for the ordinary copper-resistance test, and as is marked on the instrument, but that their positions are reversed. 1,000 ohms is first unplugged between A and B. The battery key S is then depressed, and the galvanometer key T is lightly tapped to see in which direction the galvanometer needle turns when *more* resistance is required for the adjustable arm A M. Then the resistance in the arm A M is adjusted till no deflection is obtained on depressing the galvanometer key T, the battery key S always being depressed first or kept permanently down.

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If, when all the resistance between A and M is unplugged, the galvanometer still asks for more, the infinity plug should be taken out. If then the direction of the deflection is not reversed there is a mistake in the connections. If everything is correct and the removal of the infinity plug reverses the direction of the deflection as it should, this plug is reinserted and $r = 100$ must be tried, and if this fails $r = 10$. If balance can then not be obtained the fault is very near to the end C. Then the connections of the cable loop to the bridge are reversed, $r$ is made 1,000 or 1,110, and A M is adjusted until balance is obtained.

The formula for the distance of the fault from the end connected to C is

$$x = \frac{r}{r+q} l, \quad \ldots \ldots \quad (20)$$

$q$ being the resistance unplugged between A and M, and $l$ being the length of the loop,

If $l$ is in yards the distance $x$ is also in yards.

If an ordinary stretched wire bridge be used (Fig. 18A), C A M represents the stretched wire, C being the zero end of the scale and A the sliding contact. The key S is replaced by this contact maker on the slider, which must always be released before the slider is moved. The position of the slider is adjusted until no deflection is obtained on depressing the galvanometer key T when the slider key is down.

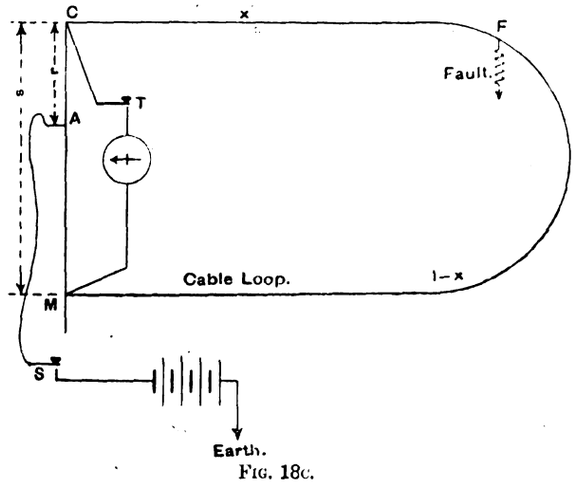


FIG. 18c.

If $s$ is the length of the whole stretched wire C A M, and $r$ is the length of the portion C A when "balance" is obtained, the distance of the fault from C is, as before,

$$x = \frac{r}{s} l \quad \ldots \ldots \quad (21)$$

If a stretched wire bridge with two sliding contacts be used (Fig. 18c), C is again the zero end of the scale, and the slider M is set to the reading on the scale equal to the length of the loop. Then the slider A is adjusted until balance is obtained just as in an ordinary stretched wire bridge. The reading C A will then be the distance of the fault from the end C.

It is always a good plan to reverse the connections of the loop on the bridge, and to make a second test as a check on the first. If the positions of the fault indicated by the two tests differ only by a few yards the mean position should be taken as the correct one. If there is a considerable difference the connections should be looked to and all contacts tightened, The error introduced by contact resistance and the method of avoiding it will be considered later.

*Example I.*—A 37/16 concentric cable, 116 yards long between two substations, had a fault in its outer conductor. The two conductors were known to be of equal resistance. The cable was disconnected from the transformers and short-circuited at one end, and the localisation test was carried out at the other end. A stretched wire bridge not being available, a Post Office pattern bridge was used in conjunction with a reflecting galvanometer. There was no convenient place for the galvanometer quite near to the cable, so the connections between the cable loop and bridge were made with leads of 16 gauge copper wire, each three yards long. (We will call the lead connected to the outer conductor lead 1, and the lead connected to the inner conductor lead 2).

The equivalent length of the loop was, therefore,
$37 \times 3 + 116 + 116 + 37 \times 3 = 111 + 116 + 116 + 111 = 454$ yards.

The connections were made as on Fig. 17B, lead 1 being first connected to C, and lead 2 to M.

$r = 1{,}000$ ohms was first unplugged in the arm A B.

It was found that there was too small a current to be able to determine the balancing value of $q$ more accurately than to within 40 ohms or so. Therefore 100 ohms was substituted for 1,000 in the arm A B; and balance was obtained for $q = 241$.

The connections were now reversed, lead 1 being connected to M, and lead 2 to C. $r = 100$ was unplugged in the arm A B, and balance was obtained for $q = 43$.

From the first test the calculated distance of the fault from the bridge end of lead 1 was

$$\frac{100}{241+100} \times 454 = \frac{45{,}400}{341} = 133 \text{ yards.}$$

and, therefore, 133 − 111 (111 being the equivalent length of one lead) = 22 yards, is the distance of the fault from the testing station.

From the second test, the calculated distance of the fault from the bridge end of lead 2 was

$$\frac{100}{43+100} \times 454 = 317 \text{ yards.}$$

Therefore $454 - 317 = 137$ yards is the distance of the fault from the other end of the loop, that is to say, from the bridge end of lead 1; and, therefore, the distance of the fault from the testing station was, according to the second test, $137 - 111 = 26$ yards.

The mean of these two results, viz., $\frac{22+26}{2} = 24$ yards from the testing station, was taken as the correct position of the fault.

*Example II.*—A loop of 205 yards of 37/14 cable had a fault of low resistance. No testing apparatus was to be had, but a reflecting galvanometer and an ordinary key. The fault was localised as follows:—

About a yard of No. 20 bare-tinned copper wire was chosen and connected across the ends of the loop, a soldered joint being made. Two wires leading to the galvanometer circuit were also soldered on at the same place. One pole of the battery (10 gravity Daniell cells in series) was connected to earth, and the other to a wire which was used to make contact with different points of the bare No. 20 wire. Thus the bridge on Fig. 18A was obtained, the yard of No. 20 wire forming the two arms C.A.M., and the bared end of the wire from the battery constituting the sliding contact point at A. This sliding contact was moved along the bare wire until the position of balance was obtained. This point was then marked, and the length of the wire between it and the nearer cable-end was carefully measured. This length was $11\frac{5}{8}$in., the length of the whole wire between the cable ends being 3ft. $1\frac{1}{4}$in.

Therefore the distance of the fault from the cable-end nearer to the point of balance was

$$\frac{11\frac{5}{8}}{37\frac{1}{4}} \times 205 \text{ yards} = \frac{93 \times 205}{298} = 64 \text{ yards.}$$

*(To be continued.)*

**X-Rays.**—The Natural Research Department of the Animals Institute, under the auspices of Sir Henry Hawkins, President, H.S.H. Prince Edward of Saxe-Weimar and a strong council, are offering gold medals and other prizes for improvements in the X-rays to aid the diagnosis of disease and lameness, and for the best developed photographs of the limbs and internal organs of human beings and the lower animals. Apply, Prof. Matthews, St. Paul's House, Wilton-place, S.W.

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# ON THE PROPERTIES OF A BODY HAVING A NEGATIVE ELECTRIC RESISTANCE.*

BY PROF. SILVANUS P. THOMPSON, F.R.S.

1. In the Paper recently read by Messrs. Frith and Rodgers on the electric arc, the conclusion is drawn that the true resistance of the arc itself may under certain circumstances be a negative quantity. The admissibility of this view, apart from the experimental basis of facts and the arguments employed, is certainly open to question. For, admitting to the full the accuracy of the experimental observations, and reserving for the present any question as to the validity of the arguments, it is impossible to accept so novel a conclusion without raising the question whether there are any *à priori* reasons for or against the possibility of the existence of such a property as a negative electric resistance. Before entering upon any consideration of the validity of the reasoning employed by Messrs. Frith and Rodgers, it is proposed to consider what are the properties of a body having a negative electric resistance, if such a body can exist.

2. Two modes of defining resistance have hitherto been recognised by electricians, based respectively upon two physical phenomena. The one makes resistance the measure of the relation of an applied electromotive force to the resulting current, the other makes it the measure of the amount of energy degraded into heat by the operation of a given current for a given time. The one is bound up in the law of Ohm, the other in the law of Joule.

Writing the law of Ohm in its usual form,

$$\frac{E}{R} = C,$$

and observing that if any two of these quantities are defined the third is defined by the algebraic relation between them, it follows that if E and C are defined as primary quantities the definition of R is necessarily that expressed algebraically as

$$\frac{E}{C} = R. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

According to this definition, the resistance of a conductor expresses the ratio of the electromotive force applied to that conductor to the current thereby produced in it. It is the ratio of cause to effect. And in most cases it is known as an experimental fact that, apart from any secondary effects such as the heating of the conductor or any change in its magnetic state, this ratio is independent of the value of the current, and is for a given piece of conducting material a constant. We have no right, however, particularly in the present inquiry, to make this limitation; for if any substance is found in which the ratio of E to C is not independent of the value of C, the definition of (1) still holds good.

The law of Joule is usually written

$$C^2 R t = W,$$

where W is the amount of heat (expressed in dynamical units) generated in the resistance R in time $t$ by the flow of current C. Hence the implicit definition of R as

$$\frac{W}{C^2 t} = R. \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The definition is also general, including the conceivable case where R is not independent of C; though it is generally supposed and held that, apart from secondary effects as aforesaid, the heat evolved in a conductor by a current in a given time is proportional strictly to the square of the current, the ratio between W and $C^2 t$ being experimentally found to be a constant in all metals.

On consideration it will be noted that some of the methods used by physicists in the so-called determination of the ohm are based on the former definition, while others are based on the latter definition.

There is a third possible definition of resistance based on the law

$$\frac{E^2 t}{R} = W,$$

giving by implication

$$\frac{E^2 t}{W} = R, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

or, the resistance of a conductor is measured by the ratio of the square of the voltage applied to it, to the heat generated in it in a given time. I am not aware that this definition has been made the basis of any of the numerous determinations of the ohm.

3. Now consider what will be the effect of attributing a negative sign to R in the expressions for the laws of Ohm and of Joule. In the former it has the effect of causing an electromotive force of $+E$ to produce a current $-C$; or the current will flow in a sense opposed to that of the electromotive force. Or, if a current C is forced in either sense through a negative resistance, instead of producing a fall of potential in that sense it will produce a rise. In the case of the law of Joule the attribution of a negative sign to R results in the appearance of a negative sign to W; that is to say, a negative resistance is one which, instead of being heated by the passage of a current, is cooled by it. In other words, instead of receiving energy from the circuit and degrading it into heat, the conductor possessing negative resistance will abstract heat from the external system and impart energy to the circuit.

If we consider what is the effect of the magnitude of a negative resistance the logical issues are no less striking. Consider a conductor the resistance of which is at first positive and large. Let it be supposed to be continuously changed so as to become small, diminish to zero, then change sign and become negative, and gradually pass to a large negative value. If during such a series of operations a constant electromotive force is supposed to be applied, the current will be at first small and positive, then larger, then infinitely great, and at the moment when it is infinitely great will change its sense and become an infinitely great negative current which will then subside gradually to a small negative current. If it is said that one may pass from positive to negative values without going through infinity, the logical difficulty recurs that, in order that the positive current should be reduced to zero and thence assume negatively increasing values, the resistance must be first increased to $+\infty$ and then changed *per saltum* to a value of $-\infty$, which is equally inadmissible,

4. It is a familiar circumstance that any counter electromotive force in a circuit acts as a (positive) resistance in producing a drop of potential. This drop of potential, however, does not increase with the current, as is the case with the drop of potential due to a fixed resistance. Were an invariable current used, it would be impossible to discriminate by mere electric tests as to whether the cause of any observed drop of potential was due to the interposition of a resistance, or to the interposition of a counter electromotive force. In like manner, if a rise of potential is observed at any part of a circuit, it might be due either to an adjuvant electromotive force or to a negative resistance, and no electrical tests in which an invariable current was used would enable the two to be discriminated. A (positive) resistance, in fact, acts like a counter-electromotive force that varies in direct proportion to the current; in either case doubling the current would double the drop of potential at that part of the circuit. In like manner a negative resistance acts like an adjuvant electromotive force directly proportional to the current. Indeed, Maxwell's theory of the operation of electric conduction as a displacement which is continually giving way is but a mode of saying that what we call resistance is made up of back electromotive forces proportional to the current; the electric stresses evoked by the current and proportional to it giving up their potential energy (which is proportional to stress and strain jointly, and therefore proportional to the square of the current) to be continuously converted into heat.

It was remarked above that as between a constant (positive) resistance and a counter electromotive force of constant value, there could be no discrimination by electric tests if an invariable current was used; though if the current was varied the difference between the drop of potential in the two cases would furnish a criterion. But as between a constant (positive) resistance and a counter electromotive force varying proportionally with the current this criterion fails; they are identical with respect to any current variable or invariable, unless the counter electromotive force is one that does not change its sense when the current is reversed.

This is not saying that there are no other criteria than purely electric tests. If inspection were to reveal that at any part of a circuit where a drop of potential occurs there was a machine with revolving armature, or some cells performing chemical functions, or simply a long thin wire, a judgment might at once be formed from experience as to the possible cause of the observed drop.

5. One element toward a criterion in such cases is furnished by the consideration of the location of the drop of potential. In a mere resistance the drop is distributed along its length, uniformly distributed if the resistance is also uniform. If the counter electromotive force were also uniformly distributed along the length of the part in which the drop is observed, the drop would be uniformly distributed. But while resistance in the usual case of wires is so uniformly distributed, in the usual cases of counter electromotive forces the distribution is otherwise. All chemical effects are non-distributive—they are always end-effects occurring at electrode surfaces, and the drop of potential which they produce is always an abrupt drop (positive or negative) located at some definite section across the circuit. The electromotive forces due to magneto-electric induction are, on the other hand, though not uniformly, distributive. Thermo-electromotive forces, to which some attention will be presently devoted, are in some cases distinctly localised, in other cases distributive. Saving, however, in the case of magneto-electric induction, electromotive forces are in general localised, while resistances are in general distributive. Hence a *primâ facie* criterion as to whether a drop of potential is due to a counter electromotive force or to a resistance is (with the exception just named) afforded by the nature of the drop of potential as to whether it is localised, or whether it is distributive.

* Paper read before the Physical Society, Friday, June 26th.

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6. Wherever a current flows through a part of a circuit wherein there is a drop of potential, whether localised or distributive, there electric energy leaves the circuit, being transformed into some other form of energy, determined by the physical nature of the process operating at that part of the circuit. Similarly, wherever a current flows through a part of a circuit where there is a rise of potential, whether localised or distributive, there energy is coming into the circuit from some external source, chemical, mechanical, thermal, &c. A negative resistance, as shown in § 3 above, is cooled by the passage of the current and acts as a source of energy.

Suppose then a simple circuit made up of two parts, one a conductor having a certain positive resistance, the other having an equal negative resistance. The total resistance of the circuit being zero, the smallest electromotive force (such for example as a slight movement in the earth's field) would result in an indefinitely great current, warming one half and cooling the other half equally. If the two parts of the circuit were unequal, the negative resistance being the greater, when any current was set up it would absorb more energy in cooling the negative part than it would spend in warming the positive part. The difference would go to increase the current, which, therefore, would be unstable. The circumstance that stability is only consistent with positive coefficients of resistance is pointed out indeed by Maxwell ("Electricity and Magnetism," Art. 300).

7. If a negative resistance is placed in series with positive resistances in a circuit, and a current is transmitted through the series, there will be, as we have seen, a fall of potential along the parts possessing positive resistance and a rise of potential along that possessing negative resistance, since it is impossible in a simple circuit that the current should flow in opposite senses in the different parts at the same time. If, however, a negative resistance is placed in parallel with positive resistances (Fig. 1), the respective currents which flow will be proportional to the resistances, and will in the negative resistance flow in a counter sense. The joint resistance will be the reciprocal of the algebraic sum of the reciprocals of the resistances, and will depend for its sign upon the sign of the algebraic sum.

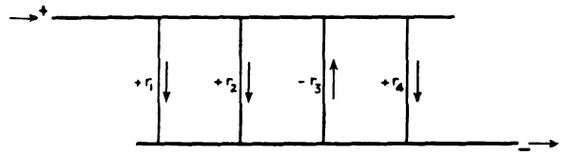


FIG. 1.

8. It was remarked in § 4 that electric tests afford no criterion to discriminate between a constant resistance and a counter electromotive force that is directly proportional to the current (that is, if the electromotive force is, like the electromotive forces of polarisation, always counter, reversing when the current is reversed). As a corollary it follows that the criterion equally fails as between a counter electromotive force of constant value and a resistance that varies inversely as the current. Suppose a resistance, whether positive or negative, to vary inversely as the current. It may be written as $\pm\frac{a}{C}$ where $\pm a$ is the value it has for unit current. If the circuit also includes an ordinary invariable resistance, R, we may write :—

$$\frac{E}{R\pm\frac{a}{C}}=C,$$

whence $$E=CR\pm a,$$

and finally, $$\frac{E\mp a}{R}=C. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In words, the resistance that is inversely proportional to the current is undistinguishable from an electromotive force. If it is a positive resistance it acts as a counter electromotive force, if a negative resistance it acts as an adjuvant electromotive force. No electric test affords the slightest criterion as between the two, unless indeed the electromotive force were one that persisted after the current had ceased.

9. It is most instructive by the light of the foregoing principles to reconsider the phenomenon of thermo-electricity.

First take the Peltier effects, which are localised at junctions. Suppose a piece of iron to be joined in between two pieces of copper in a circuit with junctions $J_1$ $J_2$ (Fig. 2); and that a current is sent from left to right, as indicated by the tailless arrows. Experimentally it is found that $J_1$, where current flows from copper to iron, cools, while $J_2$, where current passes from iron to copper, heats. Clearly there is energy being given out by the circuit at $J_2$, and energy is being received by the circuit at $J_1$. At $J_2$ there is a counter electromotive force located, at $J_1$ an adjuvant electromotive force; and the amounts of heat respectively emitted and absorbed are measures of these two (Peltier) electromotive forces. But there is absolutely nothing in this to show that these are not resistances; that at $J_2$ being a positive resistance inversely proportional to the current, that at $J_1$ a negative resistance also inversely proportional to the current. A presumption that they are not resistances is afforded by the circumstance that they are localised and not distributive. But all doubt is set at rest by the simple experiment of reversing the current. Were these really resistances, whether positive or negative, each would still operate the same way, irrespective of the sense of the current. But they do not do so; $J_2$ now cools, while $J_1$ heats. They are, therefore, each an electromotive force acting always in the sense from copper toward iron (provided always that the temperature is not raised above the neutral point).

Next take the Thomson effects. Suppose an iron bar to be heated at a point B (Fig. 3), situated between two points, A and C, that are colder, and that a current is transmitted from A to C. It is experimentally found that the slope of temperature between A and B is raised, while the slope of temperature between B and C is lowered. In other words, the region between A and B is being warmed, while that between B and C is being cooled by the current. It is as if the piece A B possessed a positive resistance, while the piece B C possessed a negative resistance; and the distributive nature of the effect suggests *prima facie* that these are resistances, not electromotive forces. But again reversing the

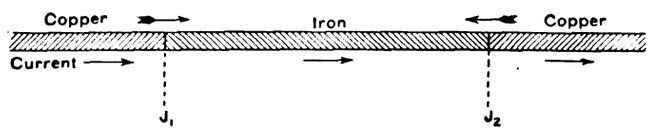


FIG. 2.

current reveals the fact that the effects also reverse. The actions must, therefore, in spite of their distribution, be recognised as due to electromotive forces acting always from hot iron toward cold iron.

10. Turning now to the observations on the arc of Messrs. Frith and Rodgers, it appears that they have found something which acts as a negative resistance, and which, as their own tabular data show, is approximately proportional inversely to the current. Unless there is some other test available, their measurements afford no criterion whatever as to whether that which they have observed is what they suppose it to be, or whether it is simply an adjuvant electromotive force. Unfortunately in this case it is experimentally impossible to reverse the current to see if the effect reverses sign. Moreover, their experiments give no clue as to whether the effect is localised at one point or is distributed along the arc.

A closer examination of their Paper and of its appendix show that they have defined resistance neither according to the law of Ohm nor according to the law of Joule, but in a new way of their own, as the ratio of the increment of V (the potential difference across the arc) to the increment which is given to C. Whether it is legitimate to define $dV/dC$ as the resistance of the arc or of anything else depends upon the question whether R is itself directly or

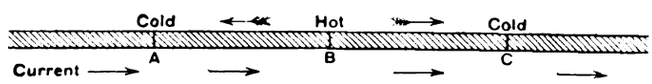


FIG. 3.

indirectly dependent on C. If it is independent, their definition is identical with that resulting from Ohm's law. If it is not independent, then the quantity $dV/dC$ is not the resistance as hitherto defined but means something else. Now their own results show that what they have measured is not independent of the current.

The case may be considered as follows :—Suppose part of the resistance of a circuit to be dependent on the current. Then if C is altered so as to become $C+dC$, the result will be that R becomes $R+dR$; and at the same time, as a result, V will become $V+dV$.

Now by Ohm's law, initially,

$$V=CR, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and $$V+dV=(C+dC)(R+dR)$$

$$=CR+RdC+CdR+dCdR. \quad . \quad . \quad (5)$$

Subtracting (4) from (5) and neglecting the small quantity of the second order, we have

$$dV=RdC+CdR,$$

$$\frac{dV}{dC}=R+C\frac{dR}{dC}.$$

Now Messrs. Frith and Rodgers find that, after discounting the known fixed resistance from the observed values of $dV/dC$, the remainder is a negative quantity approximately inversely proportional to C. Hence we may write

$$\frac{dV}{dC}-R=C\frac{dR}{dC}=-\frac{a}{C},$$



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whence $$\frac{dR}{dC} = -aC^{-2},$$

whence finally $$R = \frac{a}{C} + \text{constant};$$

that is to say, all that their observations prove is that that part of the resistance which is not constant is a positive resistance that varies inversely as the current. Because it varies inversely as the current, the term $\frac{dR}{dC}$ will be negative, and so will be the quantity $C\frac{dR}{dC}$, which is what they have tabulated as a negative resistance. That the resistance of the arc itself should vary inversely as the current is most natural. It may be regarded as a column of vapour, the cross-section of which is proportional to the current, and therefore increasing in its canductance in direct proportion with the current. There is no need even to suppose any (distributive) adjuvant electromotive force, which would be the other alternative to the suggestion they have made.

DISCUSSION.

Mr. SWINBURNE asked if the numbers on which Messrs. Frith and Rodgers based their arguments were obtained by taking successive readings of a voltmeter.

Prof. AYRTON said that what they maintained was, that if the arc acts as if it had a back electromotive force and a resistance, then the resistance is a negative quantity. In ordinary cases we do not know what really constitutes a resistance, but simply say that a circuit in which electrical energy is being dissipated at a rate proportional to the square of the current has resistance. If the loss is proportional to the first power of the current, then we say there exists a back electromotive force. Is it impossible to imagine a circuit in which a loss of electrical energy occurs proportional to the current, and a return of energy to the circuit proportional to $C^2$? If in a curve showing the relation between V and C you draw a tangent at any point, it is not the tangent of the inclination of this tangent which Messrs. Frith and Rodgers have called the resistance; it is another quantity, which they call the electrical $\frac{dV}{dC}$. In conclusion, the author seems to have based his Paper on three misconceptions:—1. That it had been claimed that a negative resistance could exist alone. 2. That the curves given by Messrs. Frith and Rodgers showed that the ordinates were inversely proportional to the current. 3. That what was measured was the geometrical $\frac{dV}{dC}$.

Mr. FRITH said that in a Paper by Mr. Rodgers and himself they had defined the resistance of the arc as the ratio $\frac{dV}{dA}$, where by $\frac{dV}{dA}$ they meant, not what was ordinarily understood by this expression, but the value of the ratio obtained by superposing an alternating current on a direct current arc. In order to show that, in cases analogous with that of the arc, but in which the true resistance can be verified, the electrical $\frac{dV}{dC}$ obtained by superimposing an alternating current gives correct results for the resistance, some experiments have been carried out. In one case a glow lamp was placed in series with some 50-ampere secondary cells and a current sent through against the electromotive force of the cells. The value obtained for the electrical $\frac{dV}{dC}$ agrees very well with the value of the resistance obtained by dividing the potential difference between the terminals of the lamp by the current. At very low frequencies for the superimposed alternating current it is evident that the electrical oscillations would travel along the steady valve curve; and this is clearly the meaning of the critical frequency observed with cored carbons, namely, that under the critical frequency the superimposed alternating current travels on the steady valve curve, and over that frequency along the line, joining the point on the curve and the instantaneous origin.

Mr. FRITH exhibited a mechanical model of the arc which he has devised. This model consists of two rods of carbon dipping in two mercury cups, which are traversed by the current. The current also passes through a solenoid which attracts an iron core attached to the carbon rods and draws them down into the mercury, thus reducing the resistance of the instrument. Hence it can be arranged so that the potential difference between the terminals decreases as the current increases. With this model it is found that, for superimposed oscillatory currents of such a frequency that the moving parts are not able to follow the changes in the current, the oscillations of the current and of potential difference are in phase, and the electrical $\frac{dV}{dC}$ gives the resistance of the apparatus for various currents.

Mr. TREMLETT CARTER asked the author how on his vapour column theory he explained the difference in the behaviour of solid and cored carbons.

Mr. ENWRIGHT asked why it was absurd to suppose that a negative resistance could exist. Prof. Ayrton and Mr. Frith had made in their definitions certain restrictions. It ought, however, not to be necessary to make any such restrictions.

Mr. BLAKESLEY asked if since the title of the Paper by Messrs. Frith and Rodgers was entitled the "*True* Resistance of the Arc," it was to be inferred, as the results given were negative, that a negative ohmic resistance existed in the arc, Prof. Thompson's Paper appeared to him (Mr. Blakesley) to be rather a mathematical than a physical Paper.

Prof. RÜCKER said that the discussion showed that considerable confusion existed, and that the introduction of the term "negative resistance" only tended to fog matters. It was entirely wrong to argue that because you have a quantity with a positive value, therefore a negative value must also be possible. As an example take the case of mass. If you define as a positive mass that which is attracted to the earth, and then found that cork when immersed in water was repelled from the earth, would you therefore say that cork had a negative mass? Is not "negative resistance" a term for which some equivalent could be found which would not lead to confusion?

Prof. THOMPSON, in his reply, said that he did not dispute the accuracy of the results obtained by Messrs. Frith and Rodgers, but it was the interpretation which they had given of their results to which he objected. Mr. Frith now makes a new reservation, namely, that the results depend on the particular way in which the increment of C and the decrement of V are made He supposes that if the experiment is made in a particular way a new slope is obtained which is proportional to what we call the true resistance, and hence gets a new definition of the quantity $\frac{dV}{dC}$. He (the speaker) endorsed all Prof. Ayrton had said as to the interest of the model exhibited. The question is, is there anything in the arc which acts as a source of energy to the circuit, either as a negative resistance or as an adjuvant electromotive force? Mr. Frith's experiments do not give us any hint as to the point where the negative resistance occurs, and the absence of any such energy-giving portion of the arc is rendered probable by the fact that the arc itself is hotter than the crater. In reply to Mr. Carter the anomalies which occur with cored carbons are so great as to prevent any argument being based on their behaviour.

The CHAIRMAN (Captain Abney) said that the mere fact that the quantity $\frac{dV}{dC}$ had been defined in two distinct ways showed that the definitions would have to be modified in some way.

## PROPOSED ELECTRIC TRACTION SCHEME FOR BERLIN.

Dr. M. Kallmann, municipal electrical engineer of the German capital, read a Paper before the Elektrotechnischer Verein of Berlin, a few weeks ago, on "The Organisation of Street Traffic and the Technical Requirements of Electric Tramways in Berlin." He first drew up a picture of the rapid development of the street traffic of Berlin in the last 20 years, and stated that in the relatively small area of about 23 square miles, or about five times smaller than that of London, Berlin with about 1¾ millions of inhabitants, has at present over 310 miles of horse and steam tramlines. These are worked by ten different companies. The concession of the largest expires in 1911. All the undertakings are considering at present the adoption of electric traction, and as there are about 33,000,000 car kilometres (20,460,000 car miles) run annually on the existing horse lines, it would take 17,000,000 kilowatt hours to operate the same electrically. The number of persons carried per car kilometre is five. Dr. Kallmann then dealt with the different systems of electric traction, and he comes to the conclusion that practically 90 per cent. of the lines can be arranged on the overhead system, leaving the remainder to be tackled by some other method. On the latter lines there could be employed either a conduit system or locomotives working with accumulators, or a mixed system as used in Hanover. As regards costs, Dr. Kallmann thinks electric traction would reduce the working expenses from 2·2d. to 1·4d. per car kilometre. The cost of converting the lines would be about £1,175,000. If the supply of current were carried out from one large generating station under the control of the municipality, the cost of energy would not exceed 1·2d. per kilowatt hour. As explained in a former Paper, the municipality might undertake the laying of all the necessary mains and feeders. The undertakers, being thus relieved of the erection of generating stations and cable networks, would be able to quicken the conversion of their lines. The cost of the power stations of a total capacity of 10,000 H.P., which would be required for the working of all the existing horse lines, is estimated by Dr. Kallmann at £300,000, and the cost of the necessary cables at £175,000. With a consumption of about 500 watt hours per car kilometre, and a tariff of 1·1d. per kilowatt hour, the cost of energy per car kilometre would be 0·5d.

A good idea of the working of a central station for light and power is given by the Hamburg station. According to the returns for 1895 the total number of units generated amounted to 5½ millions, of which about 4 millions, or about 75 per cent., were used for traction. The total cost per unit generated was 0·84d., but it is expected that with the erection of 1,000 H P. engines this figure will be reduced to 0·7d. or 0·65d. With a consumption of over 20 million kilowatt hours for all the Berlin tramways the total annual expenses would be from £90,000 to £100,000, which the tramway companies would have to pay to the electricity works.

Dr. Kallmann all through his Paper advocates the centralisation of electric supply stations and their municipal ownership, and believes this to be a great advantage to electric tramway companies.

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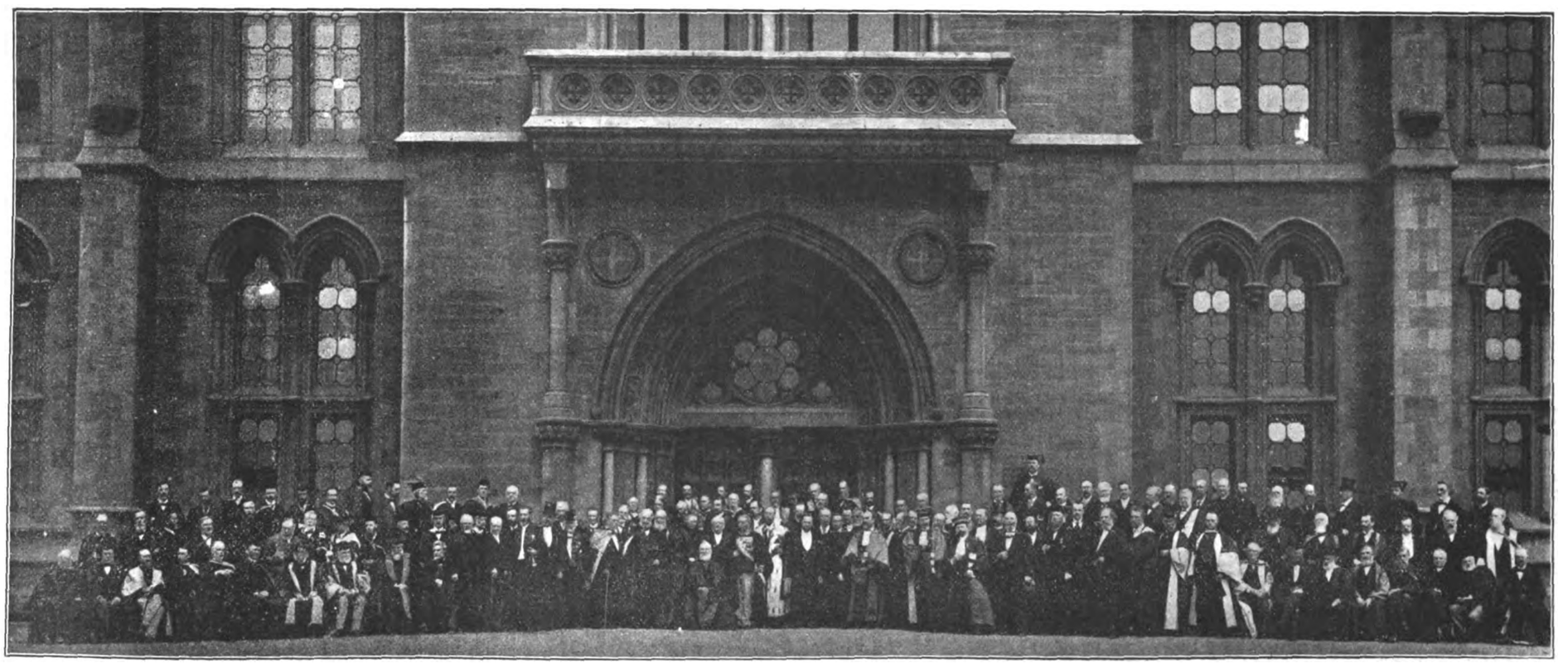
# THE KELVIN JUBILEE.

After the long ceremonial on Tuesday morning, June 16th, the delegates attending the Kelvin Jubilee adjourned to the main entrance of the Glasgow University, and, after much marshalling and driving away of unbidden guests, were forthwith photographed. If colour photography were a completely accomplished fact we should perhaps have been able to give our readers a better idea of this extremely brilliant gathering; as it is, they must rest content with the gray coloured reproduction of the photograph taken by Messrs. Lafayette, of Gordon-street, Glasgow.

In the centre of the group, sitting down between Lady Kelvin and the Italian Ambassador, is Lord KELVIN. Exactly behind Lord Kelvin, hard against the door, the heads of Prof. PERRY, Prof. AYRTON, and Mr. T. C. MARTIN, of the *Electrical Engineer* of New York, are just visible. On the left of the line, as we face it, another aggregation of men well known to our readers will be found. Standing up, the third from the end of the second row, is Dr. JOHN HOPKINSON, with Prof. ANDREW GRAY next beyond him, whilst sitting down in front and between them is Prof. VIRIAMU JONES, Sir G. G. STOKES being only three seats further on. Towering up at the very back, almost directly behind Sir G. G. Stokes, is Dr. OLIVER LODGE. Directly in front of the extreme left pillar of the gateway are M. MASCART and M. HENRI MOISSAN, in the official costume of the Académie des Sciences. Immediately on the other side of the gateway (the right hand as we face it) the heads of Prof. J. M. THOMSON, of King's College, Prof. A. B. W. KENNEDY and Prof. SILVANUS THOMPSON are to be seen, and standing up on Dr. Thompson's left front is the tall figure of Dr. DU BOIS. Exactly in a line with the extreme moulding of the window will be seen the head of Sir FREDERICK ABEL; and just behind, hard against the window, that of Capt. ABNEY, who is next but one to Prof. W. RAMSAY, who is nearly in a line with the central moulding. Coming back to the centre of the group, Prof. G. CAREY-FOSTER will be noticed, standing well on the right of the doorway, as we face it, just behind two extremely mediæval-looking figures; and right at the back, in the corner of the doorway, Prof. W. GRYLLS-ADAMS stands out conspicuously.

Besides those we have mentioned there are several in the group whose names are well known to electrical readers, but the Cartesian equations of whose *loci* are somewhat unmanageable.



GROUP OF DELEGATES.



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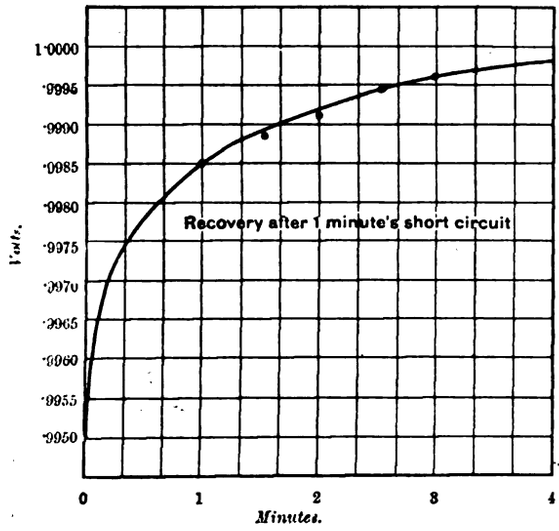
## A ONE-VOLT STANDARD CELL.

BY W. HIBBERT.

For the last two years, the writer has been trying, with the help of one of his assistants, Mr. Sewell, to perfect a 1-volt cell as a standard potential difference. The original stimulus in that direction was partly sentimental, arising from the frequency with which students asked why the nominal standard volt was not actually on sale, in the same way as the standard ohms. Other reasons, however, were not wanting, and I determined to test the merits of a cell which was first designed by Helmholtz for other purposes. It may be well to say at once that all our experience has been of a favourable character. We have had to consider carefully some points which only arise when it is proposed to transport the cells by ordinary carriage, or to fit them for the somewhat rougher experiences of the school and workshop; but in no way has it appeared that the cell was inherently weak or untrustworthy. Some account has already been given of the behaviour of nine of these cells, which we had submitted to Mr. Fisher (see *The Electrician*, March 13th, p. 648).

The general construction of the cell is easily explained. It is in most respects like the Latimer Clark cell now used, with the substitution of chlorides for sulphates. Thus, the active metals are zinc and mercury, the liquid is a solution of chloride of zinc, and the paste is made with mercurous chloride. A diaphragm is required, and the details of this are of some importance.




Mr. Fisher found that the agreement of the cells was "remarkably close, their temperature coefficient negligible, their recovery to full value after charge and discharge accomplished in very much less time than that taken by the Clark standard."

The voltage of the cell depends chiefly on the proportion of zinc chloride that the liquid contains. The density required for 1 volt, is always near 1·380, but impurities are of considerable importance. There are two points of interest here. To begin with the liquid is not so easy to prepare. Zinc chloride is not a crystallisable salt like the zinc sulphate used in the Latimer Clark cell. Purification must, therefore, be sought by more elaborate procedure than recrystallisation. Again, the density given has to be arrived at by careful adjustment, instead of the easily defined "saturation" value of the sulphate. Out of this arises the advantage that the liquid cannot crystallise. Consequently, the internal resistance, which is lower than that of the Latimer Clark cell, remains constant. Again, it is impossible for local differences of density to arise by virtue of crystallisation or solution. These points explain how it is that the new cell may claim to be better than the Latimer Clark. But another advantage is that the temperature coefficient is less than 0·0002 volt per 1°C. This means such a small variation for ordinary temperature changes that it can be neglected. A thermometer is unnecessary, even though there is a certain lag of voltage behind temperature. But even the slight changes which occur can be met, if desired, by adjusting one of two or three cells to give 1 volt at a temperature of 10deg. (say), the other at 20deg. All the ordinary winter and summer temperatures may then be covered by one or other of the cells without fear that any appreciable error will influence the result. It is to be noted that these peculiarities will enable the user to employ the standard cell without any misgiving as to the effect of temporary and local variations in temperature.

We have tested our cells at temperatures as high as 35deg., a week's work under these conditions producing no detectable changes.

We have notes of cells running over the best part of two years, showing a constancy as good as can be wished, so that there seems every ground for confidence that the cell may take a lasting position, and claim to be an improvement on the Latimer Clark.

In conclusion, it may be worth while to give the following "recovery" curve. The cell was short-circuited for one minute, and the voltage then determined at short intervals. It will be seen that the recovery is practically complete in four minutes. This curve may be compared with those for Latimer Clark's cells, given by Mr. Fisher (*The Electrician*, March 13, 1896).

## PHYSICAL SOCIETY.

At an ordinary meeting of the Physical Society on June 26, 1896, Captain Abney, President, in the Chair, Dr. F. BEDELL read a Paper on

**"Admittance and Impedence."**

The Author discusses the application of the method of "vector diagrams" to the solution of questions connected with alternating currents. He shows how, by a consideration of the *loci* of the different lines on such a diagram many problems which require for an analytical solution a lengthy investigation, may be simply and expeditiously solved.

Mr. BLAKESLEY asked the author what was his test of resonance? Was it that the primary current and E.M.F. were exactly in the same or in opposite phase? The term "resonance" was an acoustical one, and he did not see why it should be applied to one particular case in the electrical problem.

Mr. INWARDS asked what degree of accuracy the author had obtained?

The AUTHOR, in reply, said that if the applied E.M.F. and the current were brought into phase by means of a condenser in the secondary, then he called that a case of resonance. The agreement between the experimental and theoretical results was generally within from 1 to 3 per cent.

Prof. S. P. THOMPSON read a Paper on

**"The Properties of a Body having a Negative Resistance."**

This Paper is printed in full, together with an abstract of the discussion, in another part of our issue this week.

**Electric Traction in Rome.**—The Municipality of Rome has approved a measure compelling the Roman Tramways Company to entirely abolish horse traction and to substitute electric traction on its entire network, urban and suburban; the transformation to be completed within four years. The overhead trolley system will be adopted on most lines, with the Siemens underground conduit in the principal thoroughfares. The work will be entrusted partly to the General Electric Company of America and partly to Messrs. Siemens and Halske, of Berlin. The work is in active progress. The motive power will, it is expected, be derived from the Tivoli-Rome transmission, additional power being transmitted by polyphase currents. We learn in this connection that Messrs. Siemens and Halske have for some time past been making, and successfully using, shunt-wound motors for electric traction purposes at Halle, and these will probably be used in Rome. In the new motors the field is so massive and the magnetism is so strongly retained after interruption of the exciting circuit, as to entirely do away with any evil consequences resulting from momentary interruption of the current. The cost of the shunt wound motors is, however, some 15 or 20 per cent. greater than that of the usual series-wound ones.

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## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June 19, 1896.*

**Chicago Electric Elevated Railway.**—The Lake Street Elevated Railway, the second in this country operated exclusively by electricity, was opened in Chicago on June 14. This line was formerly operated by steam power. It runs west from the vicinity of the Masonic Temple, about six and a-half miles. The current is conveyed along the line by a third rail just outside of the guard timbers. This rail is supported by pillar insulators set every six feet, and is protected by two planks set on edge. This arrangement is made to prevent accident from carelessness. Each train is propelled by a motor car which hauls two or three ordinary coaches as trailers. The motorman's cab is at the front right-hand corner of each motor car, and contains the controller and automatic circuit-breaker, the air brake levers and an electrically-driven pump for the compressed air, which pump starts automatically when the pressure in the tanks runs down. From all reports the system is working satisfactorily.

**Obituary.**—Mr. Harrison J. Smith, superintendent of the operating department of the Edison Electric Illuminating Company of this city, on June 14th met with an accident at his home, in a suburb of New York, which resulted in his death on June 16th. Mr. Smith was in his barn and stepped on a plank which was insecurely fastened. He fell to the floor, a distance of 15ft., and sustained a fracture of the skull and internal injuries. Mr. Smith was well known among the electric light people of the country, and had a great number of friends, who were deeply shocked at the news of the accident and his subsequent death. Mr. Smith was president of the National Electrical Exposition Company, under whose auspices the recent electrical exposition was held in New York City.

**The Kelvin Jubilee.**—In connection with the celebration of the 50th anniversary of Lord Kelvin's professorship at the Glasgow University, the Commercial Cable Company, through its president, Mr. John W. Mackay, extended a special invitation to several prominent electrical people and to the electrical press, to meet in its offices in this city on Monday afternoon last, to attend the pleasant ceremony of changing greetings with Lord Kelvin over a special cable circuit arranged for the purpose. Among those who were present were Mr. Nikola Tesla, Mr. Frank Sprague, Dr. Charles E. Emery, Mr. George A. Hamilton, Messrs. John and H. Bottomley, and the representatives of several electrical papers. Various messages of a congratulatory nature were sent to Lord Kelvin, and replies to the same were received.

**The American Bell Telephone Company.**—Notwithstanding the apparently great opposition to the American Bell Telephone Company, the power of that wealthy concern to make money does not seem to be at all affected. The Company has just declared a regular quarterly dividend of 3 per cent. and an extra dividend of 1½ per cent. The last extra dividend declared was 1½ per cent., on December 11, 1895. During the year 1895 a 12 per cent. dividend was declared regularly, and 3 per cent. extra. The stockholders of the Company have subscribed for 17,230 shares of the new issue, leaving but 4,270 to be sold by auction.

**An Abandonment of the Love Conduit System.**—It is reported that the Third Avenue Railroad Company, which has been operating an experimental line on the Love underground conduit system, in the upper part of the city, will extend the lines four miles farther out, but will equip it with an overhead trolley system and abandon the underground. The Company gives as a reason for this step that it had to pay so much for its franchise that it would rather put up an overhead system, which is much cheaper, than go to the expense of building the underground conduit. Besides, it would take about two years to finish the work on the latter system, while the overhead lines can be constructed within two months. While the present underground system seems to be working satisfactorily it does not offer sufficient advantages to warrant its extension.

## CORRESPONDENCE.

### THE RESISTANCE OF THE ARC.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As the lateness of the hour required the meeting of the Physical Society on Friday last to be adjourned with the conclusion of Prof. S. P. Thompson's remarks, there was no opportunity of pointing out that his last argument against the arc behaving as if it possessed a back E.M.F. and a negative resistance was as inconclusive as the other arguments contained in his Paper. This last argument of his was that a negative resistance in the arc would require the arc to be cooler than the carbons, whereas it was known that the arc was hotter than the crater itself.

After the work of Capt. Abney I was not aware that anyone could hold the view that generally the arc itself was hotter than the crater; but as there may be others, who, like Dr. Thompson, are not clear on this point, it may be worth while to describe a result which Mrs. Ayrton mentioned to me and others at the close of the meeting, and which entirely disproves the generality of the view put forward by Dr. Thompson. On using a very thin exploring carbon to ascertain the distribution of potential in an *unconfined* arc she finds, as the result of *daily* experience, that, whereas the end of this exploring carbon is quite rigid and springy when in the arc not close to the positive carbon, it softens so much as to bend when touched against the crater of the positive carbon.

It is true that Prof. Moissan finds that the temperature of the arc increases with the current (*Comptes Rendus*, p. 777, Vol. CXIX., 1894), and that Prof. Violle, expressing agreement with that conclusion, adds that he considers the temperature of the arc is generally higher than that of the positive carbon, and that it increases with the electrical energy expended (*Comptes Rendus*, p. 949, Vol. CXIX., 1894). But these two experimenters expressly state that their results were obtained with arcs *enclosed* in an electric furnace having a *small volume*. Consequently they are not applicable to an *unconfined* arc such as that employed by Messrs. Frith and Rodgers, of which the cross section can expand *ad libitum*.

Further, even if it were a fact that the gaseous portion of an arc were hotter than the carbons, no information could be deduced therefrom as to the character of the resistance of the complete arc, *i.e.*, the resistance (exclusive of back E.M.F.) between a point on the positive carbon and a point on the negative.

But, what is even more interesting, Mrs. Ayrton reminded me that her very first piece of work on the arc consisted in her predicting, and experimentally proving, that what Mr. Frith has called the "geometrical $\frac{dV}{dA}$" must, in the case of an arc formed between cored carbons, differ *in sign* from the "electrical $\frac{dV}{dA}$." And, on looking up the first letter, dated July 15, 1893, which I received from her on my arrival at Chicago, I find that this was unquestionably the case, and that nothing but my own want of appreciation of the importance of that letter has delayed the more general understanding of the point until the present time.

Before quoting from this letter I may mention, for the benefit of those who were not at the last meeting of the Physical Society, that by the "geometrical $\frac{dV}{dA}$" Mr. Frith means the ordinary differential coefficient of the function which gives the *steady* value of V (the P.D. between the carbons) in terms of A (the current flowing); whereas by the "electrical $\frac{dV}{dA}$" he means the ratio which exists between a *small alternating* P.D., and the small alternating current so produced when such a small alternating P.D. is impressed on an ordinary *direct*-current arc.

At the time of my departure for America in June, 1893, the students were engaged in completing the experiments on the effect produced by *suddenly* changing the current that had



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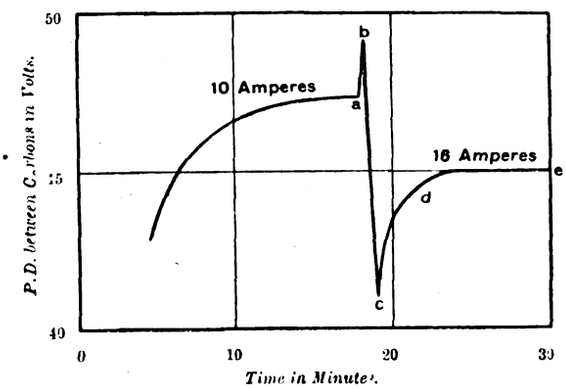
been steadily flowing for some time through an arc of fixed length maintained between a cored positive and a solid negative carbon. The account of these experiments was subsequently given in *The Electrician* for February 15th and March 1, 1895, the three sets of curves in Figs. 24 and 25 of *The Electrician* for March 1st, for a cored positive and a solid negative carbon, having been plotted before Mrs. Ayrton commenced her work on the arc at the end of June, 1893, while those for *both* carbons *solid*, in Fig. 24, were obtained at a later date. Mrs. Ayrton's letter, from which the following is an extract, had reference therefore to experiments with a *cored* positive and a *solid* negative carbon.

"This is my theory of the sudden drop in volts in the time curves when a bigger current is put on, and their gradual rise to a steady potential.

"When the extra current, say 16 amperes, is put on, at the first moment the conducting medium in the arc is only that which conveyed the original current, say, 10 amperes, and has, therefore, too great a resistance for the new current. This great resistance causes a *small first rise of potential*, and a great heating of the positive carbon. Then the carbon there volatilises more abundantly in consequence of this great heating, particles of carbon are melted off and fall on to the negative carbon, creating a *greater* flow of conducting medium than that necessary to conduct 16 amperes. This flow after a time falls to its normal value, and then the P.D. becomes normal. The proofs that this theory is approximately correct are that the *first small rise in potential, which I predicted from it, has been proved to take place every time the current is suddenly changed from a lower to a higher value.* It has never been put down on the curves, because no one noticed it till I pointed out it ought to take place, since when we have all noticed it every time.

"The second proof is that when the current is increased the negative carbon grows suddenly bright and *grows* (in size) for a short time, and then it gradually loses its brightness and decreases (in size) again."

In other words, theoretical reasons led Mrs. Ayrton to the following result, which she confirmed experimentally, three




Change of P.D. with sudden change of Current. Carbons, 13mm. cored; negative, 11mm. solid. Length of arc, 3mm.

years ago, viz., that if a current of a certain value is kept for some time steadily flowing through an arc of fixed length maintained between a cored positive and a solid negative carbon, and then this current is suddenly increased and maintained at a higher value, the P.D. instantly *rises* along some such line as *a b*, then falls very quickly along the line *b c*, and finally creeps slowly along the curved line *c d e* to the new steady value which accompanies the larger value of the current. And Mrs. Ayrton explained that the first instantaneous rise *a b*, which is not shown in any of the curves in Figs. 24 and 25 of *The Electrician* for March 1, 1895, but which is in reality the variation of P.D. that Messrs. Frith and Rodgers have been dealing with, occurs when "the conducting medium in the arc is only that which conveyed the original current"—that is, occurs without any change being produced in the cross-section of the arc, and, therefore, may be used in measuring its resistance.

That the "electrica $\frac{dV}{dA}$" should differ not merely in magnitude but also in sign from the differential coefficient of the *steady* value curve is not surprising, seeing that the latter, which is the only $\frac{dV}{dA}$ considered by Prof. S. P. Thompson in his Paper read at the last meeting of the Physical Society, has no more to do with the experiments of Messrs. Frith and Rodgers than has the differential coefficient of the function of the time which gives the position of a motor car in the ring at the Imperial Institute with the velocity with which the rider would rise if the cylinder burst. But I must confess that I have felt surprise that the curves in Figs. 24 and 25, page 544 of *The Electrician* for March 1, 1895, which purport to represent the "change of P.D. with sudden change of current" contained no indication of a first *rise* of P.D. on increasing the current flowing through an arc produced with a cored positive carbon. Mr. Frith recently suggested to me that the experiments made by Mr. Rodgers and himself indicated that such a first rise in P.D. probably did occur, and that possibly the extreme shortness of its duration was the reason why it had eluded detection in the experiments of 1893. He was, therefore, actually making arrangements to test for it, neither he nor I realising before to-day that the existence of this first sudden rise was both predicted and experimentally proved by Mrs. Ayrton three years ago.—Yours, &c.,

W. E. Ayrton.

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TO THE EDITOR OF THE ELECTRICIAN.

Sir: Prof. Ayrton's letter, of which by the courtesy of the Editor I have been favoured with a copy, raises several points for brief reply.

1. I have nothing but admiration for the exceedingly interesting experiments of Messrs. Frith and Rodgers, and not less for those of Mrs. Ayrton. The only dispute that can arise is concerning the interpretation of results.

2. Prof. Ayrton misses the point that I raised last in speaking in reply at the Physical Society. I remarked that as yet there was no evidence as to the location of the negative $dV/dA$, but that, assuming that it was distributed along the arc, then on the interpretation that a negative $dV/dA$ meant an absorption of energy it would follow that the arc itself must be cooler than the carbons. I did not go on to say that "it was known that the arc was hotter than the crater itself." I was aware that Violle had held this view on the strength of some experiments on a zinc arc; but I had other reasons for thinking, particularly in the case of cored carbons, that the arc is cooler than the crater. I therefore threw out the suggestion, not as an argument to score a point in debate, but as a clue to the discovery of the truth, regardless whether it should tell on the one side or the other in the mere controversy. But Prof. Ayrton must remember, if he relies on the arc temperature to prove the case he champions, that he has got to account for opposite results in the case of cored and of uncored carbons; and that if he is right, cored carbons should produce the *hotter* arcs.

3. Have I misunderstood Mr. Frith or Prof. Ayrton? In Mr. Frith's experiments, was not the current the independent variable? I was under the impression that in his experiments he was operating on the continuous current of an ordinary arc, causing small alternating changes in its value, and then observing the resulting small alternating change of voltage; but now Prof. Ayrton says "a small alternating P.D. is impressed" on the ordinary continuous-current arc, and that Mr. Frith has been measuring "the small alternating current so produced," It may not be of great importance, but it is of some, to know which was cause and which was effect. Is it not a fact that in Mr. Frith's experiments $dA$ is the cause and $dV$ the effect?

4. How it happens that one of the two $dV/dA$'s can be electrical and the other not, is not very clear, when both $dV$'s are differences of voltage and both $dA$'s differences of current. It is quite certain that Mr. Frith's experiments were not made by going from one steady value to another, but by performing small cyclic operations. The surprising thing would have been if the cyclic operation had not given a different result from the transition from one steady value to another. It is known and admitted all round that the values of $dV/dA$ for a transition from one steady value of A to another do not measure the true resistance. But the fact that the values of the cyclic $dV/dA$ differ from those of the $dV/dA$ for transition does not *prove* that this cyclic $dV/dA$ is a measure of the true resistance. In fact, down to the present time no proof has been put forward that in an arc the cyclic $dV/dA$ is a measure of the true resistance. On

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the contrary, the circumstance that in some arcs the cyclic $dV/dA$ has negative values is *prima facie* evidence to every physicist that what it is measuring is not the resistance.—Yours, &c., SILVANUS P. THOMPSON.

[In view of Mrs. Ayrton's discovery, and the obvious ambiguity in speaking of an "electrical $dV/dA$" and a "geometrical $dV/dA$," we would suggest that the terms "unstable $dV/dA$" and "stable $dV/dA$" be employed respectively for the two sets of conditions.—ED. *E.*]

# LEGAL INTELLIGENCE.

## Medhurst v. Kyffin.

In the Queen's Bench Division, yesterday (Thursday), this case came before Mr. Justice Kennedy and a special jury. It was brought by Mr. F. H. Medhurst to recover from the defendant, J. B. Kyffin, a draper and clothier, of Hackney-road, London, N., damages for alleged slander. The defendant denied that he spoke and published the words complained of, and, alternatively, that if he did speak them, they were privileged and spoken without malice.

Sir EDWARD CLARKE, Q.C., for the plaintiff, said that the plaintiff was a consulting electrical engineer and a member of the Institution of Electrical Engineers, holding several public appointments. In the early part of July, 1895, the plaintiff was invited to become consulting electrical engineer to the Vestry of Hackney (London), as the Vestry had determined to adopt electric lighting. A committee had been formed, consisting of 12 members of the Vestry, the Chairman of which was a Mr. Sheehan. Amongst the members of the Committee was the defendant and a Mr. George Raper, who would be called as a witness. The constitution of that Committee seemed to have annoyed the defendant. On July 17th the plaintiff received a letter from the clerk to the Vestry, acting under the instructions of the Electric Lighting Committee, asking him to attend the various places the Committee desired to visit in order to test and examine the different systems of electric lighting. On August 8, 1895, the Committee went to Portsmouth, the defendant being accompanied by his son, a young man 17 or 18 years of age, who was desirous of becoming an electrical engineer. While they were at Portsmouth the defendant's son spoke to the plaintiff on the subject, and the plaintiff told him to call and see him at his office. Next day the young man called and asked the plaintiff to take him into his office. This, however, the plaintiff refused to do, telling him that he thought it very likely his motives for doing such a thing would be misinterpreted. This seemed to have annoyed the defendant, and on August 21st he, in a conversation with Mr. Raper said, "Mr. Raper, I say, have you heard the scandals which are going about in reference to the Electric Lighting Committee. I heard Medhurst has given Sheehan a £50 note." This was (said the learned counsel) a very serious accusation against Mr. Medhurst, as well as against the Chairman of the Committee, and Mr. Raper thought it his duty to see the plaintiff on the subject, and on August 23rd he, accompanied by a friend named Shandor, went and saw the defendant and had a conversation with him. Mr. Kyffin admitted at that interview that he did tell Raper about the rumours as to the plaintiff bribing the Chairman with £50. He also went on to say that during the visit of the Committee to Portsmouth Alderman Ellis called his son aside and warned him against the plaintiff. He said that Ellis told his son that he (the defendant) ought to be careful about the plaintiff being entrusted with the installation scheme, and that he had heard some damaging things about the plaintiff. At that meeting the defendant was asked who was answerable for the statement as to the bribe, but the defendant declined to say. The matter was then reported to the plaintiff and to Mr. Sheehan, and on August 24th the plaintiff, Mr. Shandor and Mr. Sheehan had an interview with the defendant, and then the defendant promised to get the person who was answerable for the statement to repeat it before Mr. Raper. During conversation Mr. Raper asked the defendant whether it was a Mr. Pressland who had made the statement. Mr. Pressland was an electrical engineer, who was endeavouring to be appointed as consulting electrical engineer to the Vestry. Mr. Kyffin then denied that it was Pressland who made the statement, but on another occasion he said it was Pressland, although he did not give the name in writing. On the 13th of September, after Mr. Medhurst and Mr. Sheehan had denied that there was any truth in the rumours, the defendant said to Mr. Raper: "You know Medhurst will never be electrical engineer for Hackney. Neither will Sheehan be Chairman. This will be an Old Bailey case, after which it will be public property."

On September 12th the plaintiff instructed his solicitors to write to the defendant, and on September 16th he (the plaintiff) received the following letter from the defendant:—"Sir: Mr. Pressland called on Wednesday as arranged, and I was prepared to have done what I could to have helped you in this matter; but as you have thought fit to threaten me before giving the information I promised to do, I must now leave you to do your worst and I will do my best."

On September 17th a special meeting of the Committee took place, it being called at the request of the plaintiff, who was present, the defendant and the other members of the Committee being also present. The defendant then declined to give the name of his informant, but he asked permission to second a resolution expressing unabated confidence in Mr. Sheehan. This, Sir Edward Clarke said, was a very peculiar thing for the defendant to do, because, if Mr. Sheehan did not receive the £50 note, Mr. Medhurst was entitled to receive atonement for what took place.

Continuing, the learned counsel said that on September 25th the defendant wrote in answer to a letter written to him on August 23rd by the plaintiff's solicitors, the following letter: "I am in receipt of yours of the 23rd inst. The whole question was submitted to a committee of the Hackney Vestry, and their decision taken thereon, Mr. Medhurst and myself both being present. The incident, as far as I am concerned, is closed." That, said the learned counsel, was untrue, as the opinion of the Committee was not taken thereon. A resolution was passed that the Committee should take no action in the matter while the controversy was pending between the plaintiff and the defendant. The plaintiff made his report on the electrical supply question on November 27, 1895. It was accepted by the Committee and passed by the general body of the Vestry, but it had since been referred back to the Committee, of which the defendant was a member, and from the time it was referred back until now the consideration of it was postponed from time to time by the Committee. Whether that had been done in any way through the influence of the defendant he (the learned counsel) could not say. There could be no doubt, however, that the position was a very serious one for the plaintiff.

The plaintiff and Mr. Raper gave evidence in support of the opening statement of counsel, the former stating that he told the defendant that if he would give the name of his authority for circulating the rumours and apologised he would be satisfied, and that the defendant had never expressed any regret for what had happened.

Mr. COCK, Q.C., for defendant, said that the question before the jury was one of great importance to public men, and he maintained that the defendant had from beginning to end done no more than it was his bounden duty to do under all the circumstances. The occasion on which the words complained of were used was a privileged one. Unless the jury believed that the defendant acted from some evil or vindictive motive he was entitled to their verdict.

Defendant was placed in the witness-box, and practically admitted having made the statement in question to Mr. Raper. He had no ill-feeling against Mr. Medhurst or against Mr. Sheehan. He had not circulated the statement outside, but had only made it to Mr. Raper. He had never been in favour of Pressland having the work. Pressland had not denied to him that he had made the statement. The sum Pressland told him was, he thought, £50. Mr. Medhurst's pay if the whole scheme was carried out would be about £4,000, but that work had not yet been begun.

Sir E. CLARKE said that he heard with amazement the statement made by the defendant in the box, when he was given an opportunity of withdrawing the slander, that he would express no opinion upon it, and in face of the state of affairs he asked the jury to give his client such damages as would compensate him for the injury which his reputation had sustained.

The summing up was postponed till to-day (Friday).

## Westminster Electric Supply Corporation v. Young.

This was an action, tried at the Westminster County Court on Tuesday, in which the plaintiffs sought to recover payment in respect of electric current supplied to defendant at his rooms in Endsleigh-gardens.—Plaintiffs stated that for some time the defendant was supplied with the current, but owing to his failure to pay the supply was cut off, and he was subsequently sued, and judgment was recovered against him. He had made no attempt to satisfy the judgment, however, and the plaintiffs now asked that an order of committal might be made against him.—His Honour ordered payment to be made in a month, or defendant to be committed to Holloway for 12 days in default.

## Bennett v. Druce.

In the Chancery Court of Lancashire, on Friday last, a motion was made on behalf of the plaintiff, Mr. Frederick Francis Bennett, of Preston, for the appointment of a receiver and manager of the partnership business of electrical engineers, carried on at Preston by the plaintiff and Mr. William Haviland Druce, of the same place, and 33, Brazenose-street, Manchester, under the style of Bennett and Druce. Mr. Mansfield, who appeared in support of the motion, said that the plaintiff had issued a writ claiming a dissolution of the partnership, which was entered into in 1893 for 10 years, and an order to compel the defendant to make good certain losses, to pay damages for injuries to the partnership business by reason of the defendant's misconduct, and for the appointment of Mr. James Todd, chartered accountant, Preston, as receiver and manager. The defendant commenced proceedings against the plaintiff on April 10th for taking an account of the partnership, for winding up the affairs of the business, and for the appointment of a receiver. An appearance was duly entered, but no further steps were taken until the plaintiff had obtained leave to serve notice of the present motion, when the plaintiff was served with notice of motion for the appointment of a receiver in the first action. Both parties had nominated the same gentleman as receiver, Mr. Eastwood, for the defendant, said that after the commencement of the first action the parties met privately, and negotiations were entered into for a settlement of the differences. Those negotiations were only abandoned a few days ago, and as it was alleged that the plaintiff had paid partnership moneys into his private account notice of motion was given for a receiver. Counsel, therefore, submitted that the plaintiff's present proceedings were vexatious and oppressive. The Vice-Chancellor said that as both parties wanted a dissolution, and both had nominated the same man as receiver, the best and cheapest course was to appoint the gentleman named, and for the partners to come together and let the receiver settle their differences. By adopting this course they would save a great deal of costs which would necessarily be incurred if the whole matter had to be fought out through the various stages of the action. The parties having agreed to treat the motion as the trial of the



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action, the Vice-Chancellor gave judgment dissolving the partnership, directing the usual accounts to be taken and the partnership assets to be sold, and appointing Mr. Todd receiver and manager, costs to be reserved, The Judge further decided that Mr. Druce should be constituted plaintiff, but if there was any delay he would be deprived of the conduct of the case.

### Rose v. Smiths (Limited).

On Tuesday at Edinburgh, Sheriff Rutherford delivered judgment in an action brought to recover £29. 6s. damages for breach of contract. Pursuer claimed for expenses incurred through the defenders' failure to execute an electric light wiring contract with expedition, fees paid to an expert for inspecting the work done by defenders, for costs incurred in the removal of furniture in consequence of alleged carelessness on the part of defenders' workmen. The Sheriff found that the pursuer's house should have been ready for occupation at least a fortnight sooner than it was, and that the pursuer's caretaker was justified in ordering the removal of the furniture to prevent it from being injured, and assessed the damages at £21. 6s., disallowing the expert's fee (£4. 4s.). Judgment accordingly with costs.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations**

### NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied. price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application,

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

TENDERS INVITED.—The Vestry of St. Mary, Battersea, invite tenders for the supply and erection of boiler house plant, engine house plant, switchboard and connections, accumulators, wiring and fittings, &c., for electrically lighting the municipal buildings and Town Hall. Tenders to Mr. W. Marcus Wilkins, Vestry clerk, Municipal-buildings, Lavender-hill, S.W., by noon, 14th inst.

——— The Municipal Council of Mexico invite tenders for an electric light installation capable of supplying current to 600 arcs and 150 incandescents. The illuminating power of the arc lamps must be between 1,200 and 2,000 c.p., and of the incandescents 50 c.p. Contractors may tender for a high or low-tension supply system, but plans of the electrical plant and apparatus, lamp pillars, &c., must be submitted to the Council. Tenders must be accompanied with a deposit of £1,000, and be sent in to Señor D. Juan Bribiesca, Secretary, City Council, Mexico, by August 31st. A pamphlet containing further particulars can be seen at the Commercial Department of the Foreign Office, between 11 and 6.

——— The Royal Portuguese Railway Company invite tenders for 10,000 porcelain insulators with galvanised iron supports. Tenders must be sent to the Company's Offices, 28, rue de Chateaudun, Paris, by the 22nd inst.

——— The Cologne Town Council invite tenders for constructing and working 12½ miles of tramways, the motive power to be electricity. Tenders to der Registrateur B des Oberburgermeisteramt, Köln, Germany, by November 6th.

——— The Secretary of State for War issues a notice that tenders for certain quantities of electrical instruments (submarine mining), telegraph cable and wire, india-rubber goods and other stores will be invited from time to time during the coming twelve months, and that manufacturers who wish to place their goods before the authorities are requested to send particulars, accompanied by references, to Mr. A. Major, Director of Army Contracts, War Office, Pall Mall, S.W. Firms already on the War Office list need not furnish the particulars referred to.

——— Tenders are invited for the supply of engine-room stores, picks, shovels and other tools and material for the Ayr Electricity Works. Tenders by the 6th inst. to the Town Clerk, Ayr.

TENDERS ACCEPTED.—The Leeds City Council have, on the recommendation of the Highways Committee, accepted the following tenders for electrically equipping the Kirkstall-Roundhay tramways:—

| | | |
|---|---|---|
| Greenwood and Batley, Leeds | electric motor cars | £14,000 |
| Ditto | underground conduits and conductors | 4,553 |
| Ditto | steam engines | 3,507 |
| Ditto | dynamos, &c. | 3,200 |
| Clayton and Co., Leeds | boilers, &c. | 1 371 |
| Jas. Russell and Sons, Leeds | poles and brackets | 3,607 |
| Chloride Electrical Storage Syndicate, Clifton Junction | accumulators and switches | 1,341 |
| J. S. Wright, Leeds | generating station buildings | 5,815 |
| | | £37,394 |
| Crompton and Co., London | trolley wires and attachments | *3,370 |

* Since withdrawn.

——— The Cardiff Town Council have accepted the tenders of Messrs. Easton, Anderson and Goolden (Limited) for the supply of an evaporative condenser, and of Messrs. Siemens Bros. and Co. for the supply of concentric cables at £593. 15s., for the electricity department.

——— The Hammersmith Vestry have decided to accept the following tenders:—

| | | | |
|---|---|---|---|
| Callender's Company | mains | £10,170 | 2 11 |
| Siemens Bros. | arc lamps | 2,702 | 0 0 |
| Ditto | transformers | 935 | 0 0 |
| Marshall, Fleming and Jack | overhead traveller | 157 | 0 0 |

——— The Hampstead Vestry received five tenders for the erection of the extension to the electricity station buildings in Finchley-road; and it has been decided to accept the lowest, that of Messrs. Chesham and Sons, at £7,499.

TENDERS RECEIVED.—The Shoreditch Vestry received eight tenders for wiring and fitting up for the electric light the dust destructor and electricity supply station. The amounts of the tenders ranged from £428. 9s. 6d. (Messrs. Laing, Wharton and Down) to £950 (Brush Company). The tenders are being considered by the Lighting Committee.

APPOINTMENT.—Mr. C. S. Vesey Brown, borough electrical engineer of Sunderland, has been appointed electrical engineer to the Lincoln Corporation, at a salary of £300 per annum.

APPOINTMENT VACANT.—For the English Electricity Works in Madrid a chief electrical engineer is required. Particulars of the appointment are briefly set out in our advertisement columns. Commencing salary is £500 per annum, with bonus. Applications have to be sent in to Mr. R. Hammond, Ormond House, Great Trinity-lane, London, E.C., by Saturday, 11th inst.

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APPOINTMENTS VACANT.—From our advertisement columns it will be seen that an assistant lecturer and demonstrator of physics is required by the Firth College, Sheffield, after Michaelmas next. Salary, £120 per annum, together with certain allowances. Applications to the Registrar by July 9th.

——— An assistant lecturer and demonstrator in technical electricity is required for the Physics department of the Yorkshire College, Leeds. Salary, £125, with certain fees. Particulars from the Secretary. Some additional information is given in our advertisement columns.

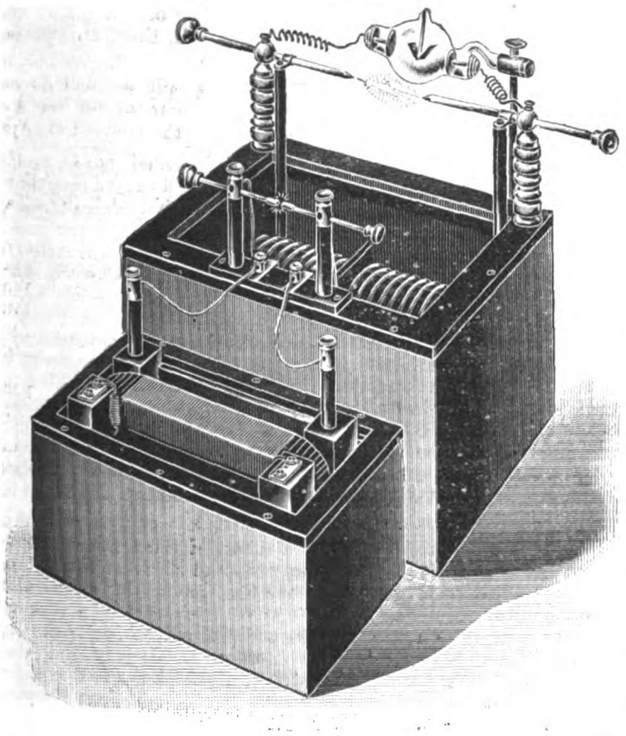
——— A junior demonstrator in physics is required at Owens College, Manchester. Applications to the Registrar by the 9th inst.

BUSINESS CHANGE.—Mr. F. C. Allsop informs us that he has taken new City offices at 97, Queen Victoria-street, E.C., and that a new catalogue of his manufactures will shortly be ready.

RETIREMENT.—Mr. Wm. Wood, Superintendent of Postal Telegraphs, Edinburgh, retired on the 30th ult., after nearly 47 years' service. He began telegraph work in 1850 with the Electric and International Company at York, and, after serving at Scarborough, Edinburgh (twice), Newcastle, Glasgow and Leith, in 1872 was finally transferred to Edinburgh, where he remained for 24 years.

LIQUIDATION.—A meeting will be held on the 27th inst. at 86, King-street, Manchester, to receive an account of the winding up of Sir James Farmer and Sons (Limited), electrical and mechanical engineers.

"TESLA" TRANSFORMERS.—The accompanying illustration represents a high-tension transformer set recently supplied by Messrs. Miller and Woods to St. Bartholomew's Hospital. It is used for working vacuum tubes in connection with the Röntgen photography of injured limbs, &c. The transformer is the invention of



Mr. Miller, and is the subject of an application for patent. The makers term it a Tesla transformer, but we are not aware that it is worked under licence of the Tesla patents, or is in any way, except by name, connected with Tesla's personal inventions. The transformer is designed to work on ordinary alternate-current supply mains.

ASBESTOS PAPER INSULATION.—We have received a sample of asbestos paper, manufactured under a process invented by Mr. J. F. Green. The fireproof and insulating properties of asbestos are well known and appreciated by engineers; and, in the form in which the material is worked up by Mr. Green's process, it is convenient for handling and serviceable for use as an insulating medium between metal surfaces. The paper is stated to have withstood an electrical pressure of 12,000 volts applied to a single thickness of 0·009in.

ALTERNATE-CURRENT TRANSFORMERS.—We have received the following note from the general manager of the Consolidated Telephone Construction and Manufacturing Company:—

"My attention has been called to a statement from Messrs. Johnson and Phillips in your issue of two weeks ago respecting the above, a statement no doubt born of a notice of ours in the preceding week. I shall be glad if I may say that we have no intention whatever of infringing anybody's rights or patents that may be legitimately existing for transformers or any other appliances, least of all have we any intention of giving umbrage to firms with whom we are on such good terms as Messrs. Johnson and Phillips. Our remark as to our new works manager having been long associated with Mr. Gisbert Kapp was only meant to convey a certain amount of guarantee of our fitness to produce these important appliances and not that we intended copying any design of Mr. Kapp's which may be the property of Messrs. Johnson and Phillips."

AWARDS.—The Electrical Standardizing, Testing and Training Institution, as a result of the recent Scholarship examination, have made the following awards:—To Mr. R. Pearson Russell, Royal Academy, Woolwich, a "Maxwell" Scholarship of 50 guineas, tenable for two years; to Mr. E. A. Thompson, Dulwich College, an exhibition of 35 guineas, tenable for two years; to Mr. John Petrie, Carlisle Grammar School, Mr. H. K. Rodwell, Felsted School, and Mr. C. C. Hurford, Epsom College, prizes of 20, 10 and 5 guineas respectively.

CHARTERED INSTITUTE OF PATENT AGENTS.—Members of this Institute dined together at the Café Royal last evening to meet the Hon. J. S. Seymour, the Commissioner of Patents of the United States. The guests included the Attorney-General (Sir Richard Webster), the Comptroller-General of Patents (Sir H. Reader Lack), Prof. Dewar, and many other gentlemen. The chair was occupied by the president of the Institute, Mr. Lloyd Wise, well supported by members of the Council, and Fellows and Associates of the Institute.

"CASSIER'S MAGAZINE."—The contents of the July number of this magazine include: "A Novel Seashore Electric Railway," by Magnus Volk; "Steam Boilers, their Equipment and Management," by Albert A. Cary; "Vertical v. Horizontal Turbines," by Samuel Webber; "Foundry Cranes," by A. E. Outerbridge, jun.; "Locomotives of the Great Western Railway, England," "Megass and Refuse Furnaces," "American Practice in the Use of Steam for Pumping Water," "Water Works Machinery," and "Early American Saw Mills."

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ABYSSINIA.—It is stated that in order to obviate any damage being done to telegraphs and telephones in Abyssinia, the Emperor Menelik has caused an announcement to be made by the priests that the telegraph and telephone are sacred objects. The Emperor's palace is stated to be in both telegraphic and telephonic connection with the principal centres of population in Abyssinia.

ASYLUM LIGHTING.—The Somerset County Council have instructed the Finance Committee to make provision for the installation of the electric light at the new asylum at Cotford, at an estimated cost of £3,500.

BILBAO (SPAIN).—The British Consul at Bilbao reports that the use of electric current is daily increasing in this district. "The light is used in streets, in villages, on the river, and in many houses. An electric tramway has been laid down from Bilbao to Santurce, and another is under construction down the right bank of the river. But I do not notice the names of British firms on any of the apparatus. None of it is made in Spain (the manufacture of batteries has just begun here); all has to be imported, so that there is a fair field for competition. The only thing is that the Germans have got the start. I should think it well worth the while of British firms to try whether they cannot secure part of the business. Even if they cannot compete in price it is to be hoped that they can excel in quality, and I may observe that, as regards price, the Germans are handicapped by the payment of a heavy duty. If these remarks meet the eye of electrical plant manufacturers they will (that is, the more enterprising ones), unless they are different from other manufacturers, write to ask me for lists of firms to which they may send their price lists, which are made out in English, and I shall reply that a list of firms will be found in the *Libro de Bilbao*, published by Larrañaga y Lejarcegui, Calle de Iedesma, No. 22, Bilbao, who will send it post free for 3s., but that it is far the best plan to send a traveller. The fact is that a traveller is almost necessary when it is desired to supersede an article already in possession, but unfortunately the use of travellers never seems to commend itself to British firms."

BOURNEMOUTH.—The District Council have asked the local Electric Light Company to submit a scheme and estimates for lighting the pier.

BRISTOL.—The reports and plans of the borough electrical engineer and architect for the extension of the electricity station have been passed by the Electrical Committee, and as soon as the Local Government Board sanction the borrowing of an additional sum of £75,000 the works will be commenced. Many applications for current are being received, but it has been decided to defer making connections or further extensions of the mains until they can be undertaken out of the profits of the department.

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BURY (SUFFOLK).—The Ratepayers' Association have passed a resolution protesting against the proposed expenditure of the Council on the introduction of the electric light and other improvements. The Chairman of the Electric Light Committee has received a letter from Messrs. Laurence, Scott and Co. (Limited) correcting certain erroneous statements made by Alderman Ridley during a recent discussion on the electric lighting question as to the financial position of the Norwich Electricity Company. The firm enclosed a copy of the last report of the Norwich Company, and we append the following extract from the communication :—

"Since the annual meeting of the Norwich Company the business has been growing faster than it has ever done before, and the remarks of Alderman Ridley, which were evidently meant to give the impression that only some of the larger places had adopted the light, are most misleading. Practically all the larger places of business have adopted the electric light. In the principal streets three-quarters of the shop-keepers have adopted it. The Norfolk and Norwich and the Bethel Hospitals have recently adopted it. Six or seven places of worship have it, and now that the mains are extended in residential districts, private houses are taking the electric light very fast indeed. Moreover, there are considerably over 30 electric motors driven off the electric mains. These are employed by builders, hairdressers, shoe manufacturers, printers, &c., and they cannot but help to tend to develop the trade of the city. Altogether there are upwards of 600 customers of the Company."

CARDIFF.—On the occasion of their recent visit to the Cardiff Exhibition the Prince and Princess of Wales visited the electric lighting works established by Messrs Strode and Co., and took a great interest in the plant and apparatus, complimenting Mr. Strode on the admirable effect produced by the lighting arrangements. His Royal Highness accepted a portable battery and lamp as a souvenir of his visit.

COLCHESTER.—The Town Council have decided to make a canvass of ratepayers and tradesmen in order to ascertain the amount of support likely to be accorded to their electric lighting scheme.

COST OF ELECTRIC CURRENT IN THE CITY.—At the last meeting of the London Common Council Mr. Brooke Hitching asked the Chairman of the Committee of Sewers if, as the electric lighting companies outside the metropolis had reduced the price of electric current, the Commission would approach the City of London Electric Lighting Company with a view to inducing that Company to make a reduction in its charges. Mr. Turner, the Chairman, replied he was not in a position to answer the question, but Sir A. Altman said a member of the Commission would probably bring the matter before that body.

EAST GRINSTEAD (SUSSEX).—The East Grinstead Electric Lighting Company, which has only just been formed, has notified the District Council of its intention to apply for a Provisional Order. The matter is being considered by the General Purposes Committee.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from June 24th to June 30th, with the ports of destination :—

*Australasia*—Adelaide, £27; Albany, £1,374 (telegraph materials); Fremantle, £450; King George's Sound, £82; Melbourne, £383; Port Darwin, £150 (telegraph apparatus); Sydney, £501; Wellington, £44. *Belgium*—Antwerp, £42; Brussels, £2,756; Ostend, £372. *Ceylon*—Colombo, £76. *Chili*—Valparaiso, £100. *Egypt*—Port Said, £66. *France*—Brest, £2,500 (telegraph material). *Holland*—Amsterdam, £75; Flushing, £193. *India*—Calcutta, £25. *Japan*—Kobe, £297 (telephone wire). *Portugal*—Lisbon, £15; Oporto, £20 (telegraph material). *Russia*—St. Petersburg, £55. *St. Helena*—£8. *South Africa*—Cape Town, £18; Delagoa Bay, £175; Durban, £1,175; Mozambique, £17 (telegraph material); Port Elizabeth, £1,564. *Straits Settlements*—Singapore, £16. *Sweden*—Gothenburg, £83 (telegraph wire); Stockholm, £210 (including £175 telegraph material). *United States*—Baltimore, £28 (telephone material).

FERMOY.—It is proposed to form a company for the purpose of establishing electricity supply works in this town. In the event of the company being floated the Town Commissioners have decided to take current for public lighting. Mr. F. J. Warden-Stevens is consulting engineer for the scheme, and a circular has been sent out to the ratepayers in order to ascertain the probable demand for current for private lighting. At a recent meeting of the Commissioners the members guaranteed to take 300 lights.

FOLKESTONE.—The Town Council have decided to engage Dr. J. Hopkinson to report upon the terms of the agreement for the transfer of the Council's Provisional Order to Mr. Hopkins.

GLASGOW.—The Mechanical Traction Sub-Committee have considered the reports of the two deputations which recently visited Hamburg for the purpose of inspecting the electric tramway system of that town, and have unanimously decided to recommend the Tramways Committee to equip at the earliest possible date the Kelvinside-Dennistoun tramway route on the overhead electric system. The cost of equipping this section of the tramways is estimated at £70,000.

HALIFAX.—The new infirmary is now lighted electrically. The plant includes a 52 H.P. Bumsted and Chandler steam engine, coupled direct to a Greenwood and Batley dynamo. A reserve plant, consisting of a 10 H.P. Crossley gas engine and dynamo, has also been provided. In addition, a complete electric bell and telephone installation has been erected by the contractors, Messrs. Ullathorne and Hartley and S. J. Waring and Sons (Limited).

HAMPSTEAD (LONDON).—The demand for electric current in this district increases at a satisfactory rate. At Christmas last the Electric Light Committee had received 261 applications, and there was an equivalent of 19,407 8 c.p. lamps connected, while at the present time there are 385 customers and 25,292 8 c.p. lamps connected. It has been decided to give an order for high and low-tension cables for further extensions to the Prescot Company. The owners of the three-wire patent (the Westinghouse Company) have written as to the system of supply employed by the Vestry and as to obtaining a licence to use same. The Vestry have, however, decided to repudiate the claims of the Company.

HOSPITAL LIGHTING.—The Crewe Town Council are going to expend £800 in installing the electric light at their new isolation hospital.

HULL.—The Town Council intend to apply to the Local Government Board for sanction to borrow £42,000 for electric light extension purposes.

KESWICK.—At the District Council meeting on Monday, the question of the purchase of the local Electric Lighting Company's undertaking was discussed. Various suggestions were before the Council, and the Chairman (Mr. Mumberson) said the decision which the Council had previously arrived at to purchase the undertaking was out of order, on the ground that it had not been entered on the agenda paper. The Clerk was appealed to as to his view of the matter, and claimed that the decision was perfectly in order. The Chairman, however (who is, by the way, a shareholder in the local gas company), stated that if twenty lawyers said this was so, he would contradict them. If the purchase took place, and he was alive to see it, he would take care that the Government Inspector knew how it was done. In fact, the Council meeting may be described as a "breezy" one, the Chairman being notified that if he voted on the subject now before the Council, he would be liable to a penalty. It was ultimately decided, however, to appoint a committee of five to consider the proposed purchase, and report to the Council.

KINGSWOOD (BRISTOL).—The District Council have given notice that they do not at present intend to purchase the electric lighting plant of the Western Counties Electric Light and Power Syndicate.

KIRKALDY.—The District Council have a dispute in hand with the Postmaster-General, on the subject of a charge for wayleave for the erection of telegraph poles. The Post Office have notified the Council that the Postmaster-General has statutory powers to take abvantage of all roads and streets without payment; but the Chairman of the Council (Mr. Budge) states that he has failed to find any Act giving the Postmaster-General these powers without payment. The matter is to be discussed at the next meeting of the County Council.

LEEDS.—Elsewhere we give particulars of the tenders accepted by the Leeds City Council for the proposed electric tramway from Roundhay to Kirkstall. Altogether the Council have authorised the expenditure of nearly £41,000, apart from certain preliminary expenses that it is reasonable to assume will be incurred. The greater portion of the tenders have gone to Leeds firms, the exceptions being Messrs. Crompton and Co., of London and Chelmsford (whose tender for trolley wires and attachments was accepted, but has since been withdrawn), and the Chloride Electrical Storage Syndicate, of Clifton Junction and London, who will supply accumulators and switches. The subject of the tenders was discussed at the meeting of the Council on Wednesday, Mr. Hannam moving the resolution authorising the acceptance of the tenders. He pointed out that Messrs. Crompton and Co.'s tender for £3,370 had been withdrawn, and the next lowest tender was £5,620, an increase of £2,250, and the Committee would have to consider the matter further, and report to the next meeting of the Council. The Committee had selected the lowest tenders in most cases; but in two or three instances, after taking counsel with Dr. John Hopkinson and the City Engineer, had accepted tenders above the lowest. Alderman Hepworth said that the contracts for steam engines and dynamos were those of a Leeds firm, and amounted to £6,707, although tenders had been received offering to supply the machines for £5,620. An amendment to the acceptance of the tenders was moved by Mr. Smithson to the effect that, as the Yorkshire House-to-House Company had offered to supply current at 1¼d. per unit, the tenders for engines, boilers and generating station should be referred back to the Committee with a view to their coming to terms with the Company. Mr. Smithson estimated that by postponing the erection of the station for three years,

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during which period the offer of the Company extended, the immediate saving of between £17,000 and £20,000 would be effected. He criticised adversely many of the estimates prepared by Dr. Hopkinson, and inquired upon what grounds the Committee based their confience in Dr. Hopkinson's advice. Mr. Connellan said the Committee had carefully and fully discussed the matter before arriving at the decision now before the Council, Mr. Smithson being the only person supporting his own amendment. Mr. Leuty, M.P., asked if it was true that one of the tenders proposed to be accepted (that for electric motor cars) was a joint one from Messrs. Greenwood and Batley and Messrs. John Fowler and Co., and on being informed that this was the case desired to know why the second name did not appear upon the list of tenderers, and further pointed out that one of the tenders proposed to be accepted was £500 in excess of that of a non-local firm. Mr. Dennison explained that the higher-priced tender was accepted because the firm who sent in the lower tender would not accept the conditions imposed by the Committee. The Town Clerk pointed out that no member of the Council was prohibited from dealing with the Corporation by reason only of being a member of a joint-stock company. Alderman Wigram said that it had been suggested some time back that he should join the Highways Committee, but, seeing that his firm was likely to be interested in tenders for the tramway work, he asked to be excused. He had taken no part whatever in any way in influencing the Committee in their action. Mr. Hannam, in reply to the remarks of councillors, stated that £500 was a small matter in a contract of the kind, because they would not only be supplied by a local firm, but the firm would be handy for repairs. It would be much more costly if they had to go a hundred miles away to get their work and repairs done. The resolution to confirm the Committee's recommendation for the acceptance of the tenders was adopted.

Lundy Cable.—Communication with Lundy Island was interrupted for about a fortnight, but was restored on Tuesday. The fault was found about three miles out from Croyde.

New Cable Steamer.—The "Tutanekai," a twin-screw steamer built and engined by Messrs. David J. Dunlop and Co., of Port Glasgow, for the Government of New Zealand, performed her official trial trip last week. This boat has been specially designed and constructed for cable laying and repairing work, but has been fitted and furnished with a view to carrying the lighthouse keepers and their families to and from the various stations in the Colony, and other similar work which may be considered part of the Colony's telegraphic department. The cable machinery and fittings for the ship have been supplied by Messrs. Johnson and Phillips, the whole being sufficiently portable to allow of its being carried only when the vessel is employed on cable work. The concentric wiring of the boat for the electric light has been carried out by Messrs. W. and J. Robinson and Co. and Messrs. Clarke, Chapman and Co. have supplied powerful winches and other machinery for the ship, which has been designed and constructed under the superintendence of Mr. W. H. Preece and Mr. W. R. Culley, of the Post Office. The "Tutanekai" sails for New Zealand immediately.

Newport.—Mr. F. H. Tulloch, M.I.C.E., held a Local Government Board inquiry on Tuesday into the application of the Town Council to borrow £12,000 for electric light extension purposes. The Town Clerk (Mr. A. Newman) supported the application, and gave particulars of the progress made since the start of the works. There was a constant increase in the demand for current, and £6,793. 18s. 9d. of the present loan had already been expended, that sum representing excess of actual expenditure over the original estimates. The capital expenditure to date is £34,793. 18s. 9d. The consulting engineer (Mr. R. Hammond) also gave evidence, after which the Inspector visited the station.

Nottingham.—Col. A. G. Durnford, R.E., held a Local Government Board Inquiry on Thursday last into the application of the Town Council for sanction to borrow £40,000 for electric light extension purposes. The Town Clerk (Sir S. G. Johnson) and the Borough Electrical Engineer (Mr. H. Talbot) appeared in support of the application. The Town Clerk stated that the electricity works were established in 1894, and during the first six months of working the Council cleared expenses. The demand for current was increasing in a very satisfactory manner, and it had become absolutely necessary to make additions to the plant at the station, and the matter was so urgent that it was important they should begin the extensions at once. Sir S. Johnson then referred to certain preliminary expenses, including interest on capital while the works were being erected, salaries of engineer and clerk of works, &c., and which amounted to £2,300. He thought these items of evanescent expenditure ought to be charged to capital, and they were writing off this amount out of the profits. £500 had been written off from the profits to March 1st last, and they expected to be able to write the whole off within the next three years. Mr. Talbot, the electrical engineer, stated that the initial capital outlay on the works was £45,000. At the end of March, 1895, they had an equivalent of 8,267 8-c.p. incandescents connected, and at the end of March, 1896, 15,466, while at the present time they had 18,570. Applications for current were constantly coming in and a large capital expenditure would have to be incurred in order to meet the increasing demands. Mr. Talbot estimated that these extensions would cost £40,000, viz., buildings, £5,430; boilers, engines and dynamos, £12,527; main switchboard and connections, £950; meters and house connections, £2,550; motor transformers, £3,200; mains, £14,300; and contingencies, £1,043. There was no opposition.

Oldham.—The Town Council have decided to apply to the Local Government Board for sanction to borrow £10,000 for electric light extension purposes.

Peterborough.—The Local Government Board have refused to sanction the borrowing of £20,000 by the Town Council for establishing electricity supply works. It is rumoured that the promoters of the electric light scheme intend to form a company to work the scheme.

Poplar (London).—The Board of Trade has granted the Board of Works an extension of time in which to comply with the terms of their Provisional Order. A Committee has been formed to consider and report upon the advisability of establishing joint electricity and refuse destructor works.

Southampton.—An important discussion took place at the last meeting of the Town Council on the report of the Works Committee recommending the Council to open negotiations with the Southampton Tramways Company for the purchase of their undertaking. Mr. Lemon, who moved the adoption of the report, said that the present was an opportune time to purchase the tramways, as the Council had recently decided to purchase the Electric Light Company's undertaking, and they could arrange to supply electrical energy for working the tramways from the supply station, and when the Committee were putting up standards for lighting purposes they could also erect such standards as would be necessary to carry the wires required for working the tramways. After some discussion the motion was unanimously adopted.

Telegraph Messengers.—Lord Wolseley, the Commander-in-Chief, held an inspection of telegraph messengers in Hyde Park on Tuesday, and it was announced that the battalion numbered 1,079 members. The Commander-in-Chief expressed his satisfaction at the manner in which the messengers performed their military duties. The Eastern Central District messengers have an institute, and the annual meeting was held last week. Mr. Spencer Walpole, who presided, stated that, though the telegraphs had only been 26 years State property, there were former messengers who had already risen to posts of high responsibility in the telegraph department.

Telegraph Tariffs.—The rate for telegrams to Madagascar has been reduced to 5s. 8d. per word.

Telephone Experiments in Brussels.—The Belgian authorities have recently made some interesting experiments with the loud-speaking telephone instrument and electrical fire-alarm appliances of the Single Wire Multiple Telephone Signal Company, of London. Under the auspices of His Excellency M. Vandenpeereboom, Minister of Posts and Telegraphs, and under the superintendence of M. Banneux, Engineering Chief of the Direction Technique des Administrations des Telegraphs, Mr. G. R. Neilson, Secretary, and Mr. A. C. Brown, the Engineer of the Company, and inventor of the apparatus, represented the Single Wire Company; and amongst those present at the experiments was the Baron de Knsel, who is well known to the English colony in Brussels, and takes considerable interest in matters electrical. In addition to the apparatus to test the adaptability of which the experiments were arranged, a new patent portable loud-speaking combined telephone and telegraph instrument, specially designed for military purposes in the field during operations, formed a feature of interest, the extreme portability and light weight of the whole apparatus attracting considerable attention. It was proved, to the surprise of those present, that although the wires connecting the instrument were cut, Morse signals were quite audible even when several feet of damped twine were interposed in the circuit. We understand that the British military authorities are taking an interest in the instrument, and that a demonstration of its special suitability for military purposes will shortly be given.

Telephone Trunk Wires.—Shrewsbury has been added to the towns connected with the trunk telephone system. This circuit is being worked for the present by the National Company on the Postmaster-General's behalf.

The National Revenue.—There has been an increase in the past quarter in receipts from the telegraph service of £25,000, the total sum received being £695,000.

Torquay.—A Local Government Board inquiry will be held by Colonel A. G. Durnford, R.E., on Friday next, into the application of the Town Council to borrow £22,300 for electric lighting purposes.

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WATFORD.—Fifteen applications for the post of consulting electrical engineer have been received by the District Council, and have been referred to a special committee for consideration.

WELLS.—By the casting vote of the Mayor it has been decided to break off negotiations with the gas company for the purchase of their undertaking.——The contract for lighting the streets by gas will shortly expire, and terms for a renewal of the contract have been submitted by the gas company, who offer to light the streets for one year for £506. 12s. 4d., for three years at £450 per annum, or for a seven years' contract at £400 per annum. The Company recently offered to continue the present arrangement at £350 per annum, a reduction of £90 per annum on the price now paid for street lighting by the Council. The Council having definitely broken off negotiations for the purchase of the gas works, intend to proceed with their electric lighting scheme, and the Council may be relied upon to circumvent any attempt on the part of the gas company to embarrass them on the lighting question.

WILLESDEN (LONDON).—The Willesden Green Electric Light Supply Company recently wrote to the District Council asking for consent to an application for a Provisional Order, but the Council have resolved not to comply.

WILMSLOW (MANCHESTER).—The District Council recently received a letter from the Alderley Edge and Wilmslow Electric Supply Company asking for sanction to an application for a Provisional Order. The Council have, however, decided to themselves apply for an Order.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

June 1, 1896.

11,858. J. C. MERRYWEATHER. London. Improvements in portable electrically-driven pumps.

11,891. W. PHILLIPS. London. Improvements in automatic grip clutch for straining wires for telegraphic, telephonic, and like or similar purposes.

11,894. S. CAMBIE. London. Improved means for opening and closing doors by electricity.

11,903. H. SOBERSKY. Liverpool. An improved frictional electric machine.

June 2, 1896.

11,973. A. DALOLRY. Ealing. An improved movable platform for electric lamp posts.

11,931. J. G. LORRAIN. London. Improvements in and connected with electrical indicating apparatus. (M. Pfatischer, E. S. Hosmer, and H. Binney, United States).

11,985. C. E. H. EDMAN. London. Improvements in and connected with electric arc lamps.

11,999. R. J. CROWLEY. London. In or relating to marine telegraphy.

12,038. R. J. BOTT. London. Improvements in and relating to caps for electric incandescent lamps.

12,039 G. MARCONI. London. Improvements in transmitting electrical impulses and signals, and in apparatus therefor.

June 3, 1896.

12,070. W. E. DALBY. Cambridge. Improvements in transmission dynamometers.

12,149. T. J. HOLLAND. London. Improvements in electrolytic apparatus.

June 4, 1896.

12,178. A. H. TAMPLIN. Leicester. Tamplin's new electric bicycle lamp.

12,183. W. COPE. Birmingham. An improved method of electric traction by means of the conduit system.*

12,187. G. W. PRIDMORE, T. J. STURGEON, and E. YORKE. London. A new or improved shade and reflector for electrical and other lighting.

12,227. L. EPSTEIN. London. An improvement in secondary voltaic batteries.

12,244. E. OLDENBOURG. London. New or improved electrical lighting apparatus.

12,248. W. J. DAVY. London. Improvements in or connected with automatic switches for controlling electric lamps.

12,249. W. J. DAVY. London. Improvements in electric arc lamps.

12,250. C. MARSCHNER. London. Improved plates for secondary galvanic batteries and a method of producing the same.

12,259. V. A. FYNN. London. Improvements in or connected with dynamo-electric machines.

12,266. W. M. MORDEY. London. Improvements in electricity meters.

June 5, 1896.

12,275. M. TWOMEY. Cork. Self-lighting and part driving of bicycles and other vehicles by electricity.

12,312. J. L. DOBELL. London. A new or improved apparatus for electrically smelting metals and for other purposes.

12,329. G. BINSWANGER. London. Improvements in electrical switches.

12,330. G. WILKINSON. London. Improvements in electrical switches.

12,341. E. NAGLO. London. Method of indicating at a telephone station whether the telephone lines are engaged or not.*

12,345. E. NAGLO. London. Automatic apparatus for the working f telephone stations.*

12,360. F. F. WELLINGTON and E. P. ALLAM. London. Improvements in or connected with variable gearing applicable to wheeled vehicles driven by electricity, petroleum, steam, or other motive power.

12,362. J. TABRAR. London. Improvements in and applicable to electrical accumulators.

June 6, 1896.

12,390. A. W. STAVELEY, J. H. PARSONS and T. J. MURDAY. Leicester An improved form of integrating watt or ampere hour meter for continuous or alternating currents.

12,398. L. DAVIS. London. A flexible crystal covering for electrical conductors.

June 8, 1896.

12,504. B. P. SCATTERGOOD. Leeds. Improvements in or in connection with the transmission and or transformation of electric currents specially applicable for lighting purposes.

12,531. A. SLATTER and W. RIXON. London. Improvements in switches for making and breaking electric currents.

12,549. D. G. FITZGERALD. London. Improvements in and in the manufacture of elements for secondary batteries.

12,550. A. LURASCHI. London. Improvements in electrical circuit closing thermometers.

June 9, 1896.

12,581. P. J. PRINGLE and J. M. V. MONEY-KENT. Sideup. Improvements in the method of supplying electricity to electrically-propelled tramcars and other vehicles, and in apparatus therefor.

12,587. R. BAKER, J. FILMER, E. L. RYDER and A. GARTNER. London. Improvements in telescopic supports for telephone transmitters.

12,588. R. BAKER, J. FILMER, E. L. RYDER, and A. GARTNER. London. Improvements in telephone receivers.

12,635. G. SENIOR, jun., and T. D. DUNDAS. London. Improvements in electrical switches.

12,637. W. H. COOLEY. London. Improvements in electric machines and in the method of operating the same.

12,650. H. B. COX and THE COX THERMO-ELECTRIC COMPANY (LIMITED). London. Improvements in thermo-electric generators.*

12,676. J. B. GRANJON. London. An improved dynamometer.

12,696. X. M. ROUX. London. Improvements in electrical accumulators.

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

10,250. SLOPER. Telephone systems.

10,359. LANCASTER. Gas and electric light fittings, &c.

10,746. BENHAM and SMITH. Incandescent electric lamps.

11,153. BLACKBURN and SPENCE. Motor generator transformers.

13,265. PARTRIDGE and CHERRY. Mariners' compasses.

13,444. MARCH. Electric heating apparatus.

13,530. HAMM and OTHERS. Telephones.

13,695. HEADLAND. Electric railway carriage, &c., lamps.

15,470. ABEL (Société Anonyme pour la Transmission de la Force par l'Electricité). Asynchronous electrical machines.

17,821. KING. Secondary batteries.

17,825. BECK (Johnson and another). Porous plate, body, or electrode.

21,523. SAYER. Supplying electric power to railway vehicles, &c.

23,865. BOULT (Wunderlich). Thermo-electric generators.

1896.

3,375. PAYNTER and WALKER. Electric contact devices for clocks, &c.

5,191. PETZENBURGER. Electric railways.

7,791. ST. PETER. Electric stop motions for engines.

7,882. DEVONSHIRE (Potter). Electric motors.

8,141. SIEMENS BROS. AND CO. (Siemens and Halske). Electromotors.

8,316. WRIGHT and OTHERS. Electric switches.

**RAND CENTRAL ELECTRIC WORKS (LIMITED).**—The Directors of this Company, who recently decided to make a final call of 5s. per share, state that, notwithstanding the recent troubles in the South African Republic, they hope to be in a position to supply electrical energy by the beginning of November next. The contractors, Messrs. Siemens and Halske, are preparing the final shipments of plant and materials, and the present call has been decided upon to meet further payments to that firm.

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# COMPANIES' MEETINGS AND REPORTS.

## Thomas Parker (Limited).

The annual general meeting of this Company was held at the offices, Wednesfield-road, Wolverhampton, on Friday last, the Chairman (Mr. C. T. Mander, J.P.) presiding.

In moving the adoption of the report and accounts, the CHAIRMAN congratulated the shareholders on the success they had met with, and on the fact that, after little more than a year's working, they were able to pay a dividend of 5 per cent. This augured well for the future of the Company, and, with the able management of the Managing Director and his staff, he thought they might look forward to the time, in the very near future, when they would be able to increase the dividend to 7½ or 10 per cent. He justified the Directors' decision not to write anything off the capital assets of the Company for depreciation, by stating that everything was new. The buildings and plant were for the most part in an almost perfect condition, and part of the buildings and plant had been erected since the last annual meeting. During the year they had spent about £12,000 in additional plant, buildings and machinery, and this sum was included in the total assets of that class, now standing at £61,000. So much being recent, it had been deemed unnecessary to write anything off. The item of "Stocks on hand, as certified by the Managing Director," £7,900, included a fair proportion of uninvoiced finished goods ready to go out, and profit on such stock might have been credited in the account, thus materially increasing the surplus. At present there were 1,148 shares unissued, and it had been decided to issue these to existing shareholders at par, applications to be sent in by the 20th inst. A call of £3 per share would now be made on these shares. In the event of all the shares not being taken by the shareholders he would advise that they be offered to the public at a premium of, say, £1. It was possible that in the near future they would increase their operations to such an extent that it would be necessary to ask the public for further capital, and increase the capital from £75,000 to perhaps £100,000. They would certainly be able to charge a premium of £1 on all shares so issued.

Mr. T. PARKER seconded the resolution, and said that this time last year they had scarcely commenced working, but now they were in full working order.

In reply to a question, the CHAIRMAN said that they had written off the value of their patterns to the extent of 50 per cent. This had meant a reduction of stated assets from £603 to £301, plus £758 for additional patterns obtained during the year. He thought it inadvisable to issue a trading account, as it would give too much information to rival concerns.

The resolution was then carried unanimously, and a dividend of 5 per cent. for the past year declared.

The retiring Director (Mr. R. Armistead) and the accountants, Messrs. Allen Edwards and Smith, were re-elected.

# NEW COMPANIES, STATUTORY RETURNS, &c.

**BRITISH INCANDESCENT ELECTRIC LAMP COMPANY (LIMITED).**—This Company was registered on June 26th, with a capital of £10,000, in £1 shares, to carry on the business of electrical engineers and manufacturers, and to manufacture, sell and deal in incandescent electric lamps.

**EAST GRINSTEAD ELECTRIC LIGHTING COMPANY (LIMITED).**—This Company was registered on June 26th, with a capital of £15,000, in £1 shares, to carry on in the parishes of East Grinstead, Forest Row, and Worth, Sussex, and in the parish of Lingfield, Surrey, and elsewhere, the business of an electric lighting company in all its branches, and to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity and manufacturers of electrical apparatus. The subscribers, with one share each, are: C. W. Bell, J.P., D.L., H. S. Martin, W. H. Dixon, A. A. Winser, C. M. Wilson, W. H. Hills and T. L. Manning, all of East Grinstead.

**PRESTON ELECTRIC COMPANY (LIMITED).**—This Company was registered on June 25th, with a capital of £3,000, in £1 shares, to carry into effect an agreement with Mr. George W. Preston, electrical engineer, Birmingham, and to carry on the business of electrical and mechanical engineers, suppliers of electricity, telephone and telegraph engineers, machinists, &c.

**STANDARD DYNAMO AND MOTOR MANUFACTURING COMPANY (LIMITED).**—This Company was registered on June 24th, with a capital of £2,000, in 340 Ordinary and 60 Deferred shares of £5 each, to acquire and take over the business of electrical engineers and dynamo builders now carried on by Messrs. T. R. Andrews and T. Preece at Perseverance Works, Bradford, under the style of "Thomas Preece and Company," and to carry on the business of electricians, mechanical and electrical engineers, and manufacturers of and dealers in dynamos, motors, machines, meters, lamps, wires, accumulators, &c. The subscribers are:—J. Varey, engineer (12 shares), J. Tate, engineer (20 shares), T. R. Andrews, electrical engineer (10 shares), L. Whitaker, engineer (15 shares) T. Preece, electrical engineer, W. Beanland, and G. F. H. Gardner, with one share each. The first Directors are:—F. Beanland, J. Varey, J. Tate, L. Whitaker, and J. W. Perkin.

**CHAMBERLAIN AND HOOKHAM (LIMITED).**—The annual return to May 30th has been filed. The nominal capital is £100,000, divided into 5,000 "A" and 5,000 "B" shares of £10 each; 1,000 of the former and all the latter have been taken up, and the "B" shares have been issued as fully paid. £3. 10s. per share has been paid on the "A" shares.

**READING ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return to May 25th has been filed. The capital is £75,000, in £5 shares, and 4,014 of these have been taken up. The full amount per share has been called and paid.

# CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31 7/16d. per oz. (July 2nd). Consols (2¾ per cent.) 113 5/16—113 7/16 for money, 113¾—113 13/16 for account; 2½ per cent. 107½—108 (July 2nd). Stock Exchange Settling Days: Consols, Aug. 4th; Stocks and Shares Continuation Days, July 13th; Ticket Day, July 14th; Pay Day, July 15th; Mining Share Carry-over Days, July 11th.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended June 28th were £891, against £780 in the corresponding week of 1895, an increase of £111. The total receipts for the half-year amount to £24,069, against £23,873 for the corresponding period of 1895, an increase of £196.

**CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).**—The warrants for interest due 30th ult. on this Company's Debenture Stock have been posted.

**COVENTRY GASFITTING, ELECTRICAL AND ENGINEERING COMPANY (LIMITED).**—The annual report of the Directors states that the Company's electric lighting work is becoming more appreciated, and an increasing business is being done in this department. Last year's profits amounted to £1,456. 11s. 11d., out of which it is proposed to pay a dividend of 7½ per cent., to carry £500 to reserve and £184. 14s. 5d. forward. Owing to increased trade the Directors propose to issue 3,000 £1 shares, which will be offered to the existing shareholders.

**ELEKTRICITATS AKTIEN GESELLSCHAFT VORM. SCHUCKERT AND CO.** The report of this Company for the year 1895-95 has recently been issued, and is of a highly satisfactory nature. The gross profits amounted to about £260,610, compared with £148,074 in 1894-95; administration expenses came to £49,549. 15s., and interest to £19,338. 12s., and, after adding £17,216 brought forward from last year, there remained a sum of £189,459 for distribution. It is proposed to pay a dividend at the rate of 14 per cent. (compared with 10 per cent. in 1894-95), which will absorb £84,000, to set aside £37,738. 5s. for depreciation of plant, patterns, &c, and to carry forward a balance of about £33,124. The volume of business done during the past year amounted to £1,380,000, against £906,000 the previous year. Considerable extensions of the works are being carried out so as to enable the company to further develop the manufacture of continuous-current dynamos, arc lamps, electrical measuring instruments, &c. During the past year the firm turned out 3,033 continuous and alternating-current dynamos and transformers of a total capacity of about 75,000 H.P., against 40,000 H.P. in the previous year. The Company have also decided to erect a new instrument factory, metal foundry chemical laboratory, works for the manufacture of electric tramway apparatus, and to make other additions and improvements to their works. Referring to the progress made in the foreign department of the Company's business, the report states that the Vienna works of Messrs. Kremenezky, Mayer and Co. were recently purchased. It is intended to form a subsidiary company to manufacture plant and apparatus under the Company's patents in Vienna. The Company also purchased an estate near Fredrikstad, Norway, for £46,805. There is a waterfall on the estate, and it has been decided to employ this water-power for electrochemical manufacturing purposes. In conclusion, the report states that the Company have been very busy during the past year, especially in the supply of plant for electric tramway, isolated power and light and electrochemical purposes. The capital of the Company was increased at the beginning of the year from £600,000 to £900,000.

**ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY (LIMITED).**—Warrants for interest upon the First Debenture stock of this Company for the half-year ended June 30th have been posted.

**HOBART ELECTRIC TRAMWAY COMPANY (LIMITED).**—Notice is given that Coupon No. 9 in respect of the debenture interest due July 1st of this Company will be paid at the Commercial Bank of Scotland, 62, Lombard-street, London, E.C.

**ISLE OF MAN TRAMWAYS AND ELECTRIC POWER COMPANY (LIMITED).**—The recent issue of Four per Cent. Mortgage Debentures to the amount of £35,000 in this Company, redeemable in 1941, resulted in the amount being applied for twice over. The issue was a private one, and limited to the existing shareholders in the Company.

**KONTINENTALE GESELLSCHAFT FUR ELEKTRISCHE UNTERNEHMUNGEN.**—The Directors of this Company, which is in close alliance with the Elektricitats Aktien Gesellschaft vormals Schuckert and Co., have declared a dividend for the past year of 4 per cent. The report states that out of a nominal capital of £800,000 the sum of £650,000 has been paid up.

**LIVERPOOL DISTRICT LIGHTING COMPANY (LIMITED).**—This Company invite applications for 9,600 shares of £5 each, payable 5s. on application, 15s. on allotment, and the balance as required in instalments of £1. The Company, whose capital is £50,000, has been formed to supply electric current to residents in the suburbs of Liverpool. The Directors include Messrs. A. H. Holme and T. A. Von Sabbe, Chairman, and a Director of the Liverpool Electric Supply Company. Mr. A. Bromley Holmes is consulting engineer, and the registered offices (*pro tem.*) are 9, Cook-street, Liverpool. The lists opened on Wednesday and close to-morrow (Saturday).

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 28th ult. amounted to £1,219. The amount for the corresponding week last year was £1,193, increase £26.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ending June 26th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,856.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, June 24. | Price Wednesday, July 1. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending June 27. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 47 49 | 48 50 | 5 2 0 | Jan., Apr., July, Oct. | .. | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 92 93 | 92½ 93½ | 5 6 11 | " " | 93½ | 92 |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 9 9¼ | .. .. | | 9⅝ | 9½ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer)..xd | 101 105 | 100 104 | 3 16 11 | January and July .. | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 10 11 | 9 10 | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine xd | 15 15½ | 15 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15⅞ | 15 |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) ..xd | 113 117 | 111 115 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock xd | 160 170 | 160 170 | 4 2 4 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ 13½ | 12½ 13½ | 5 18 6 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 19½ 20½ | 19½ 20½ | 4 17 7 | " " | .. | — |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ 4½ | 3½ 4 | 5 0 0 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each xd | 108% 111% | 106% 109% | 4 2 7 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9¾ 10¼ | 9½ 10½ | 4 3 0 | Jan., Apr., July, Oct. | 10⅞ | 9⅞ |
| 400,000 | 10 | 2/6 | Eastern | 17 17½ | 17 17½ | 3 14 4 | " " | 17⅝ | 17½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 18¾ | 18½ 18¾ | 3 4 0 | " " | 18⅛ | 18½ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 2 19 11 | May and November | .. | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 109 | 106 109 | 4 13 3 | February & August | .. | .. |
| 250,000 | 10 | 6/6 | Eastern Extension | 17½ 18 | 17⅝ 18 | 3 17 9 | Jan., Apr., July, Oct. | 17⅝ | .. |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 132 135 | 132 135 | 3 0 2 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900 . xd | 101 105 | 101 104 | 4 16 2 | January and July .. | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900xd | 101 105 | 101 104 | 4 16 2 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) - | 105 108 | 108 109 | 3 14 5 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 110% 113% | 111% 114% | 3 10 6 | May and November | .. | .. |
| 180,227 | 10 | 2 6 | Globe Telegraph and Trust | 10½ 11 | 10½ 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅛ | 10⅜ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17 17½ | 17 17½ | 3 8 7 | " " | 17⅜ | 17½ |
| 150,000 | 10 | 5/0 | Great Northern | 23½ 24½ | 23½ 24½ | 4 1 8 | Jan., April, and July | .. | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 14 7 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 52 55 | 52 55 | 4 10 11 | May and November | 54 | 53 |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 111 113 | 111 113 | 5 7 7 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel.4% Guar. Debs. "Red" 1915 x l | 108 111 | 106 109 | 3 13 5 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 6½ 7½ | 6½ 7½ | 5 8 1 | April and October .. | 7⅛ | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 135 140 | 136 141 | 4 5 1 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph xd | 7 8 | 7 8 | .. | January and July .. | .. | .. |
| £233,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 103 106 | 103 105 | 4 16 7 | March & September | 103½ | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1932 xd | 102 107 | 93 103 | 7 15 4 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1 1½ | 1 1½ | .. | .. | .. | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 11¾ | 11¼ 11½ | 5 2 2 | May and November | 11⅝ | .. |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) ..xd | 103 112 | 107 110 | 4 10 11 | June and December | .. | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian | 9 9½ | 8½ 9½ | 4 17 7 | May and November | 9½ | 9⅜ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6¾ 7½ | 6½ 7½ | 5 3 8 | .. | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 3 | 2½ 2¾ | — | .. | 2¼ | .. |
| £135,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 105 109 | 105 109 | 5 12 2 | February & August | .. | .. |
| £216,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 105 109 | 105 109 | 5 12 2 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 2 3 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 105 | 102 105 | 5 15 11 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3½ 3¾ | 3½ 3¾ | .. | — | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing.. | 7/16 7/16 | 7/16 7/16 | .. | May and November | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅛ ¼ | 1/8 ¼ | .. .. | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7⅜ 7⅝ | 7⅜ 7⅝ | 3 9 10 | June and December | 7⅝ | 7⅛ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | " " | .. | — |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid).. | 18½ 17½ | 16½ 17½ | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6½ 7 | 6⅞ 7 | 3 11 5 | — | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) xd | 107 110 | 105 108 | 3 4 10 | January and July .. | 108⅜ | .. |
| 58,000 | 5 | 3/0 | United River Plate | 3½ 4 | 3½ 4 | .. | " " | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) ..x l | 100 105 | 99 104 | 4 17 1 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ 15½ | 14½ 15½ | 3 4 6 | — | 15½ | 15⅛ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ 17 | 16½ 17 | 3 10 7 | — | 17 | — |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) xd | 134 138 | 131 135 | 3 14 1 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | — | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. .. | 8½ 8¾ | 8½ 8¾ | .. | — | .. | .. |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — — | — — | .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid). | 8½ 9½ | 8½ 9½ | .. | — | .. | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 12½ 13½ | 13½ 13¾ | 4 7 3 | — | 13⅜ | 12⅜ |
| 8,322 | £5 | — | House-to-House Electric | — — | .. .. | .. | — | .. | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid). | — — | — — | .. | — | .. | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. | January and July .. | .. | — |
| 45,000 | £5 | .. | Liverpool Electric Supply (fully paid) | 8 8½ | .. .. | .. | — | .. | — |
| 111,000 | 5 | .. | London Electric Supply | — — | .. .. | .. | — | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 12 14 | 13½ 14½ | 2 15 2 | — | 13⅜ | 13 |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. x l | 120 123 | 119 121 | 3 14 5 | June and December | 122½ | — |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9½ 9¾ | 9½ 10 | .. | — | .. | .. |
| .. | .. | .. | Rand Electric | ¾ ½ prem. | 1⅜ 1½ prem. | .. | — | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 11½ 11¾ | 11½ 11¾ | .. | — | 11½ | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 9½ 10½ | 9½ 10½ | 3 6 8 | — | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 10 10½ | 10¼ 10¾ | 3 5 1 | — | 10⅜ | 10 |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1⅛ 1⅜ | 1⅛ 1⅜ | 5 8 8 | — | .. | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1½ 1⅝ | 1½ 1⅝ | 6 17 2 | — | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 111 114 | 112 115 | 3 19 4 | March & September | — | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref.. | 2 2½ | 2 2½ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) .. | 1½ 2 | 1½ 1⅝ | 8 11 8 | February & August | 1⅝ | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock x l | 105 108 | 103 106 | 4 4 11 | January and July .. | 105 | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) .. | .. .. | — — | — | — | .. | — |
| 110,000 | 2 | .. | Electric Construction | 1⅛ 1⅜ | 1⅛ 1¼ | .. | — | .. | .. |
| 12,845 | 2 | 2/9⅞ | Do. 7 per Cent. Cumulative Pref. | 2½ 3 | 2½ 3 | 4 13 4 | September | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ½ ¾ | ½ ¾ | .. | — | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | — — | .. .. | .. | — | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 23 24 | 21 23 | 4 6 11 | February & August | 23½ | 23½ |
| £200,000 | 100 | .. | * Do. 4 per Cent. Debentures | 105 108 | 105 108 | 5 14 1 | March & September | .. | .. |
| 15,995 | £10 | .. | International Okonite Ordinary | — — | — — | .. | — | — | — |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. .. | — — | .. | December and June | — | — |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ½ ½ | ⅝ ⅝ | .. | — | — | — |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 41 | 38 40 | 4 7 10 | March and July | 40 | 38½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds xd | 104 107 | 102 105 | 4 15 3 | January and July . | .. | — |
| 37,514 | £5 | — | Woodhouse and Rawson Ordinary (£3 15s. paid).. | .. .. | — — | .. | — | .. | — |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. .. | — — | .. | — | .. | — |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 17 18 | 17 18 | 4 8 11 | March & September | 17½ | 17⅜ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 17 18 | 17 18 | 3 17 9 | " " | 17⅜ | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 114 | 109 114 | 4 0 0 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 42 44 | 43 45 | 2 15 7 | January and July .. | 44 | .. |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15½ | 14⅜ 15½ | 3 6 5 | " " | 14⅜ | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 135 137 | 135 137 | 2 18 5 | May and November | .. | .. |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway | 13⅛ 14⅛ | 13⅛ 14⅛ | 2 2 8 | — | — | — |
| 10,000 | 10 | 5% | Do. 5% Preference | 17⅛ 17⅜ | 17⅛ 17⅜ | 2 16 10 | — | — | — |
| 125,000 | Stock | 4% | Do. 4% Debenture xd | 114½ 116½ | 112½ 114½ | 3 9 10 | January and July — | — | — |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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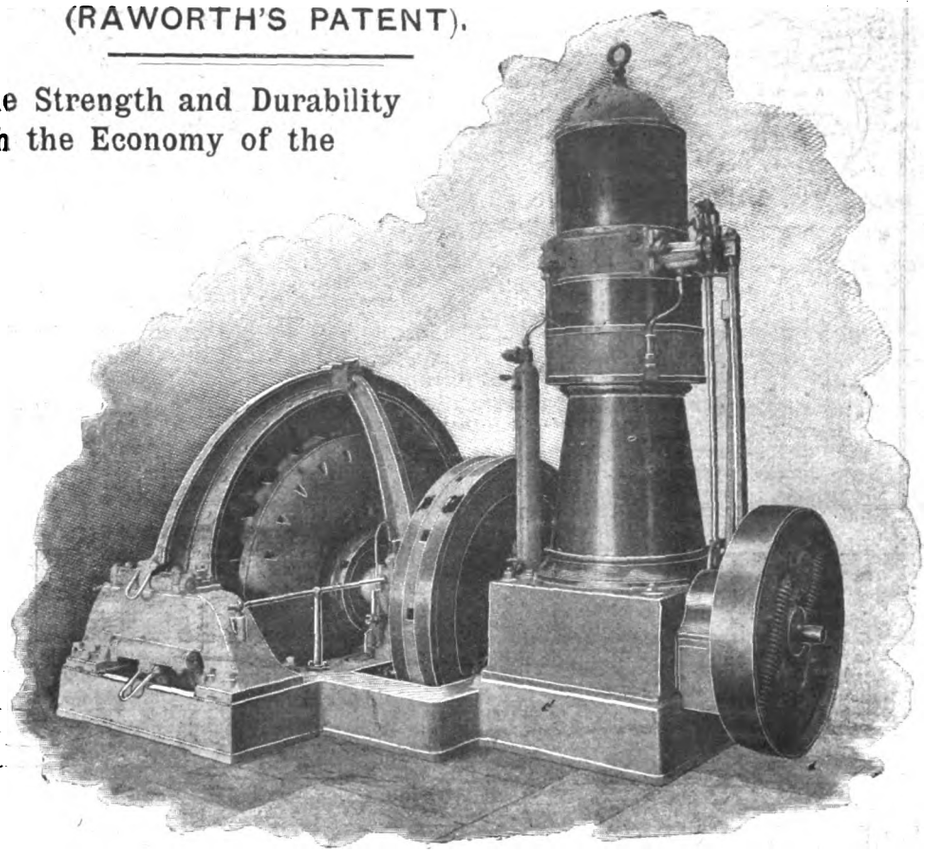

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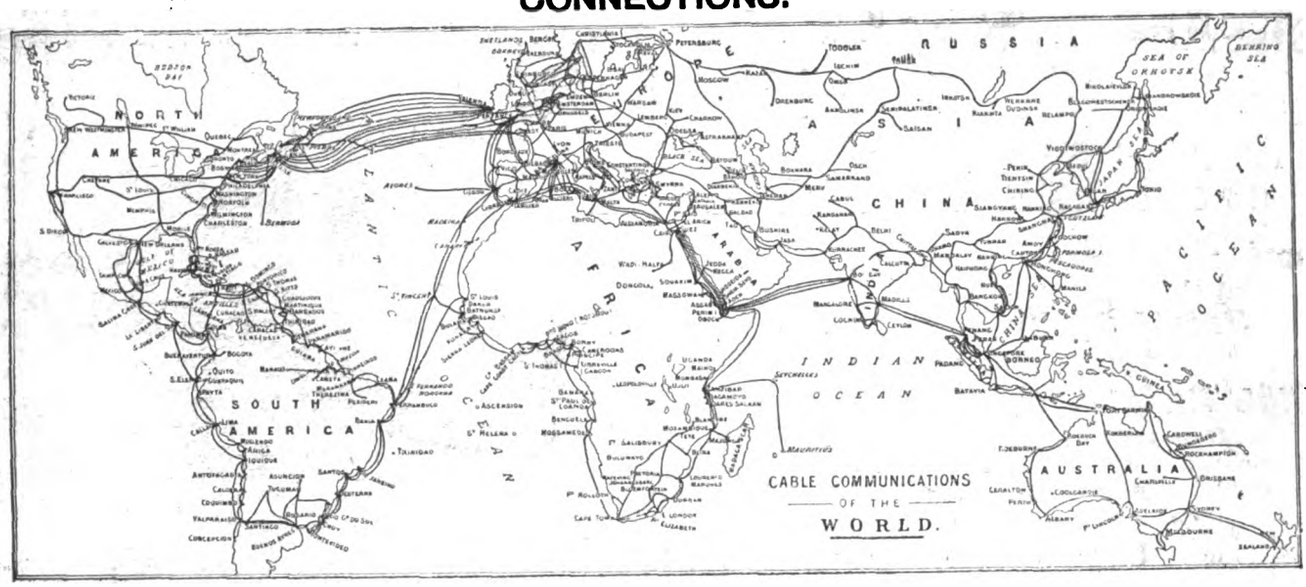
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

# EASTERN TELEGRAPH COMPANY

IN CONNECTION WITH THE (LIMITED),

EASTERN EXTENSION (AUSTRALASIA AND CHINA), BRAZILIAN SUBMARINE, EASTERN AND SOUTH AFRICAN, EUROPE AND AZORES, WEST AFRICAN AND AFRICAN DIRECT TELEGRAPH COMPANIES.

By DIRECT TRIPLICATE CABLES, to Spain, Portugal, Gibraltar, Malta, Egypt, Aden, and India.

By DIRECT DUPLICATE CABLE ROUTES to Madeira, St. Vincent, Brazil, Argentine Republic, Uruguay, also to Peru, Chili, and other parts of South America; and to Suakin, Perim, Penang, Malacca, Singapore, Labuan, Java, Australia, New Zealand, Tasmania, New Caledonia, Bangkok, Cambodia, Saigon, Tonquin, Hainan, China.

By ALTERNATIVE CABLES to Zanzibar, Mombasa, Mozambique (duplicate), Lourenço Marques (Delagoa Bay), Durban and Capetown; Bathurst, Sierra Leone, Accra, Lagos, Bonny, Bolama, Bissao, Cameroons, St. Thome, Principe, Loanda, Benguella, Mossamedes, Conakry, Grand Bassam, and Gaboon.

By SINGLE CABLE to the Azores, Tangier, Tripoli, Cyprus, Seychelles, Mauritius, and Manila.

Telegrams should be sent from the Company's Stations—

**LONDON**—11, OLD BROAD STREET, E.C.; 8, LEADENHALL STREET; 3, GREAT TOWER STREET; 42, PARLIAMENT STREET, S.W.; 206a, WINCHESTER HOUSE, E.C.; 37, HOLBORN VIADUCT, E.C.; FOREIGN AUCTION HALL, COVENT GARDEN MARKET, W.C., and 449, STRAND, W.C.

**MANCHESTER**—20, Brown Street. **LIVERPOOL**—K13, Exchange Buildings.

**GLASGOW**—141, BUCHANAN STREET.

COMPANY'S LEVANT SYSTEM:

Odessa, Constantinople, Dardanelles, Tenedos, Salonica, Smyrna, Chio, Syra, Candia, Rettimo, Canea, Sitia, Rhodes, Trieste, Corfu, Zante, Patras, Corinth, Athens, Cephalonia, Santa Maura, Tinos, Andros, Zea, and all the Greek Islands.

The Company's Cables are worked by Muirhead's DUPLEX principle upon all its Main Sections.

In sending Telegrams from Postal Stations care should be taken to mark them— "VIA EASTERN," these words being signalled gratuitously by the Postal Authorities.

Books of Forms and Tariffs forwarded post free on application at the Company's Chief Offices as above, or at

37, RUE CAUMARTIN, PARIS; and HOTEL DES POSTES ET TELEGRAPHES, MARSEILLES.

Winchester House, 50, Old Broad Street, E.C. By Order, GEORGE DRAPER, *Secretary*.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## BY SPECIAL WIRES.

## DIRECT OVERLAND TELEGRAPHS

CONNECTED WITH

**INDIA, CEYLON, BURMAH, PENANG, SINGAPORE, AND OTHER PLACES IN THE STRAITS SETTLEMENTS, CHINA, MANILA, COCHIN CHINA, JAPAN, JAVA, AUSTRALIA, NEW ZEALAND, NEW CALEDONIA, PERSIA, SOUTHERN RUSSIA, CONSTANTINOPLE, AND OTHER PLACES IN TURKEY AND THE EAST GENERALLY.**

The greatest possible SPEED and ACCURACY in the Transmission of Messages are secured by the VERY LIMITED NUMBER of TRANSMITTING STATIONS on the LINE, by the use of INK-WRITING RECORDING INSTRUMENTS, by the employment of a Special Staff of Skilled ENGLISH TELEGRAPHISTS throughout the Line, and by a System of Control which is exercised over every Message.

*Messages are accepted at the Company's Offices—*

**LONDON: 18, Old Broad Street, E.C., 6 and 8, Lime Street Square, and 10 and 11, Mincing Lane, E.C.**

**LIVERPOOL: Walmer Building, 6, Water Street.**

**MANCHESTER: 60, Spring Gardens.**

Where receipts are given gratis for the charges made and whence messages are sent direct by Special Wire, and at any Postal Telegraph Office throughout the Kingdom.

ALL TELEGRAMS SHOULD BE MARKED "VIA INDO."

No Charge is made by any Telegraph Station for the transmission of the "Via."

Books of Forms and Tariff Books containing Rules and Regulations, Lists of Stations, &c., are forwarded post free on application to the Company's Head Offices, 18, Old Broad Street, London, E.C.

W. ANDREWS, *Managing Director.*

**THE INDESTRUCTIBLE PAINT COMPANY, Ltd., 27, Cannon St., E.C.**

# BROWNING'S PRESERVATIVE ENAMEL PAINT,

**IN ANY COLOUR OR TINT.**

**READY MIXED. USEABLE AT ANY TIME.** For **SHIPS, STEAMERS, YACHTS** (inside or outside), **LAMP-POSTS** (Gas and Electric) and for **ALL PURPOSES** where a hard and washable surface is essential. Has stood years of rough wear.

**THE INDESTRUCTIBLE PAINT** resists the action of acids and alkalies. Invaluable for Iron Structures, Roofing, Gas Tanks, &c LASTS WELL WHERE OTHER PAINTS ARE USELESS, NOT AFFECTED BY FUMES, GASES, SUDDEN CHANGES OF TEMPERATURE, &c.

**BROWNING'S PRESERVATIVE ANTI-FOULING COMPOSITIONS.**

**BROWNING'S COLOURLESS PRESERVATIVE SOLUTION** is a Perfect Cure for Damp Walls. Makes Bricks, Porous Stone, Cement, &c., weatherproof. It was applied to **CLEOPATRA'S NEEDLE IN MAY, 1879,** and after eleven years exposure to the trying climate of London, Mr. Dixon, C.E. (who brought the Obelisk to London), described the successful result in *The Times*, May 28th, 1890.

**THE PAINTS and the SOLUTION SECURED the HIGHEST AWARDS at each of the EXHIBITIONS—**

**FISHERIES, HEALTH, and INVENTIONS, in 1883, 1884, and 1885.** *Telegraphic Address: "WEATHERPROOF LONDON."*

# HALLOWEEN.

FOR

**INDIGESTION, WIND, BILE, SICKNESS, HEADACHE.**

A pure and harmless Cordial, and a splendid Pick-me-up.

*A BOON TO JADED WORKERS AND THINKERS.*

Of all Chemists, in Bottles, 1s. 1½d., 2s. 9d., and 4s. 6d.; or of the

**DYSPEPSIA CURE CO., 18, Eldon St., FINSBURY, E.C.**

# Duncan Wallet and Co.,

**EXPORT PROVISION MERCHANTS,**

**Shippers of Wines, Spirits, Teas, Coffees, &c., in Bond.**

***114, FENCHURCH STREET, LONDON, E.C.***

***Special Arrangements made for supply of Telegraph Stations & Cable Steamers abroad.***

Messrs. D. W. & Co. supply Provisions and Bonded Stores to the CABLE STEAMERS of several Companies, also to VARIOUS STATIONS of the EASTERN, EASTERN AND SOUTH AFRICAN, and EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANIES, and are prepared to execute orders on specially favourable terms on shortest notice.

# KIRKALDY'S PATENT ANTI-FOULING COMPOSITIONS

AS SUPPLIED TO THE

**WHITE STAR ROYAL MAIL STEAMERS, Messrs. SHAW, SAVILL, & ALBION CO.'s ROYAL MAIL STEAMERS, DUCAL LINE, CLAN LINE, NATIONAL LINE, STAR NAVIGATION CO., Messrs. GEORGE THOMPSON & CO., Messrs. LAMPORT & HOLT, Messrs. MILBURN & CO., Mr. W. LUND, The EASTERN & AUSTRALIAN STEAM NAVIGATION CO., and other large Fleets of Steam and Sailing Vessels. Agents at all the Principal Ports.**

Particulars, Circulars, and Testimonials will be sent in answe to applicatin made to the SOLE MAKERS,

**JOHN KIRKALDY & SON,** East London Works, **GARFORD ST., LONDON, E.**

TELEGRAPHIC ADDRESS: "KIRKALDY LONDON.


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# THE EASTERN & SOUTH AFRICAN TELEGRAPH COMPANY, Ltd.

# THE AFRICAN DIRECT TELEGRAPH COMPANY, LIMITED, AND

# THE WEST AFRICAN TELEGRAPH COMPANY, LIMITED.

**The above Companies, by means of Cables along the East and West Coasts of Africa, as shown in the Map on the opposite page, connect the following Colonies and Dependencies with the European System of Telegraphs:—**

## SOUTH AFRICA.

| | |
|---|---|
| CAPE COLONY. | NATAL. |
| ORANGE FREE STATE. | TRANSVAAL. |

## EAST COAST.

ZANZIBAR. SEYCHELLES. MAURITIUS. MOZAMBIQUE. LOURENÇO MARQUES (Delagoa Bay). MOMBASA. BAGAMOYO. DAR-ES-SALAAM.

## WEST COAST.

| *BRITISH* | *PORTUGUESE.* | *FRENCH.* |
|---|---|---|
| BATHURST (Gambia). | BISSAO. | CONAKRY. |
| SIERRA LEONE. | BOLAMA. | GRAND BASSAM. |
| ACCRA. | PRINCIPÉ. | KOTONOU (Porto Novo) |
| LAGOS. | S. THOMÉ. | GABOON. |
| BRASS. | LOANDA. | WHYDAH. |
| BONNY. | BENGUELLA. | *GERMAN.* |
| CAPE COAST CASTLE. | MOSSAMEDES. | CAMEROONS. |

Books of Forms, Tariffs and all Information can be obtained at the Company's Head Offices, Winchester House, 50, Old Broad Street, E.C.

By order,

H. E. PLANK, *Secretary*, AFRICAN DIRECT TELEGRAPH COMPANY.

GEORGE DRAPER, *Secretary*, EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.

J. CAMBROOK, *Secretary*, WEST AFRICAN TELEGRAPH COMPANY.

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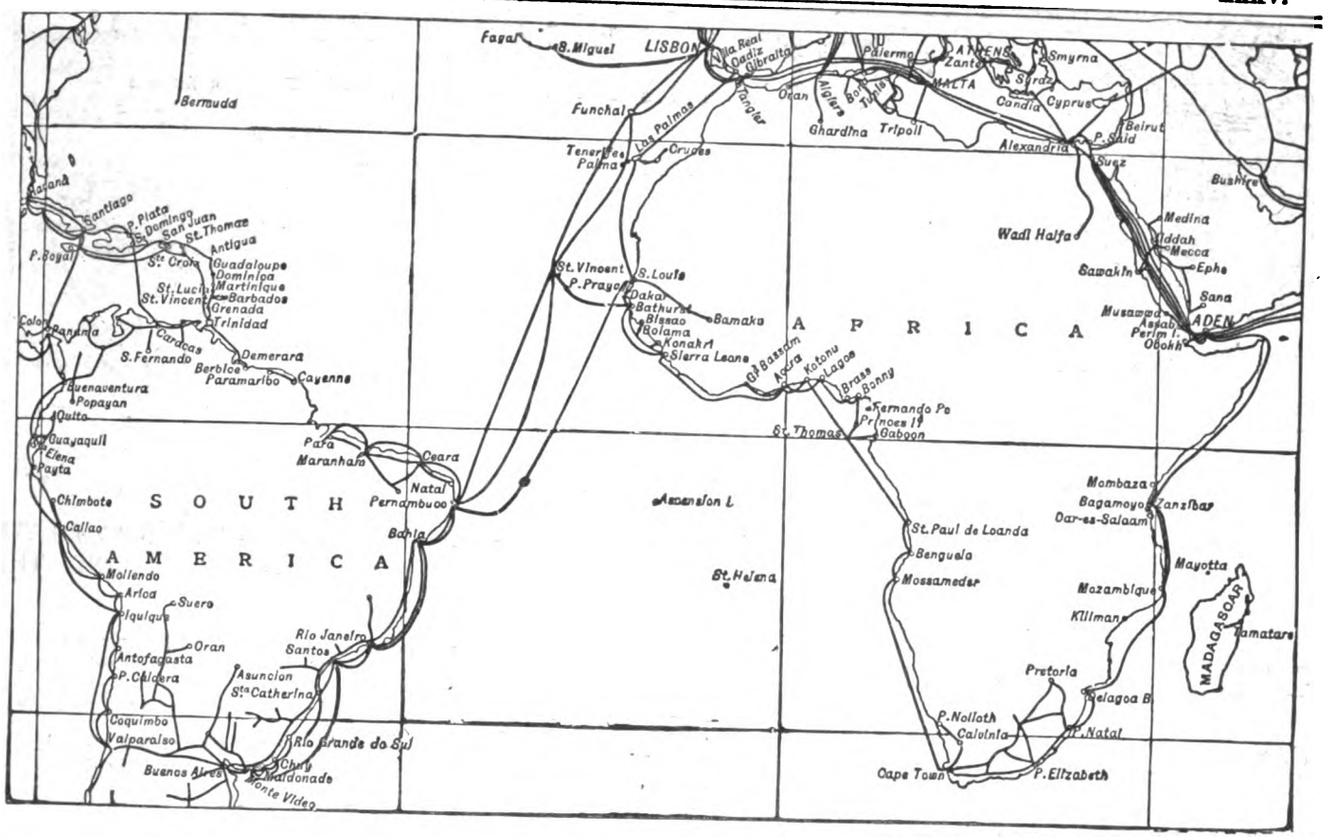


# THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY, LTD.
# THE WESTERN & BRAZILIAN TELEGRAPH CO., LTD.

**THE above Companies connect the Continent of Europe with that of South America by means of the DIRECT DUPLICATE Cables from Lisbon via Madeira and St. Vincent to Pernambuco, Bahia, Rio de Janeiro, Santos, Santa Catharina, Rio Grande do Sul, Monte Video and Buenos Ayres, also by cable from Pernambuco to Ceara, Maranham, and Para.**

**Under working arrangements with**

## THE PACIFIC & EUROPEAN TELEGRAPH Co., Ltd.,

— AND —

## THE WEST COAST OF AMERICA TELEGRAPH Co., Ltd.

**Telegrams for Chili, Peru, and Bolivia are forwarded by the new direct land lines between Buenos Ayres and Valparaiso and by the West Coast Cables to destination.**

TELEGRAMS from GREAT BRITAIN can be sent at the following Charges per word:—

| | s. | d. |
|---|---|---|
| Madeira ... ... ... ... ... ... ... ... | 1 | 2 |
| Cape Verde Islands—St. Vincent ... ... ... ... | 2 | 6 |
| " " St. Iago ... ... ... ... | 3 | 5 |
| Brazil—Pernambuco ... ... ... ... ... ... | 3 | 6 |
| " All other Stations ... ... ... ... ... | 4 | 6 |
| Uruguay—All Stations ... ... ... ... ... ... | 4 | 6 |
| Argentine Republic—All Stations ... ... ... ... | 4 | 6 |
| Paraguay—All Stations ... ... ... ... ... | 4 | 6 |
| Bolivia—All Stations ... ... ... ... ... ... | 6 | 2 |
| Chili—All Stations ... ... ... ... ... ... | 6 | 2 |
| Peru—All Stations ... ... ... ... ... ... | 6 | 2 |

**Tariff-Cards, Books of Forms, and all information can be obtained at the Head Offices of the Companies. Messages should be marked "Via Eastern."**

BY ORDER,

RICHARD COLLETT, *Secretary*,

BRAZILIAN SUBMARINE TELEGRAPH CO., WINCHESTER HOUSE, OLD BROAD STREET.

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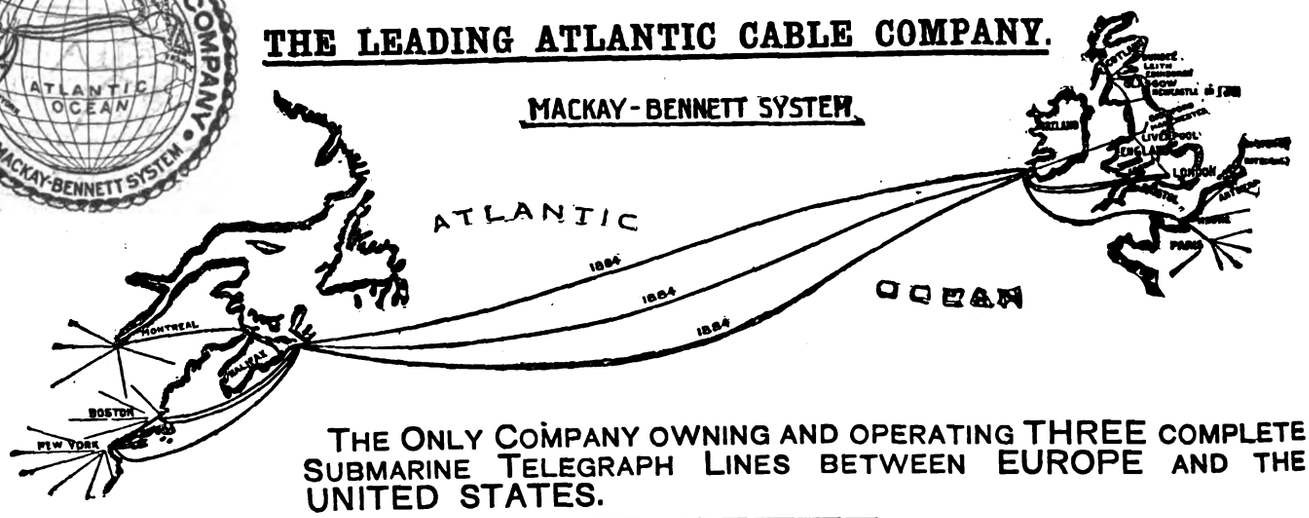
# "COMMERCIAL."

## THE LEADING ATLANTIC CABLE COMPANY.

MACKAY-BENNETT SYSTEM.




THE ONLY COMPANY OWNING AND OPERATING THREE COMPLETE SUBMARINE TELEGRAPH LINES BETWEEN EUROPE AND THE UNITED STATES.

SHORTEST AND MOST RELIABLE ROUTES TO ALL PARTS OF THE AMERICAS.

CONNECTIONS.

POSTAL TELEGRAPH CO. The greatest competitive system of Telegraphs ever maintained in the United States, covering ALL COMMERCIAL POINTS IN THE COUNTRY.

CANADIAN PACIFIC TELEGRAPHS reaching all important places in CANADA, from the Atlantic to the Pacific, and the ONLY COMPANY HAVING LINES IN BRITISH COLUMBIA.

"VIA COMMERCIAL."

*To insure your Cablegrams being forwarded by this Company's system, please mark them "Via COMMERCIAL," which indication is not charged for; or use the Company's own forms, bearing its GLOBE trade mark*

THIS COMPANY'S ROUTES AVOID ALL LONG LAND LINES ON BOTH SIDES OF THE ATLANTIC.

HEAD OFFICE: 253, BROADWAY, NEW YORK, U.S.A.
J. W. MACKAY, PRESIDENT.
GEO. G. WARD, VICE-PRESIDENT & GENERAL MANAGER.

GENERAL OFFICE, LONDON,
BISHOPSGATE HOUSE, 55 and 56, BISHOPSGATE STREET WITHIN, E.C.
FREDERICK WARD, MANAGER IN ENGLAND.

# THE WESTERN UNION TELEGRAPH COMPANY.

## EXECUTIVE OFFICES, No. 195, Broadway, NEW YORK, U.S.A.

*THOS. T. ECKERT, President and General Manager.*

## THE LARGEST TELEGRAPHIC SYSTEM IN EXISTENCE.

**TWO ATLANTIC CABLES from PENZANCE, Cornwall, to NEW YORK CITY direct. Both Cables are duplexed.**

*The LAND-LINE SYSTEM of the Company in AMERICA comprises 740,000 MILES of WIRE, and 21,000 TELEGRAPH OFFICES.*

**DIRECT WIRES to GALVESTON, TEXAS,** connecting at that place with the Cables of the MEXICAN the CENTRAL and SOUTH AMERICAN TELEGRAPH COMPANIES for

**ALL POINTS in MEXICO and CENTRAL and SOUTH AMERICA.**

**DIRECT WIRES and CABLES to HAVANA, CUBA,** connecting at that place with the CUBA SUBMARINE and WEST INDIA AND PANAMA TELEGRAPH COMPANIES for

**ALL POINTS in the WEST INDIES.**

**EXCLUSIVE CONNECTION with the GREAT NORTH-WESTERN TELEGRAPH COMPANY of CANADA.**

*To ensure the Direct and Prompt Transmission of Messages from any Telegraph Office to all places in the Western Hemisphere they should be marked*

**"Via Western Union."** (This indication will be transmitted without charge.)

The Offices of the Company in Great Britain are— **252, GRESHAM HOUSE, OLD BROAD STREET, LONDON, E.C.**

**RECEIVING OFFICES:**

40, MARK LANE, LONDON, E.C.
21, ROYAL EXCHANGE, LONDON, E.C.
109, FENCHURCH STREET, LONDON, E.C.
EFFINGHAM HOUSE, ARUNDEL ST., STRAND, LONDON, W.C.

2, NORTHUMBERLAND AVENUE LONDON, W.C.
45, EXCHANGE BUILDINGS, LIVERPOOL.
BACKHALL CHAMBERS, BALDWIN ST., BRISTOL.
99, GORDON STREET, GLASGOW.
10, FORSTER SQUARE, BRADFORD.

1, PANMURE STREET, DUNDEE.
106, GEORGE STREET, EDINBURGH.
EXCHANGE BUILDINGS, LEITH.
7, ROYAL EXCHANGE, BANK ST., MANCHEST
1, SIDE, NEWCASTLE-ON-TYNE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TELEPHONE No. 15,077 TELEGRAMS: "INDICES LONDON."

# WHEATLEY KIRK, PRICE & COULTY

(*ESTABLISHED 1850*),

## Electrical Auctioneers, Valuers,

AND ARBITRATORS.

Average Annual Valuations exceed £1,500,000 Sterling.

## 49, QUEEN VICTORIA STREET, LONDON, E.C.

## TENDERS INVITED.

NOTICE TO CONTRACTORS.

### ARMAGH DISTRICT LUNATIC ASYLUM.

The Commissioners for the Control of Lunatic Asylums will receive Sealed TENDERS up to 10 o'clock a.m. on the 3rd August, 1896, for the SUPPLY and ERECTION of an ELECTRIC LIGHT INSTALLATION for Armagh District Lunatic Asylum.

The Tender should be sent in a sealed envelope, endorsed outside, "Tender for Electric Lighting, Armagh Asylum," and addressed to the Secretary, Board of Control, Custom House, Dublin, and should be accompanied by a SEPARATE sealed envelope similarly addressed and endorsed, containing the Detailed Estimate.

Forms of Tenders and copies of Specification, which has been prepared by J. H. Greenhill, Esq., New King-street, Belfast, will be issued on application to this office on deposit of £1, which will be returned to all persons who have sent in bona fide Tenders.

The Plans can be seen at the Office of the Architects, Messrs. J. J. Phillips and Son, 61, Royal-avenue, Belfast.

The Board will not be bound to accept the lowest or any Tender.

(By Order),

P. J. TUOHY, Secretary.

Office of the Board of Control of Lunatic Asylums,
Customs House, Dublin.
7th July, 1896.

### ELECTRICAL BUSINESS FOR SALE IN NORTH OF ENGLAND.

The Subscriber has for Sale in the North of England ELECTRICAL WORKS in full employment. A splendid opportunity is afforded for an energetic party. Ingoing about £6,000. Present owner selling solely on account of ill-health. Principals or their solicitors only dealt with.

For further particulars apply to DAVID WHITE, Solicitor, 106, Bath-street, Glasgow.

### TO BE SOLD, as a Going Concern, old-established ELECTRICAL MANUFACTURING and CONTRACTING BUSINESS, owing to senior partner retiring. £18,000 required. Sums under £4,000 not entertained. Fullest investigation allowed. Would suit three or four energetic men joining capital. Established over 20 years.—SOUTHAM'S Agency, 29, Paternoster-row, London.

### MANAGING PARTNERSHIP.—Half Share in well-established business. £1,150 required. Profits over £400 per annum nett to divide. Increasing business. Practical men need only apply.—SOUTHAM'S Partnership Agency, 29, Paternoster-row, London. Speciality: Auto Car partnership.

### THE EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (Limited).

NOTICE is Hereby Given that the FOUR PER CENT. MORTGAGE DEBENTURE STOCK REGISTER will be CLOSED from the 28th to the 31st instant, both days inclusive.

By order,

W. R. LYNE, Assistant Secretary.

Winchester House, Old Broad-street, E.C.,
8th July, 1896.

### SUBMARINE CABLES TRUST.

NOTICE is Hereby Given that on and after the 15th July the sum of £1, balance of the COUPON due 15th April, 1896, will be PAID by Messrs. GLYN, MILLS and CO., of 67, Lombard-street, between the hours of 10 a.m. and 2 p.m. The Coupons should be left with the Bankers for examination FOUR clear days before payment.

By Order of the Trustees,

A. BRODRICK, Secretary.

Winchester House, 50, Old Broad-street, London, July 8th, 1896.

### CITY AND GUILDS OF LONDON INSTITUTE.

SESSION 1896-97.

THE COURSES OF INSTRUCTION IN ENGINEERING AND CHEMISTRY at the Institute's Colleges commence in October, and cover a period of two to three years. The MATRICULATION EXAMINATION of the **Central Technical College** will be held on September 21st to 24th and the ENTRANCE EXAMINATION of the Day Department of the **Technical College, Finsbury**, on September 22nd.

**CITY AND GUILDS CENTRAL TECHNICAL COLLEGE**

(Exhibition-road, S.W.), a College for Higher Technical Instruction for Students not under 16 years of age preparing to become Civil, Mechanical or Electrical Engineers, Chemical and other Manufacturers, and Teachers.

THE MATRICULATION EXAMINATION will be held on September 21st to 24th, and the new Session will commence on October 1st.

Professors:—O. Henrici, LL.D., F.R.S. (Mathematics); W. C. Unwin, F.R.S., M.I.C.E. (Civil and Mechanical Engineering); W. E. Ayrton, F.R.S. (Physics and Electrical Engineering); H. E. Armstrong, Ph.D., F.R.S. (Chemistry).

**CITY AND GUILDS TECHNICAL COLLEGE, FINSBURY**

(Leonard-street, City-road, E.C.). The DAY DEPARTMENT provides Courses of Intermediate Instruction for Students not under 14 years of age, preparing to enter Mechanical or Electrical Engineering and Chemical Industries.

THE ENTRANCE EXAMINATION will be held on September 22nd, and the new Session will commence on October 6th.

Professors:—S. P. Thompson, D.Sc., F.R.S. (Electrical Engineering); R. Meldola, F.R.S. (Chemistry).

JOHN WATNEY, Hon. Secretary.

City and Guilds of London Institute,
Gresham College, Basinghall-street, E.C.

**The LIST of SUBSCRIPTIONS will be OPENED on THURSDAY, 9th July, and CLOSE at or before 4 o'clock on FRIDAY, 10th July, 1896.**

# THE RIVER PLATE ELECTRIC LIGHT AND TRACTION CO., Ltd.

### AUTHORISED SHARE CAPITAL:

£150,000 IN 30,000 SIX PER CENT. CUMULATIVE PREFERENCE SHARES OF £5 EACH, AND ENTITLED TO PRIORITY IN CAPITAL;
AND £150,000 IN 30,000 ORDINARY SHARES OF £5 EACH.

## ISSUE of £125,000 Five per Cent. (part of a total authorised issue of £150,000) FIRST DEBENTURE STOCK at 97½,

Redeemable by the Company at Six Months' Notice at 107½.

**ISSUE PRICE £97 10s., payable as follows: £5 per cent on Application; £20 on Allotment; £40 on 30th September, 1896; £32 10s. on 31st December, 1896—total, £97 10s.**

Prepayments will be accepted on Allotment under discount at the rate of 2 per cent. per annum.

### ABRIDGED PROSPECTUS.

THE RIVER PLATE TRUST, LOAN AND AGENCY COMPANY, Limited, 52, Moorgate-street, E.C., are authorised by the Company to offer the above-mentioned Debenture Stock for subscription.

The interest will be payable half-yearly, on 1st January and 1st July in each year. Scrip Certificates to bearer will be issued against Bankers' Receipts and Allotment Letters, to be exchanged on completion of all payments for the Certificates of the Debenture Stock.

The Debenture Stock will form a first charge on the whole of the Company's stations and property, and will be secured by a Trust Deed to be executed by the Company in favour of the River Plate Trust Loan and Agency Company, Limited, as Trustees for the Debenture Stockholders.

The Company's Electric Lighting Stations, already in operation, are in the cities of LA PLATA (the Capital of the Province of Buenos Aires), and ROSARIO, the principal commercial port of the Province of Santa Fé. A well-equipped station is in course of construction by the Company in the City of TUCUMAN, the Capital of the Province of that name, and the centre of the great sugar industry of the country. This station is now nearly completed.

The further Capital raised by the present issue is chiefly for the purpose of carrying out the erection of a Station in Buenos Aires, for which the requisite authorisation has been obtained.

The Lighting Receipts of the two Stations already at work have increased from £14,816 11s. 0d. in 1892 to £23,911 14s. 7d. in 1895, and the gross profit thereon from £3,928 16s. 2d. to £11,124 8s. 11d.

The net revenue of the pioneer Company last year—after providing for all general expenses, which bear heavily upon a business in its first development—was £10,050 17s. 2d. Since the close of these accounts, further important Contracts have been obtained, which will, it is estimated, bring the net Revenue of the present Company up to £15,000 or £16,000 (including that from the Tucuman Station) so soon as the plant now in course of shipment and erection, is in operation. These figures do not include provision for depreciation, which is estimated at £3,000.

The present Revenues acquired and arranged for may, therefore, be put at £12,000 *net*, and that of the Buenos Aires Station at not less than the same amount. The net results of the four Stations would thus not fall short of £24,000, without counting on anything from Tramway Traction, for which there is a large field in Buenos Aires alone.

The interest of the Debenture Stock being £6,250, it follows that there will be ample margin of security.

Full Prospectuses and Forms of Application may be obtained from The River Plate Trust, Loan and Agency Company, Limited, 52, Moorgate-street, E.C.; the Brokers, Messrs. Snell & Swaffield, 9 & 10, Tokenhouse-yard, E.C.; and the Solicitors, Messrs. Ashurst, Morris, Crisp & Co., 17, Throgmorton-avenue, E.C.

London, *7th July, 1896.*

The following are the particulars of the Company's Board and Officials:

**DIRECTORS:**

J. H. DUNCAN, Esq., Director Monte Video Water Works Company, Limited.
THOS. FARRELL, Esq., Director River Plate Trust, Loan and Agency Company, Limited.
C. J. GUNTHER, Esq., Chairman of Liebig's Extract of Meat Co., Limited.
E. J. HALSEY, Esq., J.P., Director of The City of Santos Improvements Co.
FRANCIS INCE, Esq., of Messrs. Ince, Colt and Ince, Solicitors, London.
W. R. CASSELS, Esq., Managing Director in the River Plate.

**Consulting Engineers:**

Messrs. KINCAID, WALLER & MANVILLE, 29, Great George-street, Westminster, S.W.

**Solicitors:**

Messrs. ASHURST, MORRIS, CRISP & Co., 17, Throgmorton-avenue, E.C.

**Auditors:**

Messrs. DELOITTE, DEVER, GRIFFITHS & Co.

**Brokers:**

Messrs. SNELL & SWAFFIELD, 9 & 10, Tokenhouse Yard, E.C.

**Bankers:**

Messrs. GLYN, MILLS, CURRIE & Co., Lombard Street, E.C.; and THE LONDON & RIVER PLATE BANK, London and Buenos Aires.

**Secretary and Offices:**

T. S. HAMILTON, Esq., 78, Coleman Street, E.C.



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**STANLEY** 2 Gold Medals.

Manufacturer of

**DRAWING and SURVEYING INSTRUMENTS**

Of Every Description, of the Highest Quality and Finish, at the most Moderate Prices.

— PRICE LIST POST FREE. —

Address: **GREAT TURNSTILE, HOLBORN, LONDON, W.C.**

Telegrams, "Turnstile London." Telephone, 65188.


## APPOINTMENTS VACANT.

THE YORKSHIRE COLLEGE, LEEDS.

DEPARTMENT OF PHYSICS.

Applications are invited before July 26th for the Appointment of ASSISTANT LECTURER and DEMONSTRATOR in TECHNICAL ELECTRICITY. Salary £125, with certain fees, which amounted last year to £78.

Particulars may be obtained from the SECRETARY.

## SITUATIONS VACANT AND WANTED.

WANTED, a first-class man as FOREMAN of Instrument-making Department; must have a thorough knowledge of gravity and Cardew instrument work. Good wages paid to a thoroughly competent man.—Apply, stating age and experience, to 2235, *Electrician* Office, Salisbury-court, Fleet-street, E.C.

A young gentleman is desirous of obtaining a SITUATION in Chemical or Electrical Works, without salary. Has had four years' training at the City and Guilds of London Central Institute, Kensington.—Address, "S. O.," care of Street and Co., 30, Cornhill, E.C.

ADVERTISER seeks SITUATION as IMPROVER in Central Station or with first-class Electrical Firm. Age, 21 Three years' practical experience, good theoretical knowledge, good draughtsman.—Address, "E. M. F.," care of Bookstall, 94, Edgware-road, London, W.

ELECTRICIANS.—NOTICE to EMPLOYERS.—Please note we have a number of First-Class ELECTRICAL MEN upon our Books. Kindly send us particulars of any VACANCIES you may have. We can introduce you, free of charge, to the best men now at liberty.

Address, CHAS. RICHARDSON and CO., Engineers' Bureau 342, Strand, London, W.C

PARTNERSHIPS.—ELECTRICAL ENGINEERS and others WANTING PARTNERS, or wishing to SELL, can be introduced to Clients with Capital; and GENTLEMEN Seeking Investments can obtain personally (or through their solicitors) particulars of bona-fide OPENINGS. Strictest confidence observed.—Address, CHAS. RICHARDSON and CO., 342, Strand, London, W.C.

PRACTICAL EVENINGS; running engine, dynamos, &c. Mondays, Wednesdays, Fridays.—ELECTRICAL ENGINEER, 51, Sinclair-road, West Kensington.

ELECTRICAL FITTER (27), 13 years' mechanical and electrical experience, wants job as journeyman, foreman, or would take charge of lighting, heating, and water supply of country estate, first-class reference; moderate wages for permanency.—WICKENS, 76, Tonbridge-street, Euston-road, London.

## WANTED, and FOR SALE.

PLATINUM UTENSILS, SCRAP, LAMP TOPS.—Best prices given by Derby and Co., 44, Clerkenwell-road, London, E.C. N.B.—Platinum sold

ACCUMULATOR CHARGING.—C. H. CATHCART and CO., having plant specially adapted for this purpose, Charge Cells of all sizes promptly, thoroughly and cheaply. Terms on application. Accumulators on Hire for temporary lighting, experimental uses, &c.—3, Dorset-buildings, Salisbury-square, Fleet-street, E.C. (Telephone No. 65,266.)

ADVERTISER wishes to acquire knowledge of process of Manufacture of Incandescent Lamp Filaments. Zinc chloride or other similar process.—Letters to be addressed to "Z. N.," *Electrician* Office, Salisbury-court, Fleet-street, E.C.


**PORTABLE ELECTRIC**

# SAFETY LAMPS

FOR:—

MINES, FACTORIES, GAS WORKS, &c., &c.

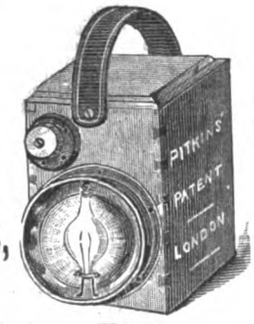


FIG. 1A.

SHIPS, FIRE BRIGADES, TRAVELLERS, &c., &c.

MAKER

**J. PITKIN,**

**56, Red Lion Street, Clerkenwell, E.C.**


**LIST of APPLICATIONS will CLOSE on or before TUESDAY, the 14th July, 1896.**

# THE ROLLER-BEARINGS CO., LTD.

*Incorporated under the Companies' Acts 1862 to 1890, whereby the liability of Shareholders is limited to the amount of their Shares.*

**Capital £150,000, divided into 75,000 Six per Cent. Cumulative Preference Shares of £1 each, and 75,000 Ordinary Shares of £1 each.**

The Preference Shares to rank on the whole of the Property and Assets of the Company in priority to the Ordinary Shares; and in respect of Revenue to be entitled—

First—To a Cumulative Preferential Dividend at the rate of Six per cent. per annum; and

Second—To rank *pro rata* with the Ordinary Shares for further dividend after Ten per cent. has been paid on the Ordinary Shares.

Of the present Issue of 55,000 Six per Cent. Cumulative Preference Shares of £1 each, and 55,000 Ordinary Shares of £1 each; 30,000 Preference Shares and 30,000 Ordinary Shares are offered for public subscription, payable as follows:—5s. on Application; 5s. on Allotment; 5s. one month after Allotment; and the Balance at an interval of not less than Two Months.

*Interest at the rate of Four per cent. will be allowed on all Calls paid in advance.*

The present issue will provide £20,000 for Working Capital and leave 40,000 Shares for issue as occasion requires. 11,000 Shares have been applied for by the Directors and their friends, and will be allotted in full.

### DIRECTORS.

Major-General C. S. HUTCHINSON, C.B., late Senior Inspector of Railways to the Board of Trade, Blackheath, S.E., Chairman

GEORGE BUSH, Member Inst.C.E., Director of the Vendor Syndicate, 84, Cleveland-square, W.

A. J. OLDHAM, Member Inst.C.E., late Deputy Consulting Engineer to the Government of India for Railways, Northlands, Guildford.

WILLIAM SHELFORD, Member of Council Inst.C.E., 35A, Great George-street, S.W.

**Bankers.**—NATIONAL BANK OF SCOTLAND (Limited), 37, Nicholas-lane, E.C. Head Office in Edinburgh and Branches in Scotland.

**Consulting Engineer.**—Sir DOUGLAS FOX, Vice-President Inst.C.E., 28, Victoria-street, S.W.

**Solicitors.**—Messrs. ASHURST, MORRIS, CRISP and CO., 17, Throgmorton-avenue, E.C. (for the Company); Messrs. MARSHALL and MARSHALL, 3 and 4, Lincoln's Inn-fields (for the Vendors).

**Auditors.**—Messrs. FULLER and WISE, 73, Basinghall-street, E.C.

**Secretary and Offices.**—THOMAS W. HOW, 1, Delahay-street, Westminster.

### ABRIDGED PROSPECTUS.

This Company has been formed for the purpose of purchasing all right and title to a roller-bearings invention patented by Messrs. Frederick Purdon, A.M.Inst.C.E., Harry Ernest Walters, A.M.Inst.C.E., and W. Hugh Woodcock, M.Inst.C.E., together with the patent rights acquired, or to be acquired, and any further improvements relating thereto, and for developing and working the same. Patent rights have already been obtained for Great Britain, United States of America, Germany, Austria-Hungary, France, Belgium, Italy, Russia, Canada, New South Wales, the Argentine Republic, Brazil, and Uruguay.

Negotiations are in progress for the sale of the patent rights for France, Belgium, and South America.

### APPLICATIONS.

**These bearings are adapted for Railway Carriages and Wagons, Electric Motors and Dynamos, Tram Cars, Omnibuses, Cabs, Carts, Cycles, and Carriages of all descriptions, Workshop Shafting, Marine Engine Shafts, Mills, Stationary Engines, &c., &c.**

**Description.**—The invention is an improvement upon the ball bearing almost universally adopted for Cycles, and upon the other bearings in general use, by substituting rolling motion for rubbing friction. This is effected by placing the axle between solid rollers, which are so arranged that they are kept in true position, parallel with the axle, and are prevented from grinding against each other or moving laterally.

There is no other Bearing which so mechanically fulfils these conditions.

**Objects of the Invention.**—To economise the cost of traction, whether in fuel, electric current, or horse-flesh, by—

(1) Greatly reducing the friction due to the sliding or rubbing action which exists in all ordinary forms of bearings.

(2) The saving of oil and other lubricants, which by this bearing can be reduced to sufficient only to prevent rusting, with a resultant saving which is great, and constitutes an important economy in the starting and running of all kinds of vehicles.

The number of bearings used on railways, tramways, road vehicles, cycles, shafting and machinery is so great that it is impossible to attempt to give an accurate estimate of them. The latest returns of the Board of Trade show that there are upwards of **3½ millions of bearings on the axles of Railway Vehicles in the United Kingdom alone, and about 17,000 on Tram Cars,** and the number on road vehicles and cycles must far exceed these. It is obvious that the field is practically unlimited for the application of these bearings, the **success** of which is **already assured** by their adoption in the cases mentioned below.

**Estimated Profits.**—Assuming that only 1 per cent. of the axles of Railway Vehicles alone were fitted with these bearings, the income of the Company, after allowing for working expenses, would be sufficient, upon the basis of an average Royalty of 10s. per bearing, to pay 6 % on the whole of the Preference Shares and 10 % on the Ordinary Shares.

Experiments extending over the past three years have proved the superiority of these roller bearings over other existing bearings, and also that the invention is mechanically and theoretically sound. **Bearings have been applied with conspicuous success** to Railway Carriages, Wagons, Tram Cars, Dynamos, Cycles and Works Shafting; they have been worked without lubricants at speeds of from 500 to 4,000 revolutions per minute, and in no case has there been any heating. It has also been shown by a series of trials, that the effort required to start and keep in motion vehicles fitted with these bearings is only from **one-sixth** to **one-fourth** of that required for the same vehicles when fitted with the ordinary bearings.

The purchase price payable to the Vendors, who are also the promoters, has been fixed by them at £90,000, payable as to £22,500 in cash, £25,000 in Preference Shares (fully paid) or cash at the option of the Directors, £25,000 in Ordinary Shares, and the balance in cash, Preference or Ordinary Shares, at the option of the Directors.

The Vendors are also to receive half the net proceeds on the sale or licence of foreign and colonial patents.

The Vendors defray all expenses of the formation and registration of the Company and the issue of its capital up to allotment.

Prospectus and forms of application may be obtained from the Bankers, Solicitors, and from the Secretary at the offices of the Company.

*Dated July 10, 1896.*

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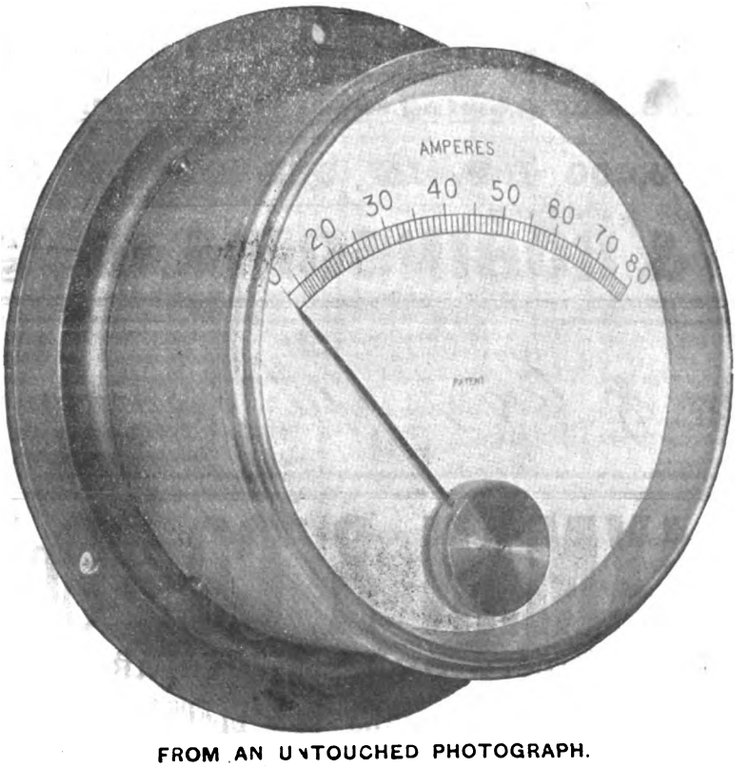


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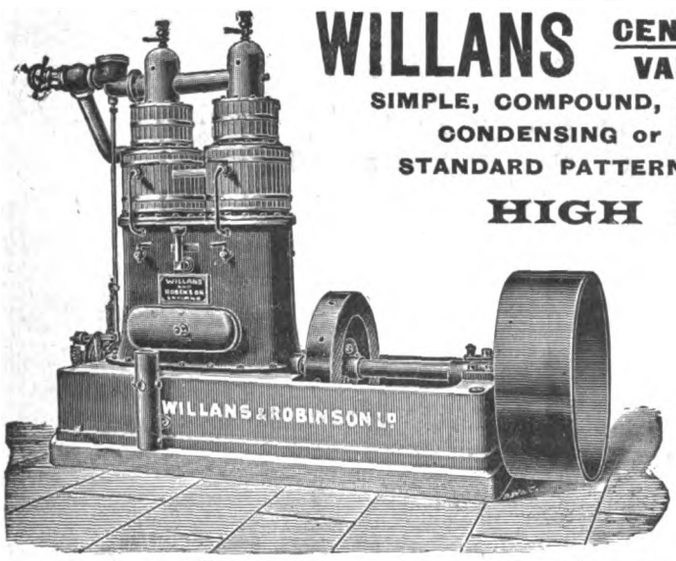


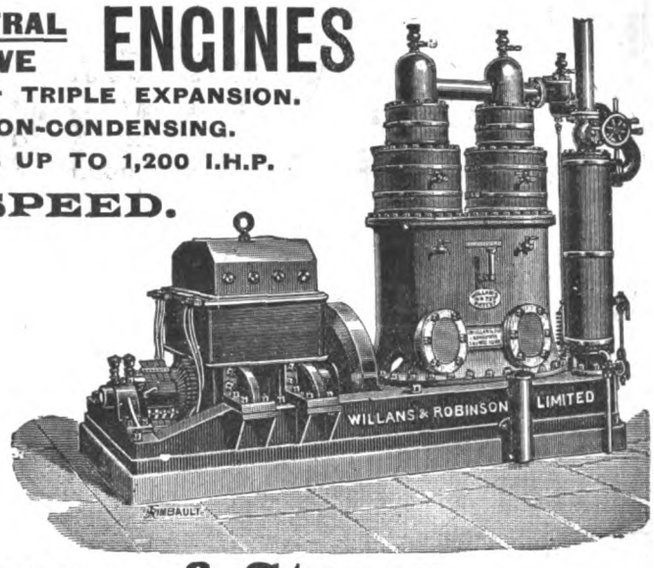


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*Crompton & Co., Ltd.* — *See Important Announcement on page vii.*

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Engineers and Boilermakers.

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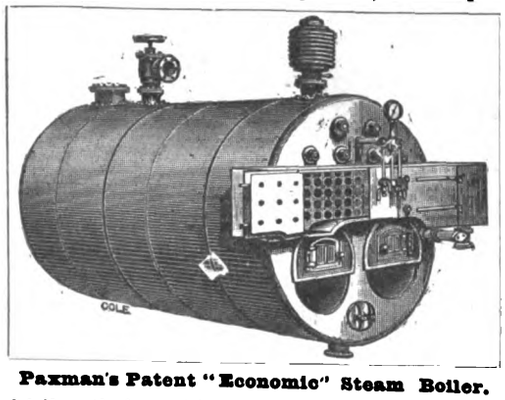


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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 947. [Vol. XXXVII. No. 11.] FRIDAY, JULY 10, 1896. PRICE SIXPENCE.


## NOTES.

In the death of SIR JOHN PENDER, *The Electrician* has lost a proprietor who was proud of his connection with the journal, and careful of its good name, and who showed his trust in those directly responsible for its management by leaving them unfettered discretion.

THE grant of a Civil List pension to Mr. OLIVER HEAVISIDE to which reference is made to-day in our leading columns, does infinite credit not only to the broad-mindedness and perspicacity of those members of the present Government more immediately concerned in the matter, but also to the band of ardent admirers, headed by Prof. PERRY, who with unwearied assiduity pressed the claims of the Hermit of Paignton until success crowned their efforts.

THAT Herr G. JAUMANN has the courage of his theory is shown by the Paper which we have had translated for to-day's issue. His Paper on "Longitudinal Light," which was reproduced a few months ago (*The Electrician*, Vol. XXXVI., p. 629 *et seq.*), attempted to find a mathematical explanation for all the known properties of cathode and Röntgen rays. It also predicted that cathode rays must be deflected not only by magnetic, but also by electrostatic forces. Such a deflection has, of course, been sought for, but had not, so far as we are aware, been satisfactorily shown up to the time of the publication of Herr JAUMANN's memoir in April. In our issue of the 26th ult., however, Prof. SILVANUS THOMPSON communicated the interesting fact of an undoubted electrostatic deflection of cathode rays, though he could find no trace of a similar deflection of X-rays. Herr JAUMANN gives a detailed and careful description of the phenomenon as observed by him; and according to him it is transient, like FARADAY's induction current. Also, it is only observed when the rays are very feeble. It is evident that further careful experimentation is wanted here. The crop of curious phenomena yielded by investigations of the properties of X-rays and cathode-rays exhibits as yet no signs of exhaustion. In addition to Herr JAUMANN's Paper, we publish two others in the present issue, one by Prof. NIPHER, announcing the existence of a peculiar rotational motion of a cathode disc in a Crookes' tube, the other by Mr. A. A. CAMPBELL SWINTON, describing some interesting effects due to the magnetic field. By altering the strength of the magnetic field, Mr. SWINTON finds that he alters the quality of the X-rays produced in much the same way as can be done by varying the vacuum, though, of course, the magnetic method is simpler and more reliable and more accurate. The proper co-ordination of all these strange proclivities will require a master mind.

WE suggested last week that the momentary fall in voltage in a carbon arc when the current is suddenly increased might arise from a reduction in a thermo-electric back E.M.F., owing to the momentary overheating of the negative carbon. It occurred to us that the matter might be put to experimental test, and the most obvious course seemed to be to artificially overheat the negative tip, independently of the heat of the arc itself. If, when the current was constant, such an artificial overheating of the negative tip led to a fall in voltage, the inference as to the existence of a thermo-electric back E.M.F. would be strengthened.

VARIOUS ways of doing this suggested themselves. The negative tip might be overheated by the $C^2R$ effect of an independent current sent laterally across it; or by focussing the radiation from another arc upon it; or by surrounding it with a sheath or hood of refractory material; or by playing an oxy-hydrogen flame upon it. Through the courtesy of Mr. W. J. DAVY, and with his kind assistance, we have been able during the past week to test our inference experimentally. In all the tests made thus far, the overheating of the negative tip has been accompanied by a fall in voltage, the duration of the lower voltage being simultaneous with the period of overheating. Experiments made with a lateral current were not conclusive, owing to the fact that this current came from the same mains as supplied the arc. But, so far as they were of any value, they pointed in the same direction. More satisfactory evidence was obtained by arranging a small cup or sheath of refractory material around the negative carbon, fitting this very loosely. Immediately this sheath, when white hot, was raised so as to enclose the tip, the voltage fell; and when it was lowered so as to expose the tip to normal cooling action, the voltage rose to its normal value. On the other hand, a sheath placed over the *positive* carbon produced no effect. These tests may serve to throw some further light on the phenomena of the arc, and we trust they may induce others to investigate the matter more fully.

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That the progress of naval signalling has not kept pace with modern requirements is, especially as regards day signalling under conditions such as would obtain in action, a generally admitted fact. However, considerable attention has of late been directed to the matter, and trials of new devices are the order of the day. Quite recently the Sellner system was tried aboard the "Inflexible," off Spithead, with apparent success. The Sellner system consists of two lanterns with all-round visibility. Each lantern is capable of producing five classes of lights—fixed white and red, white occulting, red occulting, and red and white occulting. The apparatus is worked from a pedestal about the size of an engine-room telegraph, a dynamo supplying the current for the lights, while the occulting is produced by separate batteries; though it is hoped eventually to markedly simplify the device in this respect. In order to ensure an adequate test all the coastguard stations in the vicinity of Spithead were directed to take observations and report, and temporary stations were also provided along the coast. It was found that, while it took five or six seconds to make each signal, these were clearly visible at a distance of six or eight miles. The Sellner system looks somewhat complicated on paper, though it is very possible that it is not so in reality. The principle involved, however, certainly seems a good one. There is a great diversity of opinion in the navy as to the merits and demerits of coloured lights, the rising generation, generally speaking, being in favour of them, whilst some of our best admirals are against their use. A great point in their favour, it seems to us, is the certainty they confer; a signal made in this way can be kept showing as long as required. A flashed signal can, it is true, be repeated; but, under many atmospheric conditions, no amount of repetition would add appreciably to the chance of correct interpretation.

Certainly the stout ship "Electric Traction" is being borne into port by a fair wind. At the last meeting of the Birmingham Corporation the recommendations of the Public Works Committee, summarised on page 300 of our last issue, were adopted after a 5½-hour discussion; and the Sub-Committee of the Tramway Committee of the Glasgow Corporation, after a prolonged and pleasant tour on the Continent, finds itself in a position to suggest that a trial of the overhead trolley system should be made on the Kelvinside-Dennistoun line. Both recommendations, different as they are, meet, it seems to us, the circumstances of the case, and we hope to see the two schemes go through without let or hindrance. It was specially gratifying to find that even in Birmingham, the home of the municipalisation craze, there are men honest and shrewd enough to assert boldly that municipalisation is not at all times a solution of every problem, and to admit that it does not of necessity spell profit.

**Cable Interruptions and Repair:—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Cadiz—Teneriffe ..... | June 6, 1896 ... | — |
| Jamaica—Colon ..... | June 10, 1896 ... | July 3, 1896. |
| Para—Maranham ..... | July 9, 1896 ... | — |

"**Zeitschrift für Elektrochemie.**"—The editorial work of this valuable little journal will in future be divided between Prof. W. Nernst, of Göttingen, who will undertake the scientific part of the work, and Dr. W. Borchers, of Duisburg, who will look after the technical side.

**The Willans Patent.**—The time for lodging caveats against the petition of Messrs. Willans and Robinson to the Privy Council for the prolongation of their patent (No. 4,901 of 1882) for certain improvements in high-speed engines does not expire until the 13th inst. The date of the hearing cannot therefore yet be fixed.

**The Electric Lighting of the Thames Embankment.**—Col. Ford, of the London County Council, has given notice of the following motion:—"That in the opinion of the Council it is desirable that the Victoria Embankment and Westminster and Waterloo Bridges should, without further delay, be lighted by electricity, as authorised by Act of Parliament, with a view to further relieving the congested state of the traffic in the Strand and Fleet-street."

**Patent Amendment.**—Notice is given that James Brockie, of 12, Tyson-road, Forest-hill, in the county of Kent, has applied for leave to amend specification No. 23,825 of 1894, for "Improvements in Electric Arc Lamps." Particulars of the proposed amendments were set forth in the Illustrated Official Journal (Patents) issued on the 1st July, 1896. Any person or persons may give notice of opposition to the amendment (on Form G), at the Patent Office, 25, Southampton-buildings, London, W.C., within one calendar month from the date of the said Journal.

**Lightning.**—Whilst a heavy thunderstorm was at its height on Tuesday evening at Oxford the archæological library of the Ashmolean Museum and University Galleries, situated in the northern block, was struck by lightning. After a particularly vivid flash, smoke was seen to be issuing from the roof, and an alarm was immediately given, the fire brigade being on the spot within five minutes. When the firemen reached the roof it was found that the fire had got a good hold of the wood and felt packing under the slates; but by the exertions of the firemen, aided by a good supply of water and the cutting away of portions of the burning woodwork, it was got under in marvellously quick time. There are four lightning conductors on the building, but the flash struck a gable on which there was no conductor, and travelled along a lead gutter and down a standpipe to earth.

**Electric Alarm Signal for Trolley Cars.**—A test is being made in New Orleans, says the *Street Railway Review*, of Chicago, with an electric alarm signal and indicator for trolley lines. It is an arrangement by which a car gives warning of its coming one block ahead by displaying a red signal and ringing a bell at the corner of the intersecting street, and is designed to lessen the liability of collision with other vehicles. The signalling is effected by means of a double trolley strung along either side of the wire. Upon the end of the trolley is attached an extra wheel, which is arranged to run on this auxiliary wire. The extra wire, beginning as it does a short distance from each corner, connects with a little bell and closes a box attached to the post on the next corner, and conveys current from the regular trolley to the apparatus at the corner, by which means the signals are given.

**Proposed Electric Tramway at Cheltenham.**—At a meeting of the Cheltenham Town Council, on Monday afternoon, a proposal came up for the construction of an electric tramway from Leckhampton-road, through the town to Cleeve Hill, a rapidly rising district and the scene of the golf links. The proposal was made on behalf of Mr. Thomas Nevins, of Nevins Park, Gorey, Ireland. A route was indicated to which the Highway Committee did not agree, and suggested another; but this found little favour with the Council generally, who were of opinion that the line would be for the advantage of the town, and should take a popular route. It was proposed that the Corporation should supply the electric power from their own works. The discussion resulted in the question of route being referred back to Committee, and the Town Clerk was instructed to prepare a provisional agreement as between the Corporation and the promoters.

**Institution of Electrical Engineers.**—At the special general meeting of members of this Institution, held on Monday last

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at 4:15 p.m., the whole of the resolutions altering the Articles of Association were confirmed, these resolutions having been duly passed at a previous meeting. At a subsequent special general meeting of both members and associates, held on the same afternoon, the revised accounts were accepted and their new form approved. A permanent building fund was also instituted. Some of the members present expressed a desire that in future the publication of accounts should be so full and so explicit as to leave no possible doubt whatever as to any item of receipt or expenditure. It was pointed out that to eliminate all doubt would involve the printing and circulation of a very voluminous statement of accounts. Eventually no amendment was pressed. As regards the permanent building fund, the Chairman (Sir David Salomons) stated that it was proposed to set aside a substantial fraction of each year's balance in aid of a fund for providing a separate meeting place for the Institution; the interest accruing from the fund would also be added to the building fund.

**The International Telegraph Conference at Budapest.**—During the sittings of the Conference the proceedings are regarded as private, and consequently we are unable to furnish information in regard to the discussions and decisions of the Conference. It will, however, be of interest to give an account of the movements of the delegates, who have received many marks of cordiality from the Hungarian Government and the authorities of Budapest On the 16th ult. the Minister of Commerce gave a dinner, which was attended by all the delegates, as was also a reception given on the 17th ult. by the President of the Council. On the 19th the King-Emperor gave a dinner of 50 covers, and held a reception afterwards. On the 20th a representation was given at the Volks Theatre of "Piros Bugyelláris," by Csepreghy. On the 22nd the Municipality gave a dinner to all the representatives at the Royal Hotel, where the guests were received by the Obermaster and a military guard of honour. On the 23rd a large party of the delegates went by invitation for an excursion to the Lower Danube. A special steamer awaited the party at Bazias, and took them down the Danube to the Iron Gates and through the new canal, afterwards returning to the Servian village at the entrance of the canal. Here they were entertained at the International Hotel in the name of the King of Servia, after which the steamer conveyed the party to Orsova, whence trains were waiting to take them to the Hercules Baths. A sumptuous repast in the Cursaal came next, followed by a dance. The following morning some of the party climbed the Damogled (1,300 metres). On the 30th, a representation was given at the Opera Royal of "Hunyadi Laszlo," by François Erkel, attended by most of the delegates. A steamboat trip up the Danube to Ertzegom was arranged for July 3rd. The Marquis of Tweeddale, Lord Sackville A. Cecil, Mr. J. D. Pender, Mr. Underdown, Mr. Burt, and Mr. Barber have returned to England, as also have Sir Saul and Lady Samuel, the Hon. Mr. Playford and Mr. Dicken.

**The Niagara Falls–Buffalo Transmission.**—Our Niagara Falls correspondent informs us that the Cataract Power and Conduit Company of Buffalo has just been incorporated. Its capital stock is £400,000. The Company is formed to furnish Buffalo with electrical energy. It is, in fact, to act as the distributing agent of the Niagara Falls Power Company. The same interests involved in the one support the other. The Buffalo concern will relieve the parent company of the necessity of a strict supervision of the sale and distribution of energy in that city. The business in Buffalo will be conducted under a different name, and the operations directly overseen, instead of being superintended from New York city or the office at Niagara Falls. The Directors of the new Company are Messrs. Daniel O'Day, E. D. Adams, Francis L. Stetson, Edward L. Wickes, Wm. B. Rankine, D. O. Mills and John Jacob Astor, all of New York city, and Messrs. George Urbane, jun., and Charles R. Huntley, of Buffalo. The Board is a strong one. Mr. E. D. Adams, one of the most prominent bankers in the country, is President of the Cataract Construction Company. Mr. Francis Lynde Stetson, so well known in connection with the Niagara scheme, is the Company's first Vice-President. Mr. E. L. Wickes, well known in railway circles throughout the country, is the second Vice-President. Mr. D. O. Mills is the owner of the Mills building in New York, and possesses one of the largest fortunes ever accumulated in California. Mr. W. B. Rankine is Secretary and Treasurer and the Company's chief executive at the Falls; he "engineered" the franchise through the Buffalo Common Council. The local Company will lay all lines and conduits in the streets, and take the power for distribution at the city line. The work of laying the conduits will be begun shortly, according to the plans and specifications filed by the Cataract Construction Company with the Board of Public Works two months since. The parent Company is now busy at laying its transmission lines to Buffalo. By the terms of the franchise the power must be there by June, 1897. It will be remembered that when the Niagara Falls Power Company first started its franchise agitation, one year and a-half ago, a syndicate of Buffalo capitalists was formed to buy the power outright from the Company at the city line, and distribute it thoughout the city on its own responsibility as an independent venture. The idea never came to anything, and rumour had it at the time that the enterprise was found to involve such an enormous outlay that the Buffalo capitalists decided they had better draw out while there was yet time.

**Contemporary Electrical Science**—*Wiedemann's Annalen* No. 6 contains several contributions to the advancement of electrical science. A. P. Sokolow has given a distinct experimental proof that water can be electrolysed with *any* E.M.F., however small. It all depends upon the pressure of the gas already existing at the cathodes. When the liquid is quite free from gases, no inferior limit can be assigned to the necessary E.M.F., except zero. The author actually obtained electrolysis with an E.M.F. of about a hundredth of a volt. As a rule, this is difficult to show, on account of occlusion, which in some experiments has prevented the formation of bubbles, and in some others has accounted for them. Sokolow fused two thin platinum wires into the glass near the electrodes. Any dissociated gas at the latter would be carried by diffusion to the wires, and the polarisation could be shown by an electrometer. This was actually the case, though it sometimes took hours before it was complete. Thus Helmholtz's prediction is verified. Another question which has exercised the minds of English electricians especially is that of hysteresis and Foucault losses during magnetisation by alternating currents. The frequencies experimented with have rarely exceeded 100 per second, but Ignatz Klemencic has now carried them up to 2,000 by using oscillatory condenser discharges. He determined the discharge curve of a condenser through a coil by interrupting the discharge at various stages, and noting the residual discharge. This was done by a weight dropping, and opening circuits on its way. The result was a curve, showing the damping and dying out of the oscillations. On inserting an iron or nickel core the damping was increased by hysteresis and eddy currents. The effects due to these two causes could be disentangled by noting the effect of increasing the diameter of the core or breaking it up into wires—expedients which leave the hysteresis effects untouched. The results as given are not quite consistent, but they go to show that at these high frequencies steel and nickel behave in the same manner as at low ones; but in soft iron the hysteresis loss increased from 17,000 to 32,800 ergs. The eddy loss amounted to 17,800 ergs in a wire 0·02cm. thick, which is rather surprising considering the thinness of the wire. This experimental paper is followed by a highly mathematical one by F. Kolácek, another of those Bohemian physicists who are making their influence felt in modern science. It is entitled "Electric Oscillations of a Conducting Sphere capable of Polarisation: a Contribution to the Theory of Spectra of the Simplest Kind." It is a gallant attempt to bring the vivifying light of an electromagnetic theory to bear upon the spectroscopic rules (rather than "laws") discovered chiefly by Kayser and Runge. A paper of greater practical import to technical men is that by Ebeling and Schmidt, of the Reichsanstalt, on the effect of annealing upon the magnetic homogeneity of metals. It is often supposed that such treatment improves iron and steel. It may or it may not. If the annealing is itself uniform, it may do good. But magnetic flaws in wrought iron are quite impervious to the process. The most uniform material is obtained by careful fusion.

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## SIR JOHN PENDER.

It is with deep and sincere regret that we record the death of Sir John Pender, one of the proprietors of this journal, which took place at Foot's Cray Place on Tuesday evening last, at 5:40 p.m. Sir John was struck down by a paralytic stroke several months ago; but, notwithstanding his great age, such was his strength, that he rallied and battled bravely and pathetically unto the very end. His tenacious grasp of life during the past few months was characteristic of the tenacity of purpose and determination that have all along marked his career,—a career which seems destined to become more and more rare as the race loses its once super-abundant energy, and Englishmen grow cautious and averse to risks such as Sir John Pender faced light-heartedly, though not without a careful and highly intelligent weighing of the balance of chances. Submarine telegraphy is now so much an integral part of our daily life that we are apt to forget how recently its foundations were laid, and apt to undervalue the *rôle* played by its pioneers, another of whom has just gone to his long home.

It is a matter for thankfulness that Sir John's family were all able to be with him at the end, Mr. J. Denison Pender having left Buda Pesth (where he was attending the International Telegraph Conference) on Sunday, and arriving, thanks to the success of special arrangements that were made in London, at Foot's Cray Place 70 minutes before his father breathed his last.

A vast number of telegrams and letters of condolence have reached the family from all parts of the world. Sir John's decease was announced in plenary sitting of the International Telegraph Conference at Buda Pesth in most sympathetic and appreciative terms, all members rising in their places. A joint message of condolence was sent by the delegates of the companies with which Sir John was not connected.

Sir John was the son of the late James Pender, of the Vale of Leven, Dumbartonshire, and was born in 1815, so that at the time of his decease he was in his eighty-first year. Sir John was educated at the High School, Glasgow, and began a successful business career there and in Manchester, where, during the Cotton Famine, he did noble work, which is still remembered with gratitude, in the relief of the suffering and semi-starvation which then existed. When the stream of work was turned out of its channel, through that terrible calamity, he not only kept on his workmen, but was amongst the foremost in organising relief and extending the helping hand of charity to the sufferers. He then applied his remarkable energy to the establishment and extension of submarine telegraphy, which afterwards became his life's work.

To go back to the days before the "Agamemnon" took her part with the "Niagara," "Susquehanna," and "Leopard" in the attempt to lay the original Atlantic cable in 1857, the inception of which was due to the late Mr. Cyrus Field, Sir John was one of the 345 contributors of £1,000 towards the expenses of the necessary experiments, and, as a director of the Atlantic Cable Company, he for eight years shared the failures and disappointments which baffled all attempts to telegraphically connect England with America. The breaking of the 1865 cable in mid-ocean during the now historic voyage of the "Great Eastern" proved the financial ruin of the Atlantic Company. The surviving supporters of the enterprise were utterly discouraged, and with no hope of further assistance from the Government or of aid from the public, the abandonment of the project was imminent. Fortunately, the faith of Sir John Pender and a few others in ultimate success remained unshaken.

The Anglo-American Company was formed, and negotiations were opened with Glass, Elliott and Co. and the Gutta Percha Company for the manufacture of a new cable of greater strength; but the latter Company, discouraged by the previous experience, and unwilling to set aside its ordinary business for what was then considered a mere speculative undertaking, refused to proceed without a guarantee. It was at this crisis that Sir John Pender, with characteristic courage, offered his personal guarantee for a quarter of a million sterling, and this being accepted, the two manufacturing companies were amalgamated under the name of the Telegraph Construction and Maintenance Company, with Mr. Pender—as he then was—as Chairman. It is no exaggeration to record that this action antedated the existence of sub-oceanic telegraphy by half a generation.

The new cable was successfully laid in 1866, and at the present juncture it is interesting to recall the first telegraphic words sent by Great Britain to America.—"Peace on earth, goodwill toward men." Then the "Great Eastern," under the command of Capt. (afterwards Sir James) Anderson, by picking up, and establishing communication by, the abandoned 1865 cable proved that submarine cables were a property, and effected the first of the thousands of repairs to submarine telegraphs which have since been made. Mr. Pender soon became the recognised leader in submarine telegraphy, and was ably supported by Lord William Hay (now Marquis of Tweeddale) and the late Sir James Anderson, who had already formed the Anglo-Mediterranean Telegraph Company, which, with other companies established later, were amalgamated into those now well-known organisations, the Eastern and Eastern Extension Telegraph Companies, linking to England the whole of our Asiatic and Australasian possessions, as well as China, Japan, &c. Through Mr. Pender's exertions, also, the cables of the Eastern and Associated Companies are looped around the Continent of Africa.

Successful as a pioneer, Sir John's sound commercial instincts stood him in good stead as an organiser and administrator. His high appreciation of the labours of men like Lord Kelvin, the late Cromwell Varley, the late Prof. Fleeming Jenkin, and Dr. Alexander Muirhead, gave his companies the use of the most efficient means of working, testing and repairing cables. According to the testimony of travelled men—English and others—who have visited the cable stations abroad, the *personnel* of the cable companies in all parts of the world reflects the greatest credit on those responsible for their selection; and under the presidency of Sir John Pender, these great corporations have dealt generously with their staff at home and abroad by the establishment of endowment assurances and pension funds.

It is not surprising, therefore, that the companies which he controlled are models of good management, and, while profitable to their shareholders, worthily fulfil the mission of civilisation, peace and progress. A striking instance of the work these cables are sometimes called upon to perform occurred in connection

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with the opening of the Colonial and Indian Exhibition of 1886, when, on the day following, the Viceroy of India, the Governor-General of Canada and the Governors of every British Colony and Dependency issued, by the request of the Prince of Wales, a special *Gazette*, containing a verbatim report of his Royal Highness's address to the Queen, of Her Majesty's reply, and also the late Lord Tennyson's ode on the occasion.

In recognition of Sir John's services to the Empire, Her Majesty bestowed upon him in 1888 a Knight Commandership of the Order of St. Michael and St. George, and he was in 1892 promoted to a Grand Cross of the same Order. On the occasion of the public presentation on April 23, 1888, to the late Lady Pender of Sir John's portrait, the late Lord Derby, who presided, in the course of his remarks said: "It is not too much to affirm that, but for Sir John Pender and a few others of whom he was chief, that enterprise would have collapsed, and at best a long delay would have occurred before investors consented to risk their capital in such a speculation again. Of course the thing would have been done at last . . . but in such a case as this the loss of time represented by even one generation would have meant almost incalculable loss—material loss—to England; and very likely the Americans, or some other energetic people, would have come in and would have taken the lead and all the glory and profit out of our hands . . . Well, if our friend had done nothing more than what I have told you he would still have been the greatest benefactor to the cause of telegraphy that had yet appeared. But with him this success was only the beginning. He was not content to win a victory—he knew how to improve it when won. He became Chairman of the Company that laid the first line to India; he controlled the line giving independent communication to Gibraltar, Malta and Suez; he created the present Eastern Telegraph Company, giving access to the whole of the Levant; he was mainly instrumental in establishing communication with Australia and China; and, not least important, he gave us the cable to South Africa, which, if it had been in existence a few years earlier, would have saved us an outlay larger than I like to contemplate, both in lives and in money. No doubt he has not done these things alone. Others have helped, and helped largely, but I am sure I shall not be contradicted when I say that those who have the best right to participate in the credit would be the readiest to award our friend the largest share of it."

Sir John Pender's Parliamentary career has been a long and honourable one. While he strongly felt that the integrity of the empire should be kept intact, his motto, "Telegraphs know no politics," gave him influence in foreign countries, on both sides of the House of Commons, and in the highest social, political, military, scientific and artistic circles, and enabled him, while safeguarding the interests of the Companies he represented, to serve the State in many important ways.

Sir John's long and intimate connection with Art is well-known; his Academy dinner on the evening of the annual private view will be missed by many. His magnificent collection of paintings began to be formed when he was a Manchester merchant, and from the first he made it a rule never to buy a modern picture without at the same time making the personal acquaintance of the artist, and by no section of society will he be more sincerely mourned and missed.

In the interests of the telegraph companies Sir John from time to time visited most of the European countries, and many of their rulers recognised the services he was instrumental in rendering to their subjects by conferring upon him various Orders, amongst which may be mentioned those of an officer of the French Legion of Honour, the Italian Knight Grand Cordon of the Crown, the Portuguese Orders of Christ and the Conception and others, the Greek Cross of Commander of the Royal Order of the Saviour, and the Brazilian Order of the Rose. So recently as the 1st of January last the French Government conferred upon Sir John its highest Colonial Order—that of Commandeur de l'Ordre Royal du Dragon d'Annam.

During 1894 Sir John Pender presided alone—his closest associate in telegraphy, Sir James Anderson, having passed away in 1893—at the Silver Jubilee of the formation of the Company for the establishment of Submarine Telegraphy to the East and Far East at the Imperial Institute, and was honoured with the presence of the Prince of Wales, who had 24 years before been present at Sir John's house in Arlington-street to celebrate the completion of the connection by oceanic cables of India with England.

The capital of the submarine telegraph companies over which Sir John presided amounts to nearly £15,000,000, the cable mileage to 73,640 nautical miles, their revenue in 1895 to two and a-quarter millions, and their reserve funds stand at more than three millions sterling.

Sir John was also Chairman of the Metropolitan Electric Supply Company, which is the largest undertaking of its kind in this country, and in 1895 supplied upwards of 250,000 lights. He was a J.P. for Kent, Middlesex, Lancashire, Denbigh, Argyll and Linlithgow; a D.L. for Lancashire; Chairman of the Eastern, Eastern Extension, South African, Brazilian Submarine, African Direct, West African, Direct United States, Direct Spanish, and Europe and Azores Cable Companies, of the Pacific and European Telegraph Company, of the Globe Telegraph and Trust Company; and a Trustee of the Submarine Cables Trust.

The extraordinary growth in mileage, revenue and reserve of the cable companies of which he was Chairman testifies eloquently to his energy and ability in this connection.

In harness to the last moment of his health and energy, Sir John Pender possessed in a remarkable degree the capacity for inspiring the co-operation of Governments, the confidence of his shareholders, the loyalty and assistance of his colleagues, and the devoted service of his staff. His habit of mind was to place implicit confidence in his officials, and to their honour and his be it said he was never deceived. He was ever prompt to recognise merit, intensely energetic, far-seeing, quick to decide, always available and able to keep unentangled the threads of the many interests which he represented.

His death sadly reduces the number of those connected with the attempt to lay the first Atlantic Cable, and leaves as survivors only Lord Kelvin, Sir Samuel Canning, Mr. Clifford, Mr. H. A. C. Saunders, Mr. B. Smith, Mr. Richard Collett, and Mr. C. Gerhardi.

Sir John married, first (1840), Marion, daughter of Mr. James Cearns, and in 1851 Emma, daughter of Mr. Henry Denison, of Daybrook, Notts. He was M.P. for Totnes, 1865-1866; Wick Burghs, 1872-1885, 1892 and 1895. He also contested Linlithgowshire, 1868; Wick Burghs, 1885; Stirling Burghs, 1886; and Govan, 1889. He leaves two sons and two daughters, of whom his eldest son, Mr. James Pender, is M.P. for Mid-Northampton, and a Director of several electrical companies; the other, Mr. J. Denison Pender, is Managing Director of the Eastern Eastern and South African, and West African, and a Director of other cable companies; and his eldest daughter is the wife of Sir William des Vœux. The other daughter is unmarried.

Sir John will be buried at Foot's Cray, where Lady Pender, who died in 1890, is interred.

The funeral is fixed for this day (Friday) at 12 o'clock.

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## THE MANUFACTURE OF WHITE LEAD.

BY G. H. ROBERTSON, F.C.S., A.I.C.

For a century past inventors have been busy trying to render the manufacture of white lead innocuous to health, or to find a substitute for it; but so far without any very marked success, although the fact that the regulation of the industry engaged the attention of the Legislature in 1883, and that there was a Board of Trade inquiry a few years since into the condition of the workers engaged in it, have tended to stimulate interest in the matter, and make clear the difficulties that have to be faced.

In the Brown process recently described (see *The Electrician*, June 26th, p. 272) it will be observed that the only part played by electricity is the preparation of the lead nitrate and sodium hydroxide solutions employed to obtain the lead hydroxide precipitate which is subsequently converted into lead carbonate, or true white lead. Information regarding the voltage and current density employed is not at present forthcoming, so that no opinion can be formed as to the electrical efficiency of Mr. Brown's method or of its chances of success; but in the meantime it may be of service to give some account of the methods at present employed in the manufacture of white lead, and of the substitutes which have been proposed for it.

The ordinary white lead of commerce is usually manufactured by the Dutch process, which consists in first converting the lead ore into pig-lead, which is then melted and moulded into small perforated thin cakes, which are placed in stacks, and submitted to the action of acetic and carbonic acids, and of air. The cakes are piled on rows of small earthenware pots filled with acetic acid, and over them is placed a layer of tan, and then one of deal planks. The women and girls who carry on this work continue the layers of acid, lead, tan and planks until a height of 30ft. is reached. When the tan begins to ferment, the acetic acid, volatilised by the heat, acts on the surface of the lead, which in about four months is reduced to a carbonate, so that when the women enter the stack to remove it they find a core of blue lead with a crust of white material adhering, and this is white lead in the rough. These beds breathe out poison, and the workers cannot avoid the dust settling on their persons and clothes. It finds its way into their systems, and sooner or later leads to consequences more or less fatal. After removal from the stacks, the white lead is ground in water, and finished in drying stoves, these operations adding another three weeks to the protracted period of manufacture.

The first idea of a remedy appears to have been the quickening of the process of production, and at the end of the last century M. Thuard, a French chemist, showed that when a basic solution of a salt of lead was submitted to the action of carbonic acid gas, a carbonate of lead was precipitated. The white lead was produced in a few hours, and the process admitted of being carried on continuously at little cost. This has been the basis of many of the improvements since made in the production of precipitated lead. It was soon found that the quality and covering power of the white lead so produced were inferior to that made by the Dutch process, and examination showed that whereas stack white lead was opaque and amorphous, the precipitated variety was semi-transparent crystalline, and of far less specific gravity. Good white lead is a compound which contains the hydrate and the carbonate of the metal in the proportion of one molecule of the hydrate to two or three of the carbonate, the latter amount being in the proportion of 75 per cent. of the carbonate to 25 per cent. of the hydrate, and is the composition generally assigned to white lead by good authorities Hydrate of lead and linseed oil produce a varnish-like substance, semi-transparent, and of no covering capability, while the carbonate under similar circumstances is opaque, but is also deficient in covering power. Neither of them separately produce a paint, but they do so when combined together in the proportions found in white lead, and mixed with linseed oil. White lead does not differ materially in its chemical properties whatever process it may be made by, but it may differ seriously in its physical character, that produced by precipitation being always crystalline.

In the Martin process, started on a working scale in 1880, acetate of lead was made by dissolving lead in acetic acid, and the acetate was further treated for white lead. In this process, though a carbonate is produced, the danger of contact with it is from first to last guarded against.

The MacIvor process, as improved by Dr. MacIvor, in conjunction with Prof. Watson Smith and Mr. William Elmore, consists in treating litharge in a closed vessel with acetate of ammonia. Carbonic acid gas is passed into the solution, and the precipitated lead carbonate is removed, while the acetate of ammonia is ready to be used again.

Freeman's innocuous white lead is produced by treating flakes of lead which have been oxidised in a special vat with acetic acid. Sulphuric acid is added to the solution obtained, which precipitates the lead as sulphate, which is washed and dried in the usual manner, and then a certain proportion of zinc oxide is added to it, after which it is submitted to a special treatment whereby it obtains a body and density much in excess of that of ordinary white lead.

Then there is a sublimation process, due to Mr. Hannay, which is carried out at the Caledonia Works, near Glasgow, in which galena, which is a sulphide, is converted into a sulphate of lead by rapid oxidation, and it is subsequently condensed, washed and dried. The product is then mixed with a certain proportion of lead hydroxide to render it equal to the best pigments used in the trade.

Enough has been said to show that any new process will have formidable competition to encounter; but when one considers that with however great care the Dutch process is carried out, there must still be an ever present risk from the poisonous impalpable dust produced in the course of manufacture, there can be no doubt that there is room for a good wet method, which would produce carbonate of lead.

In 1882 Prof. Gardner introduced an electrolytic process for the manufacture of white lead, which, though it produced the ordinary poisonous lead, reduced its manipulation to a minimum. Prof. Gardner's first specification contains a small treatise on the manufacture of white lead, and improvements have been made in 1885, 1890 and 1891. In this process the formation of the carbonate was aided by placing the lead in contact with some substance which is electro-negative to it, such as tin, so as to form an electric couple, and the action of this couple might be aided by a current from a dynamo; but the simple galvanic effect produced by the action of the moist acid gases on the lead-tin couple was preferred on account of requiring less skilled attention. The manufacture was carried on in a chamber the floor of which was covered with plates of pure rolled tin, and the same material was used for the bearers and shelves which were to hold the lead during its conversion, and the whole was in metallic connection. The lead gratings were laid on the shelves of a bearer, which was dipped into a bath of acetic acid and acetate of lead for one or two minutes, and was then drained and raised into the chamber. Other stands were thus treated until the chamber was full. The dipping cleansed the surface of the metal, and on exposure to the air it was speedily coated with a hydrated oxide of lead, which was the first step in the process of conversion. The chamber, when filled, was closed, and the temperature raised to about 100°F. by means of steam pipes under its floor. Then vapour of acetic acid, mixed with aqueous vapour or air, was admitted to the chamber, and passed over the lead for 15 to 20 hours. Carbonic acid, generated in any convenient way, was then passed into the acid generator, and mixed with the other gases entering the chamber, and the formation of white lead was speedily effected. The treatment was continued for about 13 days, when the supply of acetic acid was cut off, the supply of air, steam and carbonic acid being continued according as it was desired to obtain white lead rich in oxide or carbonate. After a short further period steam and air only were admitted, and, lastly, the steam supply was stopped and air alone entered the chamber which was kept heated by the coils. When the contents of the chamber were in a dry state, the operation terminated. The later stages of the process were a convenient method of washing and drying the white lead while it was still attached to the parent lead. The contents of the

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converter were turned into an agitator, where the carbonate was separated from the metallic lead. The crude white lead was passed on to the crushing rollers, and from these to the incorporaters, from which it could be removed in a dry state or mixed with oil. As the white lead was enclosed at all stages of the process, the danger to the workmen was reduced to a minimum. By this process the two or three weeks' time required for washing the white lead produced by the stack method was saved.

In 1892 Mr. Ferranti suggested preparing white lead by first electrolysing a solution of lead acetate prepared by immersing lead electrodes in a 10 per cent. solution of acetate of ammonium. The electrodes were separated by porous partitions, and arranged in tanks connected in series, a voltage of 2½ volts being allowed per cell. On the passage of the electric current lead acetate was formed in the outer, and ammonia was freed in the inner cell. The two solutions thus formed were drawn off into separate vessels, and the ammoniacal solution, after conversion into carbonate of ammonia by treatment with carbonic anhydride, was mixed with the lead acetate, giving rise to a precipitate of hydrated carbonate of lead, and leaving acetate of ammonia in solution. The precipitate was separated by means of a filter-press, and any lead remaining in solution was precipitated by chromic acid as chrome yellow, and the acetate of ammonium was returned to the electrolyser. Acetate or nitrate of soda or potash could be used instead of ammonium acetate. Later in the same year the process was improved so as to effect the precipitation of the whole of the lead in the first instance, and in 1893 the method was further improved, but these improvements did not affect the electrolytic part of it.

In 1892 also a method was described in the *Electrochemische Zeitschrift*, XIII., 442, according to which lead anodes 3mm. in thickness were employed for the electrolysis of a solution containing 300cc. nitric acid in 2,000cc. of water, and the lead salt formed was precipitated as white lead by means of a stream of carbonic acid gas. Any silver in the lead was deposited on the cathodes and could be recovered.

Electrolytic methods so far have not proved a commercial success, and though the processes given above are not a complete list of those which have been introduced, they will serve to show their general character. With the exception of the Gardner process, which is an improvement on the Dutch method of manufacture and produces white lead with the same properties, they are all precipitation processes and possess their defects. The only part played by electrolysis is in the production of one or both of the solutions which are to yield the precipitate, and these solutions must necessarily contain more or less of the original electrolyte and of the bye-products of electrolysis.

## THE ACETYLIDES OF COPPER AND SILVER.

In the current number of the *Zeitschrift für Elektrochemie* is a communication by Mr. Harry C. Jones, of the Johns Hopkins University, dealing with the question of the composition of the metallic derivatives of acetylene, concerning which there is a certain conflict of evidence. The author calls attention to the work of Prof. Keiser, who has examined the claims of the recognised alternative formulæ for the silver and copper acetylides. Berthellot was of opinion that the composition of these explosive substances is expressed by the formula $(C_2Cu_2H)_2O$ and $(C_2Ag_2H)_2O$, while, according to Blochmann's view, these should be written $C_2H_2Cu_2O$ and $C_2H_2Ag_2O$. Keiser has now prepared the acetylides by passing acetylene into an ammoniacal solution of cuprous chloride or silver chloride, and has examined the products thus obtained. Determination of the silver content in the first place showed that the formula for the silver compound must be either $C_2H_2Ag_2$ or $C_2Ag_2$.

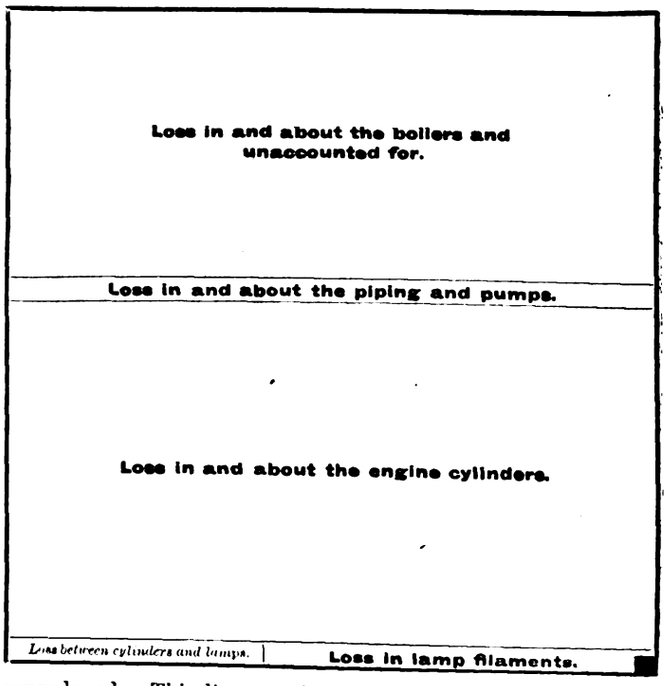
It may be remarked in explanatory parentheses that it is not always easy to decide from the figures obtained by an ultimate analysis, whether the substance under examination contains an atom or two of hydrogen or not, because of the low atomic weight of hydrogen compared with the high molecular weight of the compound in which it is suspected to exist. Thus, in the present case the substance $C_2H_2Ag_2$ would only contain 0·8 per cent. of hydrogen, and a moderate error in the silver determination, or a slight impurity of the substance analysed, might cause doubt as to the presence of hydrogen as an essential constituent.

Direct evidence on the point was, therefore, sought by exploding the acetylide in a vacuum. A weighed quantity thus treated lost no weight after explosion, whence it is concluded that no hydrogen is present in the original substance, and that its formula is $C_2Ag_2$. Similar experiments with the copper compound led to the deduction that it should be written $C_2Cu_2$. In both cases these metallic derivatives may be regarded simply as acetylene $C_2H_2$, with a monovalent metal substituted for H. Keiser has also found that when acetylene is passed through the solution of a mercuric salt a substance $C_2Hg$ is formed strictly comparable with calcium carbide $C_2Ca$.

The whole matter is not only of intrinsic interest, but well deserves to be put definitely on record in view of the great technical importance lately attaching to acetylene and the carbide whence it is derived.

## SUPPLY SYSTEM LOSSES.

To a recent issue of *Electrical Engineering*, of Chicago, Mr. E. A. Merrill contributes an article on "The Total Efficiency of Certain Central Stations." Unfortunately, the names of the stations selected are not given, but the article contains a considerable amount of instructive information. One of the examples selected is a station equipped with two 140-H.P. steam engines, driving by belts two 90-kilowatt dynamos. Steam is raised in a battery of three boilers, each having 1,200 sq. ft. heating surface. Good bituminous coal, having a calorific value of 13,000 B.T.U. per pound, is burned, and the feed-water is heated by exhaust steam to 210°F. The station works daily for 6 hours, during 5½ hours of which the two engines and two boilers are required; while in the rest of the time one engine and only one boiler take the load. The average load is 100 kilowatts, and consists of incandescent lamps. An analysis of the losses in the entire system is given in detail; but this information is supplied in a more interesting and graphic manner by means of a diagram which we have reproduced. This diagram shows at a glance where the energy is wasted, the little black square representing all that is utilised as light. Surely it is time to reclaim some of the vast waste territory!

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## ELECTRIC AND MAGNETIC RESEARCH AT LOW TEMPERATURES.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S., M.R.I.

(*Concluded from page 305.*)

In the conduction of currents at ordinary temperature, as we generally know it, two effects are inseparably connected with the conveyance of energy by this process. One is the dissipation of some of the energy as heat in the conductor, the other is loss of potential or fall of electric pressure, and which is one of the factors in the equivalent of the energy so dissipated. If, however, the conductor is at the absolute zero of temperature, there is no dissipation of energy in it, and neither of these consequences would be present. There would be no heat produced in the conductor, and no fall of potential along it either for large or small currents. What, then, under these conditions, is the function of the conductor? The answer is, that it becomes a mere boundary serving to limit the electromagnetic field and determine the direction in which the energy transmission is taking place. These experiments, therefore, may be regarded as forging one more important link in that chain of experimental evidence which compels us to look for the processes concerned in the conveyance of energy by an electric current, not inside the conductor, as we call it, but in the dielectric or medium outside. We may then ask how is it that different bodies have such various dissipative powers when acting in this way as the boundary of an electromagnetic field. The only suggestion on this point I venture to make here is as follows: Materials of high specific resistance have all probably a very complex molecular structure. The alloys of high resistivity are not, probably, merely solidified mechanical mixtures of metals, but chemical compounds, and even in the case of elementary bodies like carbon and sulphur they may have, owing to their high valency and tendency of their atoms to auto-combination, a complex molecular structure. This structure may bestow upon them the power of taking up energy from the electromagnetic medium, just as gases with a highly complex molecular structure are very absorbent of radiant heat, which, if the electromagnetic theory of light is true, is only another form of electromagnetic energy. All we know at present about the processes at work during the time a conductor is traversed by an electric current is that there is a magnetic field outside the conductor and also within the mass of the conductor, and that some mechanism is at work absorbing energy through the surface of the conductor and dissipating this as heat in the interior. The resistance of a conductor is best defined, as, and numerically measured by, the rate at which it dissipates electromagnetic energy per unit of current. For the same current, that is, for the same external magnetic field, conductors dissipate this energy at very different rates. Some, like silver and copper, which have the lowest rates, are elements of low valency and molecular volume, and have probably a simple molecular structure; others, like alloys of high resistivity, have in probability a more complex molecular structure. Both this last, as well as the molecular mobility characteristic of the liquid state, are conditions which bestow the power of taking up rapidly and dissipating the energy of the electromagnetic field, and this has to be kept supplied from energy-transforming sources. We cannot, however, at present construct profitably further mechanical hypotheses to account for this difference in the presence of our great ignorance about ether, molecules, and energy.

In passing from the liquid to the solid state there is generally an immense increase in the conducting power of metals. This is well shown in the case of mercury. A glass tube a metre in length was formed into a special coil and filled with pure mercury, suitable connections being provided at the ends. This coil was embedded in a mass of paraffin wax and a platinum wire thermometer placed in contact with it. The whole mass was then reduced to the temperature of liquid air, and observations taken of the resistance of the mercury as it heated slowly up after being removed from the liquid air. The curve in Fig. 8 shows the manner in which the resistance increases with great suddenness between – 41deg. and – 36deg., as the metal passes into the liquid condition. The resistance becomes four times greater between – 50deg. and – 36deg. in the course of 14deg. rise of temperature and whilst in the act of passing through the melting point of the mercury at – 38·8°C. This chart shows that the resistance of the mercury in the solid state tends downwards, so as to indicate that its resistivity would completely vanish exactly at the absolute zero of temperature. It is interesting to note also that the portion of the resistance curve belonging to mercury in the solid state is sensibly parallel to that portion of it in the liquid state.

We carried on a long struggle with bismuth in the endeavour to unravel some of the electrical peculiarities of that metal at low temperatures. Chemists are aware of the extreme difficulty of preparing bismuth in a state of perfect chemical purity by purely chemical means. From several different sources we procured bismuth which had been carefully prepared by the reduction of the oxychloride, or nitrate, after careful re-precipitations. This bismuth was then pressed into wire and its resistance curves taken down to the lowest attainable temperatures. We found some very extraordinary results. Although sensibly agreeing in resistivity

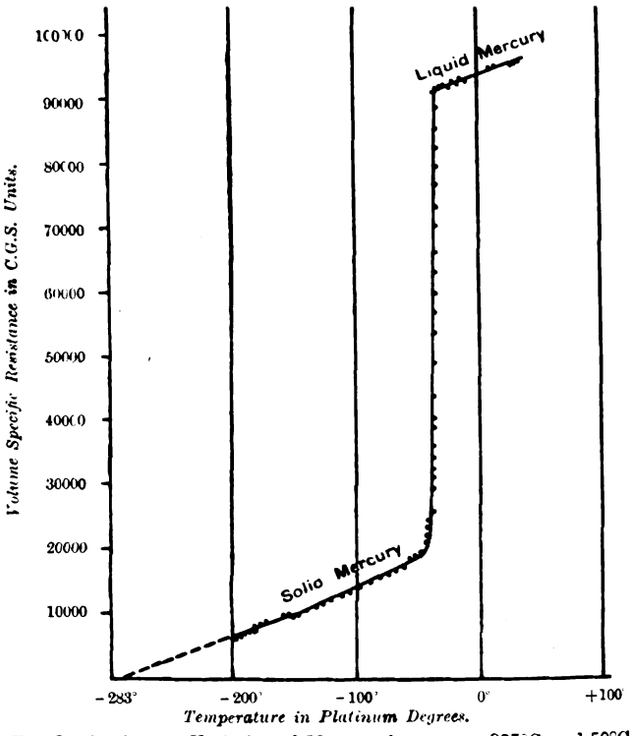


FIG. 8.—Resistance Variation of Mercury between – 283°C. and 50°C.

at ordinary temperatures, in two cases the resistance curves had a minimum point, and after reaching this at about – 80deg. tended upwards again, showing that the resistance was increasing as the metal was further cooled. These curves could be repeated as often as necessary with these samples. Another specimen gave a curve with a double bend (*see* Fig. 9).

These results convinced us that it would be necessary to prepare bismuth electrolytically, and with the assistance of Messrs. Hartmann and Braun, of Frankfort, who have made a special study of the preparation of electrolytic bismuth, we were provided with a quantity of the metal which examination showed to be chemically pure. On taking the resistance curve of a sample of the electrolytic bismuth when pressed into uniform wire under great pressure, we found that its behaviour was perfectly normal, and that the resistance line tended downwards, as in the case of all other pure metals, to the absolute zero. Also we found that the specific resistance of this last was very much less than that of the chemically prepared samples, and less even than that employed by

* A Friday evening discourse delivered at the Royal Institution, June 5, 1896, Lord Kelvin in the Chair.

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Matthiessen. Hence *pure* bismuth is no exception to the law enunciated above.

Bismuth is characterised especially by many peculiarities. It has been known for some time that the resistance of a bismuth wire is increased when it is placed in a magnetic field so that the lines of the field are perpendicular to the direction of the current flow. This is easily shown by means of one of Hartmann and Braun's spirals, manufactured now purposely for measuring magnetic fields. We have, however, discovered that if bismuth is cooled to the temperature of liquid air, the effect of any given magnetic field in changing its resistance is increased many times. Thus, for example, a certain bismuth wire we used had a resistance of 1·690 ohms at 20°C. Placed in a magnetic field of strength 2,750 C.G.S. units, its resistance was increased to 1·792 ohms, or by 6 per cent. The wire was then cooled in liquid air and its resistance lowered to 0·572 ohms. On putting it then into the magnetic field of strength 2,750 C.G.S. units, its resistance became 2·68 ohms. Hence it had increased 368 per cent. This magnetic field can then actually reverse the effect of the cooling and cause the bismuth when cooled and magnetised to have a greater resistance than when at ordinary temperatures and unmagnetised. We are at present engaged in further unravelling the problems presented by this new discovery with regard to bismuth. It is certainly very startling to find that a magnetic field which

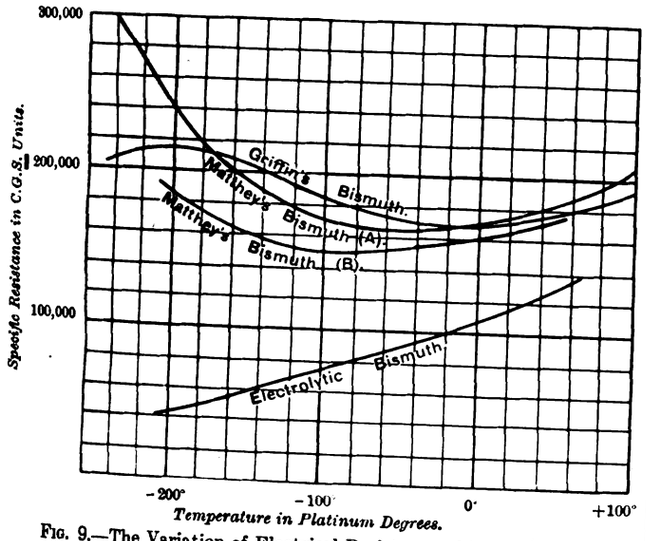


FIG. 9.—The Variation of Electrical Resistance of Bismuth with Temperature.

increases the resistance only 5 per cent. at ordinary temperatures, increases it five times at -186°C. We have recently discovered a similar effect, but much smaller in amount, in the case of nickel longitudinally magnetised.

It will be seen that this process of taking the resistance of a conductor in liquid air is one which affords us a very critical means of discrimination as to the chemical purity of a metal. It ranks almost with the spectroscope as an analytical method.

There is one other method by which we can exhibit the change of conductivity in a metal when cooled, and that is by the increased deflection which a disc of the metal experiences when suspended in an alternating current field in such a position that the plane of the disc is at an angle of 45deg. to the lines of the field.

Time will only permit one brief reference to the behaviour of carbon in regard to electrical conductivity when cooled to low temperatures. We have found that carbon in the form of carbon filaments taken from various incandescent lamps, continued to increase in resistance as it was lowered in temperature. The resistivity at various temperatures of the carbon from an Edison-Swan lamp at various temperatures are as follows:—

| C.G.S. units. | | Temp. | C.G.S. units. | | Temp. |
|---|---|---|---|---|---|
| $3,835 \times 10^3$ | at | 99°C. | $4,054 \times 10^3$ | at | - 78°C. |
| $3,911 \times 10^3$ | at | 18°C. | $4,079 \times 10^3$ | at | -100°C |
| $3,953 \times 10^3$ | at | 1°C | $4,180 \times 10^3$ | at | -182°C. |

These values when represented on a chart give almost a straight line, and show that the resistivity of carbon continually increases as it is cooled, but at a very slow rate. Its temperature coefficient is therefore negative, and of about the same absolute magnitude as many alloys of high resistivity. The resistivity of this form of carbon is about three thousand times that of silver.

Adamantine carbon taken from a Woodhouse and Rawson lamp had a resistivity 50 per cent. greater. All the so-called insulators—*e.g.*, glass, gutta-percha, ebonite, paraffin—have resistivities enormously greater than that of carbon; but, like it, their resistance increases as the temperature is lowered.

We must now pass on to consider some problems in thermo-electricity which have engaged our attention. If we construct a thermo-electric couple of two metals and connect this with a galvanometer, and if one junction is kept at a constant temperature, say 0°C., whilst the other junction is heated or cooled to various temperatures, we shall in general, but not always, find an electromotive force acting in this circuit when the junctions are at different temperatures. This electromotive force depends on three things, the nature of the metals, the temperatures of the junctions, and on a certain temperature called the neutral temperature of the metals. An important matter in the experimental study of thermo-electric action is to discover the position of these neutral temperatures, when different metals are tested with lead as the standard of comparison, and when one junction is kept at 0°C. Elaborate experiments made by Prof. Tait many years ago furnished full information on this matter for temperatures lying above 0°C., and we especially desired to extend this knowledge to ranges of temperature between 0°C. and -200°C. Accordingly, a number of thermo-electric junctions were prepared of various pure metals and alloys, the comparison metal being always pure lead. These couples were grouped together and one set of junctions always kept at 0°C. in melting ice. The other sets were cooled to various low temperatures by means of liquid air. The experimental process then consisted in measuring the electromotive force set up in each couple respectively and

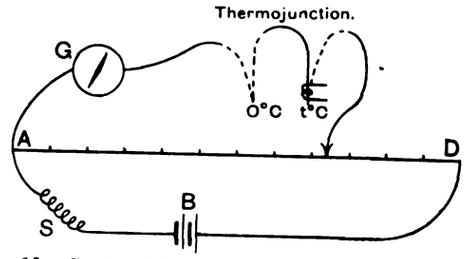


FIG. 10.—Combined Potentiometer and Resistance Balance.

at the same instant measuring the temperature of the low temperature junction. After various failures, a device was adopted for making this double measurement with great accuracy and expedition.

The arrangement consisted of a combined potentiometer and resistance balance (*see* Fig. 10). Omitting details, it may be stated that I succeeded in devising an arrangement of circuits in which the change from a potentiometer to a resistance bridge was effected by moving two brass plugs from one pair of holes to another. This instrument formed a combined resistance and electromotive force measurer, which enabled us to do two things. First, to measure the electromotive force in any thermo-couple; secondly, to measure the temperature of the low-temperature junction by measuring the resistance of a platinum wire wound round that junction and acting as a thermometer. In actual practice the platinum thermometer consisted of a small hollow copper cylinder. In the interior of this cylinder were inserted a number of the thermo-junctions, and round the outside was wound the platinum thermometer wire. Aided by this device, we were able to measure temperatures with an accuracy of one twenty-fifth of a degree at a temperature of -200°C., and to ascertain at the same instant the exact electromotive force acting in the couple. When these arrangements had been perfected the method adopted was to put one set of the junctions into melting ice. The other set enclosed in the copper cylinder were embedded in a mass of paraffin wax,

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which was then cooled down to the temperature of liquid air. The mass was then removed and inserted in a vacuum vessel and allowed to heat up very slowly. At frequent intervals during the heating the electromotive force of the couple was taken, and also the temperature of the junction.* The events which, under such conditions, happen in the case of a platinum-lead junction, can easily be shown and are very interesting (*see* Fig. 11).

At the first immersion of one junction in liquid air, whilst the other is in melting ice, we get a current, as shown by the galvanometer, in one direction. On lifting the junction out of the liquid air, it begins to warm up. The first effect of this heating is to reduce the thermo-current in the circuit, at about $-111°$ on our platinum scale, some distance, therefore, above that of liquid air, the current in this circuit falls to zero. As the junction continues to heat up, the current increases again in the opposite direction. At about $-60°$ the low temperature junction reaches the temperature called the neutral temperature, and the current is a maximum in one direction. It then begins to fall off once more, and it finally becomes zero again when the two junctions are both at the temperature of melting ice, and it lastly increases in the opposite direction as this variable junction continues to warm up from 0°C. to higher temperatures. Having carried out the observations described with all our thermo-couples, the results were represented in a chart as follows: A horizontal line was taken on which were marked off divisions representing platinum temperatures.† Vertical ordinates were then drawn at various temperatures for each couple representing the electromotive force in the couple when the cold junction was

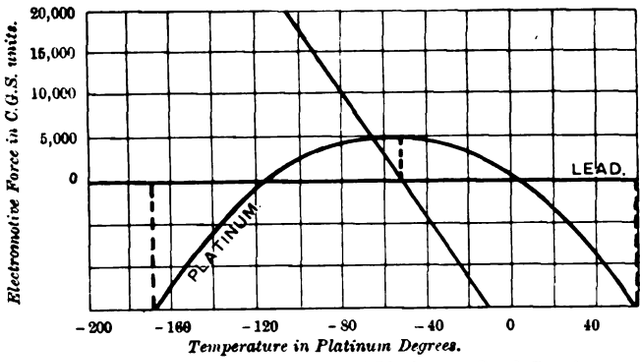


FIG. 11.—Thermo-Electric Power of Platinum—Lead Couple.

at the temperature denoted by the abscissa of that ordinate. In this way a series of curves were delineated which all passed through the point representing 0°C. These curves are the curves of thermo-electromotive force.

In Prof. Tait's researches on this subject, he adopted a method of representing the facts which has many advantages. Suppose the couple to have one junction at a constant temperature, and the other to be varying. At any instant the electromotive force of the couple is varying at a certain rate with the changing temperature of the non-constant junction. This rate measures what is called the thermo-electric power of the metals with respect to each other at that temperature. If we measure the slope of the electromotive force curve at any point, it can easily be shown that the numerical value of this slope gives us the rate of change of electromotive force with temperature. If we plot these slopes in terms of the corresponding temperature we obtain another set of curves called curves of thermo-electric power. Lead is always taken as the standard metal for comparison, because the Thomson effect on lead is zero. From our chart of thermo-electromotive forces we have constructed another one of thermo-electric powers. The lines of thermo-electric power cut the lead line in various places, and the temperature at which they do this is called the neutral temperature of that metal with respect to lead. Prof. Tait deduced from his experiments that these thermo-electric lines were straight lines for temperatures above zero centigrade, and he made, in addition, the important discovery that for certain metals, such as iron and nickel, the thermo-electric lines have sudden changes of direction at high temperatures.

The general result of our investigations at low temperatures is to show that whilst in some cases the thermo-electric lines are approximately straight lines for temperatures down to the lowest reached, they are not all by any means straight lines. In some cases, such as iron and bismuth, we find sudden changes of direction of the thermo-electric lines similar to those found by Prof. Tait at higher temperatures, and this indicates a change in sign in the Thomson effect at that point. Moreover, in many cases there is a decided tendency of the lines of many metals to bend round in a manner which indicates that their thermo-electric power probably would become zero at the absolute zero of temperature.

The temperature at which the thermo-electric line of any metal crosses the line of lead gives us the neutral temperature of that metal with respect to lead, and at that temperature the metal is thermo-electrically identical with lead. If one junction of a couple is at a temperature as far above the neutral temperature of the metals as the other is below it, the couple will give no electromotive force. This provides us with an experimental method of determining the position of certain neutral points. Thus, for instance, if one junction of a platinum-zinc couple is placed in liquid air and the other is raised to about 30deg., we get no electromotive force from that couple. This indicates that the neutral temperature of platinum and zinc is about $-85$deg., and this is shown to be the case from the chart. Two general conclusions are arrived at from a study of the thermo-electric lines as laid down in our chart. The first of these is that the thermo-electric lines of many metals are by no means straight lines over extreme ranges of temperature. Hence the thermo-electric power is not simply a linear function of the absolute temperature. The second important fact is that in the thermo-electric lines of certain metals at low temperatures there are sudden changes of direction which indicate a change in the sign of the Thomson effect in that metal, and probably therefore some important molecular change at the corresponding temperature.

In the case of the 29 per cent. nickel steel alloy there is an interesting thermo-electric phenomenon. If a loop of wire of this material is partly dipped in liquid air the portion cooled becomes thermo-electrically different from the remainder, and gives a strong thermo-current if connected to a galvanometer and warmed at one point where the changed and unchanged portions meet.

Leaving the further elaboration of these points, we must next notice some of the facts with respect to the magnetisation of iron at low temperatures. Prof. Dewar mentioned, in a discourse on "The Scientific Uses of Liquid Air," some results obtained on cooling small steel magnets. These effects we have since again explored at greater length. Let me show you, in the first place, the effect of cooling a small steel permanent magnet to the temperature of liquid air. We will first take a magnet made of knitting needle or ordinary carbon steel and examine the effect of low temperature upon it. Placing the magnets behind the small suspended magnetic needle of a magnetometer, we obtain a deflection of the magnetometer needle, which is a measure of the magnetisation of the magnet causing the deflection. On bringing up a small vessel of liquid air, and immersing in it the magnet under test, there is at once a sudden decrease in the deflection of the magnetometer needle. This indicates that a notable percentage of the magnetisation of the magnet has been removed. On taking away the air bath, and allowing the magnet to heat up again, we find that there is a still further decrease in magnetisation. On cooling it again with liquid air the magnetisation increases, and from and after that time the effect of the cooling is always to increase the moment of the magnet, and the effect of heating it up again always to decrease the moment of the magnet. Hence we see that the effect of the first immersion in liquid air was to give a shock to the magnet, which deprives it permanently of a considerable percentage of its magnetism, but when once it has survived

* For fuller information *see* Dewar and Fleming on the "Thermo-Electric Powers of Metals and Alloys," *Philosophical Magazine*, July, 1895; also *The Electrician*, Vol. XXXV., July 12, 1895, pp. 366, 367.

† This diagram was given in *The Electrician*, Vol. XXXV., p. 367, July 12, 1895.

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the treatment, then cooling it strengthens the magnet, and warming it weakens it. These changes in the magnetic moment of the magnets are graphically indicated in the diagrams in Figs. 12 and 13, in which the dotted line represents the moment of the magnet when at 15deg. C., and the fine line when at −186deg. C.

This is not by any means always the case. If we take a magnet made of the 19 per cent. nickel steel, the peculiar characters of which were explained a few moments ago, we shall find a very different state of affairs. We see here the first effect is, as before, to remove a very considerable per-

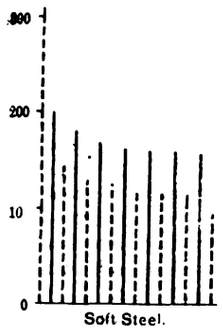


FIG. 12.—Effect of Low Temperatures on Magnetic Moment of Steel.

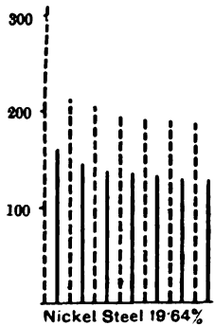


FIG. 13.—Effect of Low Temperatures on Magnetic Moment of Nickel-Steel.

centage of the initial magnetisation, but after that stage is passed then cooling the nickel steel magnet always weakens it still more, and warming it up again strengthens it. The subsequent effect of cooling is, therefore, in the opposite direction in the carbon steel and in this nickel steel.

We have in this way examined the behaviour of magnets made of a very large number of steels—chromium steels, aluminium steels, tungsten steels, silicon steels and nickel

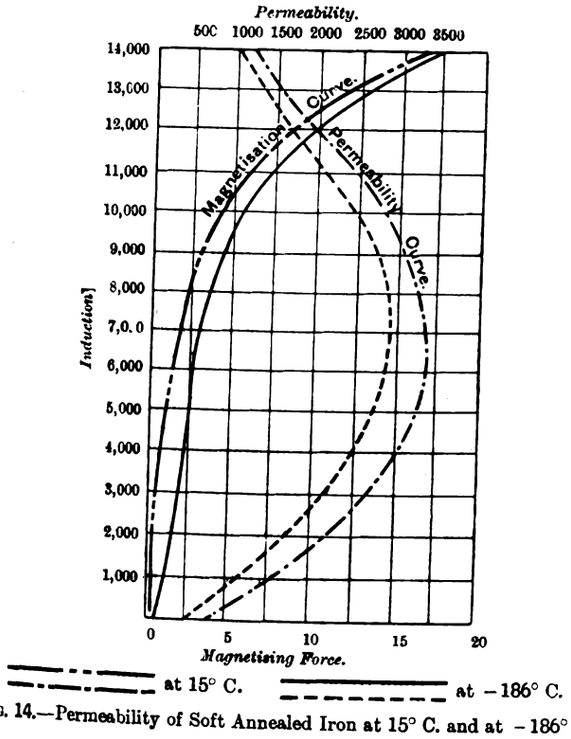


FIG. 14.—Permeability of Soft Annealed Iron at 15° C. and at −186° C.

steels in various states of temper, hard and soft. We find that in some cases there is no initial decrease of magnetism at all, and that the steady state begins at once. Broadly, however, the results amount to this. A steel magnet when plunged into liquid air generally loses some fraction of its magnetisation, but that after a few such immersions it arrives at a fixed condition, in which the effect of cooling it is in most cases to produce an increase of magnetic moment, but in a few exceptional cases to produce a decrease of magnetic moment. In the technical use of magnets for instrumental purposes they have to go through a process called *ageing* to get rid of the sub-permanent magnetism; one of the ways of ageing a magnet is to plunge it several times into liquid air.

We have given a large amount of attention to a study of the changes taking place in the magnetic qualities of soft or annealed, and also hard iron when cooled to very low temperatures.

Assisted by Mr. J. E. Petavel, who has given us most valuable help in these very tedious magnetic observations, as well as in the subsequent reductions of them, we have made a large number of observations in the permeability of a carefully annealed iron ring made of very pure Swedish iron of the highest quality.* The result is to show, as seen from the

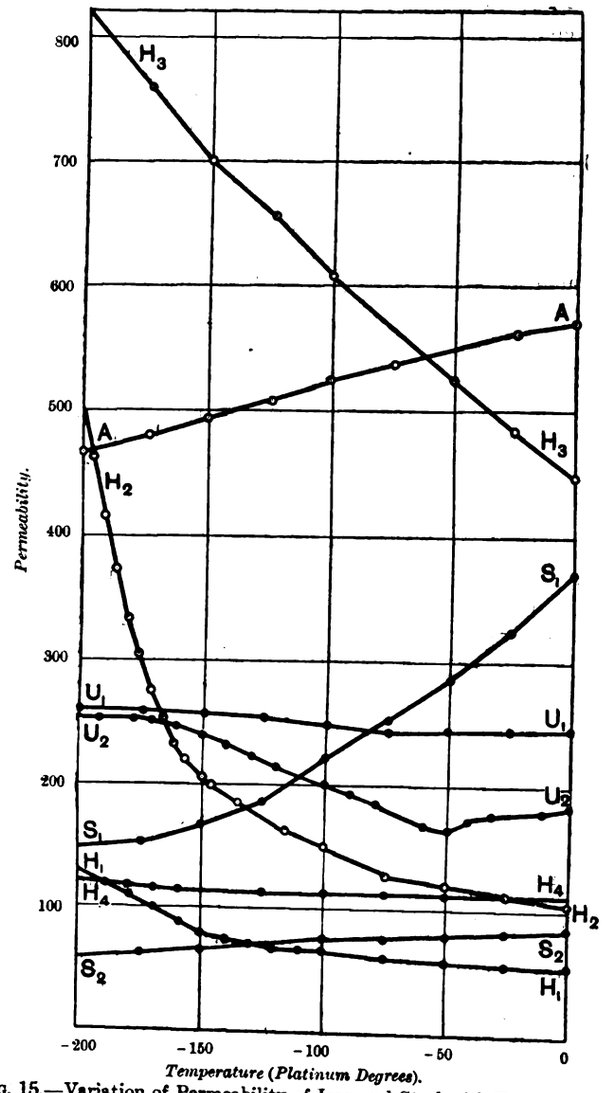


FIG. 15.—Variation of Permeability of Iron and Steel with Temperature.

A, Soft Annealed Transformer Iron, ½ scale, magnetising force, 1·77. $H_1$, Hardened Iron, magnetising force, 2·60. $H_2$, Hardened Iron, magnetising force, 4·92. $H_3$, Hardened Iron, magnetising force, 11·16. $H_4$, Hardened Iron, magnetising force, 12·77. $S_1$, Steel, magnetising force, 20·30. $S_2$, Pianoforte Steel, magnetising force, 7·50. $U_1$, Unannealed Iron, ½ scale, magnetising force, 9·79. $U_2$, Unannealed Transformer Iron, ½ scale, magnetising force, 1·78.

curve, Fig. 14, that cooling the iron to − 200deg. slightly diminishes the permeability. In other words, it requires a greater magnetic force to produce a given amount of magnetisation when the iron is at − 200deg., than when it is at the ordinary temperature. When, however, we began to study the behaviour of hardened iron in this respect we find ourselves in the presence of very curious effects. If pure iron,

* It is only right to add that in other portions of this work we have been much indebted for persevering assistance to Messrs. J. and D. Morris, and in lesser degree to Messrs. Jakeman and Tilney for help in observations requiring several simultaneous observers.

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which has been carefully annealed, is twisted, knocked, bent, stretched, or compressed, it passes into a state known as hard iron, and hard iron has very different magnetic qualities from soft iron. A very extended series of experiments with rings of hard iron have shown that hard iron, at least in certain cases, has its permeability greatly increased by cooling (*see* Fig. 15), and this change takes place with great suddenness. This can be shown by a simple experiment. If we take a hard iron ring which has two coils of wire wound round it, and connect one of these circuits to a battery, we shall send a current through the primary coil and magnetise the iron ring. If the other or secondary circuit is connected to a galvanometer, then at the instant of starting the primary current there is a transitory induced current produced in the secondary circuit. As long as the induction in the iron remains constant, no electric change will take place in this secondary circuit. If, however, we plunge the iron ring into liquid air, whilst still keeping the primary current constant, we find again a secondary current produced at the moment of cooling the iron. This indicates a sudden increase of permeability at the instant of cooling. If we bring the ring out of the liquid air, we find it retains some of the increased permeability acquired in cooling, but loses a portion of it more slowly if it is heated up again to ordinary temperatures by plunging it into a bath of alcohol. Owing to these changes we found it impossible to repeat again exactly any required magnetisation curve in the case of the hard iron. The sudden cooling alters the magnetic qualities of the unannealed iron to such an extent that it is not possible to get it twice in exactly the same state. By subjecting a hard iron ring to frequent reversals of the

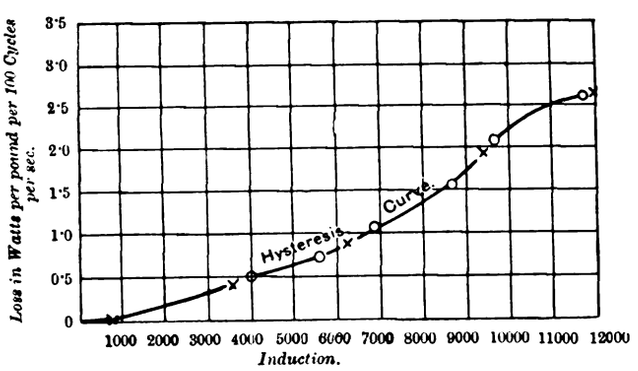


FIG. 16.—Hysteresis Loss in Soft Annealed Iron at 15° C. and at −186° C.

same magnetising force whilst it is heated up slowly from the temperature of liquid air up to ordinary temperatures we have been able to trace the gradual decrease of the permeability at any constant force throughout this range of temperature.

We have found, on the other hand, that unhardened steel pianoforte wire behaves like soft annealed iron.

We have then examined the hysteresis of iron at low temperatures. The method we adopted was the laborious but exact one of delineating a complete magnetisation curve of the iron by means of observations taken with the ballistic galvanometer for various maximum values of the magnetising force. In this way we were able finally to arrive at a curve (*see* Fig. 16) which represented by its ordinates the value of the hysteresis loss in the iron in ergs per cubic centimetre per cycle and the abscissæ the maximum value of the corresponding magnetic induction. When curves had been drawn out from all the many hundreds of observations for the same soft iron ring at ordinary temperatures and at the temperature of liquid air, we found little or no sensible difference between them. The result is, then, that there is no appreciable change in the magnetic hysteresis loss of very carefully annealed soft Swedish iron when cooled to these low temperatures. With regard to the hard iron, although the permeability is increased, it is most difficult to say yet whether the hysteresis is increased or not, as every fresh reduction in temperature of the iron alters its physical state and makes it almost impossible to obtain similar repeated measurements.

It is natural to inquire how far accepted theories of magnetic action are able to reconcile the above-mentioned results. Some of them undoubtedly are in accord with deductions from received hypotheses. It is generally considered that the facts connected with the magnetisation of iron indicate that each molecule, or perhaps small groups of molecules of the iron are complete micro-magnets, and that in the unmagnetised condition of the iron these molecular magnets arrange themselves in groups or in closed circuits so that for each little group the external magnetic action or magnetic moment is approximately zero. Magnetisation consists in arranging the members of some or all of these groups, so as to co-lineate the direction of more or less of the molecular magnets and produce an external resultant magnetic moment. Let us then consider one such little group by the aid of a model made of small magnets, such as Ewing has suggested and used. Suppose the members of this group to be at a certain distance from each other and we apply a given magnetising force, which is just sufficient to open out the group and co-lineate the magnetic axes of the several members of it. Next suppose we cool the iron, this would result in bringing the members of the group into closer contiguity. The result of this will be an increase of the interpolar magnetic forces of the different members of the group, and it would require a greater magnetic force to effect the same amount of co-lineation of the molecular magnets. This, however, corresponds with what we find to be the case on cooling soft iron to very low temperatures. Prof. Dewar's experiments have shown that the tensile strength of iron and steel is increased to about double on cooling to −182°C., and it is quite reasonable to suppose that this result is in part at least, due to an approximation of the molecules.

As regards the behaviour of magnets when cooled it is highly likely that when the groups of molecular magnets have been opened out more or less, that some of these are in a condition of instability in which bringing the members of the group nearer together will have the effect of making them close up again into magnetic circuits of no external action. Hence, if this is the case, the first effect of the sudden cooling will be to reduce the magnetic moment. These half-hearted groups of molecular magnets constitute the sub-permanent magnetism which it is our desire to get rid of in ageing a magnet. Then, as regards the effect of temperature changes on the magnet when the stable condition of affairs is reached. In order to explain this, I think we must consider the action of the molecular groups upon each other. The approximation of molecular groups will in general, after the magnet is aged, have the effect of co-lineating more completely the different members of the groups, and hence increase the magnetic moment of the magnet, whilst the separation of the molecular groups and the reverse magnetic effects will ensue on heating up. The action of the low temperature upon soft iron and upon magnetised steel would be explicable if we may legitimately make the assumption that lowering the temperature approximates the molecular groups and also the members of each group.

The result of this, in the case of existing permanent magnetisation, is to close up more or less those groups which are in an unstable condition, but it increases the co-lineation in those groups in which the magnetic moment exceeds a certain value. Hence in the case of the permanent magnet, the first effect of sudden cooling is a compound effect; it consists in a great reduction of the magnetic moment of certain unstable groups, but in an increase of moment of others. After this initial stage is past the normal effect is an increase of magnetic moment of the groups by bringing them closer together, and a diminution by increase of distance.

There remains then to be explained the anomalous behaviour of the nickel steel and hardened iron, but the attempt to throw an inner light upon the results obtained with these substances cannot possibly be successful until we have explored far more thoroughly at low temperatures the changes in mechanical as well as magnetic qualities.

However much one may be tempted to speculate upon the causes of these various changes in the properties of matter at very low temperatures, a much more important duty at the present time is the collection of facts and the completion of accurate quantitative measurements. The experimental diffi-

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culties of this low temperature research are very great, but both Prof. Dewar and I have been chiefly anxious in this particular work to prosecute preliminary explorations into as many regions of it as possible, these pioneering experiments enabling us to ascertain in what direction further inquiries will be profitable. Every step forward opens up fresh suggestions for investigation, and, I may add, fresh difficulties. In the light of the results, however, thus ascertained we shall have additional means of testing and judging existing electrical theories, and the facts themselves when built into the fabric of scientific knowledge will serve to broaden those foundations on which we may profitably erect new hypotheses of electric and magnetic phenomena, which, even if they cannot dissipate entirely that mystery which enshrouds even the most familiar facts, will serve as a continual stimulus to thought and work in days and years that are yet to come.

## ELECTROSTATIC DEFLECTION OF CATHODE RAYS.*

BY G. JAUMANN.

It has up to the present been taken for granted that cathode rays are not sensibly or not at all deflected by electrostatic forces. It will be shown in the following that the electrostatic deflection of cathode rays is as characteristic of them as their magnetic deflection. That this has not up to the present been noticed is explained by the fact that this electrostatic deflection has a totally unexpected character.

§ 1. *Preliminary Considerations.*—It follows from my theory of the cathode rays that, in the absence of a deflecting magnetic force, the axial (*i.e.*, the purely longitudinal) portion of the cathode rays follows approximately the electrostatic lines of force of the field proceeding from the cathode to the glass wall.†

Even quite recently M. Poincaré‡ quoted this very theorem as a proof of the incorrectness of my theory. And there were, indeed, grave difficulties in the way of its acceptance. The cathode rays do not by any means pass from the cathode to the anode, but are, at some distance from the cathode at least, very sensibly rectilinear. Further, Voller‖ and Hertz¶, although using very great electrostatic forces, have not found any deflection effect, so that it seems as if the direction of the cathode rays were quite independent of the course of the electric lines of force.

Against this I could have quoted nothing but Crookes's mutual repulsion of cathode rays, and Goldstein's deflection of them by a second cathode. But nobody could have admitted that these are essentially electrostatic deflections. New experiments were therefore necessary in order to justify my theory.

Since the cathode rays are to follow the electric lines of force, and since these are already strongly deflected by a rubbed glass rod, it had to be shown that the cathode rays are strongly deflected by a rubbed glass rod. However impossible this might seem after previous experiments, yet with a suitable arrangement the cathode rays may actually be strongly bent by electrostatic forces, as described in the following. This suitable arrangement I have found by bearing in mind that the cathode rays are to follow the lines of force.

§ 2. *Former Cases of Deflection of Cathode Rays.*—Crookes (1879) regarded the cathode rays as essentially rectilinear and as normal to the cathode, but thought that two neighbouring rays had a repulsive force of a special nature.

Goldstein (1876) showed that the cathode rays are naturally almost but not quite rectilinear, and that by another cathode they suffer a repulsion representing a new form of electric repulsion. At that time it was impossible to regard this repulsion as an electrostatic effect, if only for the reason that the anode exerted no attractive force or next to none.

E. Wiedemann and Ebert (1892) showed that Crookes's repulsion of two rays is a special case of Goldstein's deflection. Elster and Geitel (1895)* investigated a kind of cathode rays observed in Tesla charges, which are deflected by uninsulated conductors. The authors do not claim to have used charged conductors. This shows how far people were even recently from regarding an electrostatic deflection as possible.

All the forms of electric deflection enumerated are, I believe, connected with the electrostatic deflection of cathode rays described below. But they are already distinguished from this by the fact of their being lasting deflections, whereas the purely electrostatic deflection is a short and transitory phenomenon.

### I.—Theoretical Considerations.

§ 3. *Rectilinear Character of the Lines of Force.*—From the theorem quoted above it must not be expected that the cathode rays run from the cathode to the anode. It is well known that long sparks may be obtained from the glass wall of the discharge tube. The different points of it retain potential differences up to 3,000 volts after discharge has ceased. Hence the course of the electrostatic lines of force during discharge is not determined exclusively, or even to the greatest extent, by the anode.

The electroscopic charge of the glass wall was first investigated by G. Wiedemann†. It is not irregular or accidental, but perfectly normal, and in the cases under consideration it is always distributed in such a manner that the glass wall impinged upon by the cathode rays is strongly positive, as I have verified by electroscopic experiments of my own. As far as we can judge from this with respect to the lines of force, it would be quite possible for one of them to pass from the cathode to the fluorescent spot on the glass wall. It is therefore not impossible that the cathode rays actually follow a line of force. From the point of view of my theory we must, on the contrary, deduce the course of the lines of force from that of the cathode rays. That this criterion has a certain value for the purpose of discovery is proved by what follows.

If the cathode rays are straight, it follows that the glass wall must be charged in such a manner that the line of force is straight. If there are two cathodes, or if the form of the cathode is complicated, the lines of force in its neighbourhood can never be straight, whatever the charge of the glass wall. As a matter of fact, the rays are never straight in this case, but show Goldstein's deflection.

§ 4. *Self-Tension of the Cathode Rays.*—The charge on the glass wall implies that the lines of force do not proceed from the cathode to the anode, but along other curved lines. But the remarkable fact remains that the cathode rays are always as straight as possible whatever the shape of the glass wall or the position of the anode. A law must, therefore, exist according to which the cathode rays invariably charge the glass wall in such a manner that the statical lines of force which they follow are as straight as possible. That this is the correct view of the cause of the straightness of the cathode rays has been, as far as I can see, placed beyond doubt by the following experiments:—

§ 5. *Principle of the Experiments.*—Whatever the charge of the glass wall, my theory asserts that the rays must be deflected out of the path determined by the charges on the electrodes and the glass wall, on the approach of an electrified body. From the fact that Voller and Hertz did not discover any electrostatic deflection it follows that the tendency of the cathode rays to straighten out is so strong in the ordinary arrangement that it almost completely neutralises the deflective action. But this tendency to straighten is governed by an effect of the rays (charge of the glass wall), and will, therefore, decrease as the rays become feebler. Furthermore, the deflection of the rays corresponds to that of the lines of force, and this will be the stronger the feebler the charge on the glass wall. We must, therefore, work with exceedingly feeble cathode rays in order to have the effect desired. For these the correspondence with my theory is also perhaps improved by the fact that it was developed for rays the amplitude of which is very small compared with the static force.

### II.—Experiments.

§ 6. *Arrangement.*—A large highly-exhausted pear-shaped discharge tube, E (Fig. 1), is immersed in a glass beaker, B, filled with ordinary machine oil. The cathode, K, is fused into the lower narrow end of E, and ends in a slightly concave plate. The anode A is a small plate immersed at the top sideways into the oil, and is kept separated from E by a layer of oil 1cm. to 2cm. thick.

The charging is effected by a Holtz machine, J (Fig. 2), run at a uniform speed by a motor. The main current of this machine forms a quiet brush between the blunt points, S. A large Leyden jar, L, with insulated coatings, and the discharge tube, E, are also introduced in parallel.

The electrodes K and A assume a difference of potential of upwards of 9,000 volts, but only a feeble current flows through

* *Wiener Sitzungsber.*, 105, 2A, April, 1896.

† *Wien. Ber.*, 104, p. 776, July, 1895. *Wied. Ann.*, 57, p. 147. *The Electrician*, March 6, 1896, p. 629. All rays previously dealt with (sound, luminous and electric transverse rays, and also longitudinal electric rays according to Helmholtz and Poincaré) obey differential equations of the second order. This implies their essentially rectilinear character in homogeneous media. But the electric longitudinal rays of my theory obey a differential equation of the first order, and this gives them two characteristic properties. They are, in general, curvilinear in homogeneous media, and can only follow such curves from the cathode, but not towards it. This just gives those peculiarities which distinguish cathode rays from all other rays, and which have prevented their recognition as rays properly so called.

‡ *C. R.*, 122, p. 520 (March 2, 1896).

‖ G. Wiedemann, *Handbuch* 4, A, 436 (1880).

¶ *Wied. Ann.*, 19, p. 809 (1883).

* *Wied. Ann.*, 56, p. 733; see also *The Electrician*, Vol. XXXVI., January 17, 1896, p. 387.

† *Pogg. Ann.*, 158, p. 69 (1876).



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the badly conducting oil from A to K. It is advisable to make the cathode rays so feeble that the fluorescent spot appearing on the top of E is only seen when the eye has grown accustomed to the darkness. The fluorescent spot must shine perfectly quietly. If it flickers, it is necessary to find by ear the disturbing spark in the apparatus, and to close it.

§ 7. *Circumstances which have no Influence.*—The above arrangement is recommended for various reasons, but the experiments succeeded more or less with any arrangement. The immersion of the tube and the anode in the oil bath is only made for the purpose of obtaining very feeble and quiet rays, and for easily altering the position of the anode. The pear-shape of the tube is recommended for the sake of the broad cap and the appearance of the ring figure (*see* below). But other tubes and arrangements may be successfully employed, especially in fairly dry air instead of oil. If the tube is not immersed in oil, the finger may, for instance, be placed on the glass wall as an anode. But a fused-in anode may also be used, if feeble rays

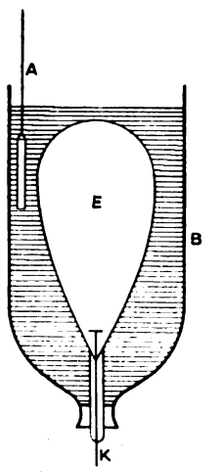


FIG. 1.

are otherwise provided for. Even with the ordinary arrangement, *i.e.*, with strong rays, electrostatic deflection may be proved; but in this case it is so feeble that one must be familiar with the appearances to perceive it at all. Finally, it is not necessary to avoid having permanently charged or uninsulated bodies (connections, iron stands, &c.), in the neighbourhood of the discharge tube. They have hardly any influence.

§ 8. *Distribution of the Radiation.*—The cathode rays have, as we know, three places of special luminosity with the form of cathode employed. It should be observed that these are just the places where strong longitudinal vibrations must be expected, bearing in mind that the inciting wire waves flow in by the stem, and have a radial course in the cathode plate. These three places of highest intensity are:—

*a.* The interference surface bisecting the re-entrant angle between stem and plate, which is marked by a green ring below the

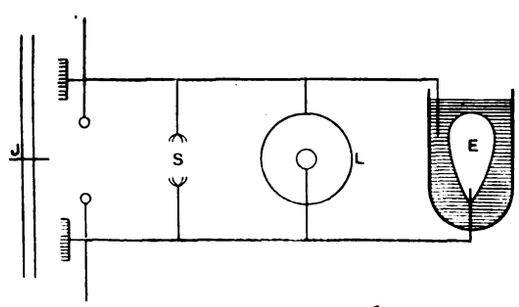


FIG. 2.

cathode plate on the glass. I have shown elsewhere.* that the rays producing this interference surface proceed from the plate and the stem respectively, and must be coherent and of equal phase, to be able to interfere in this manner.

*b.* Strong rays proceed from the edge of the plate in the direction of the radii, and mark a green ring on the glass in the plane of the plate.

*c.* An intense beam of rays proceeds in the direction of the stem, and this alone shall be investigated in the following. At its origin it has a thickness not much greater than the stem. From this beam we may arrive, by variation of the cathode shape through all the transitions, either at Crookes's "focus" or at the interference surfaces. Hence an interference of the rays proceeding from the cathode surface contributes to the formation of this beam.

9. *Configuration of the Fluorescent Spot.*—The fluorescent spot on the upper cap of the glass consists of two parts, which overlap and show a fundamentally different behaviour. We shall call these the chief spot and the ring figure.

*a.* The chief fluorescent spot consists of a comparatively very bright central place; outwards the brightness decreases without limit. The side rays are curved away from the axis, and seen by the sharp shadows cast by them.

*b.* The ring figure is probably also generally known, since it is very bright with an ordinary charge. But its brightness diminishes more rapidly than that of the chief spot as the rays decrease in intensity. In my experiments it was much feebler than the chief spot. It consisted of a bright centre of 0·5cm. radius, followed by a dark ring and a bright ring, both 0·5cm. wide. When the anode also entered the vacuum (which it did not do in most of my experiments), a bright diametral line directed towards the anode was added.

§ 10. *Deflection of the Two Groups of Rays.*—Both the chief spot and the ring figure are about equally deflected by the magnet. They therefore are due to cathode rays.

As regards electrostatic deflection, they are quite different. The ring figure is much less deflected, and as a rule not perceptibly. We shall regard it as steady. Further, the small electrostatic deflection of the ring figure obeys quite different laws from those of the chief spot.

11. *Permanent Deflection of the Chief Rays by the Anode.*—When the anode A, Fig. 1, is placed at a certain height (in the upper third of the discharge tube), the centre of the chief spot coincides with that of the ring figure. But the least raising of the anode permanently attracts the centre of the chief spot, until it falls into the bright ring. On still further raising the anode, it is not deflected further. On lowering the anode it is at once repelled out of the central position, but again not further than the bright ring.

I have usually put the anode into the sensitive position for which the centre of the chief spot coincides with that of the ring. But the experiments succeed, although not in the same manner, with any other position of the anode. If, for instance, the anode is very low, the chief spot, which is now in the ring, may be displaced along the ring by electrostatic forces, but it can hardly be deflected out of it.

When the anode itself has the form of a ring and is low down, almost the whole of the fluorescent light is evenly distributed over the ring.

It follows that the cathode rays at rest are by no means rectilinear or independent of the position of the anode. Perhaps the repulsion of the rays by the lowered anode is a hitherto unknown phenomenon. Their attraction by the raised anode may, however, be identical with the slight attraction of the anode observed by Goldstein.

§ 12. *Sensitiveness of Cathode Rays to Electrostatic Influence.*—The rays forming the chief spot are exceedingly sensitive in this arrangement for electrostatic forces. Small motions of a rubbed stick at a distance of 10cm. from the wall of the oil beaker suffice to deflect the rays right on to the wall of the discharge tube. The motion of a finger at a distance of 10cm. suffices to produce about the same deflections. On breathing against the beaker the rays are apparently blown away.

§ 13. *Difference between Electrostatic and Magnetic Deflection.*—We must at once call attention to the many differences between the electrostatic and the magnetic deflection of the rays, so that the latter may not be wrongly attributed to the former. The magnet does, indeed, deflect the currents running over the surface of the glass, and thus alters the stationary charge of the wall. The electrostatic effect of this permanently altered charge might explain the observed magnetic deflection of the rays. But in the absence of cogent proofs I reject this explanation, and consider the magnetic deflection as a property of the cathode rays as fundamental as the electrostatic deflection.

In any case it is evident—and that is the main point—that the new electrostatic deflection cannot be, on the other hand, deduced from the magnetic. It is not impossible that the motion of the electrified deflecting bodies, or generally the change of the electrostatic deflecting force, may produce currents on the glass wall or elsewhere, which are stronger than those corresponding to the induced change of charge. But their mean current strength cannot possibly be greater than the whole current of the influence machine, and this must be conducted round the tube in at least a million turns in order to have a magnetic effect equalling the observed electrostatic deflection. No change is produced if we imagine these currents on the glass wall to pass not continuously but abruptly in very short times, and with consequently high current intensities. These very short strong currents might produce not large but only very short deflections, which would not be visible, and which would be separated by long intervals during which the rays were not deflected.

* *Wied. Ann.*, LVII., p. 152.

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On this occasion I also remark that I have ascertained by sensitive electroscopic experiments that the deflecting bodies suffer no diminution of charge during deflection.

III. Electrostatic Deflection and Change of Intensity of the Cathode Rays.

§ 14. *Electrostatic Deflection. Character of the Phenomenon.*—If a rubbed glass rod is rapidly moved in the neighbourhood of the beaker from above to the level of the cathode and is held there, the rays are repelled. A dark and fairly well-defined surface rises on the side of the discharge tube turned towards the glass rod, which sweeps down the chief spot quite to the other side of the discharge tube. After about 0·2 second it returns, followed by the fluorescent spot. As the dark surface falls down along the side of the tube towards the rod, it regains the normal brightness of the region. But the centre of the chief spot does not at once rejoin the centre of the ring (see § 11), but goes through five or six small damped oscillations of about 0·2 second duration. The permanent lowering of the deflecting rod has, therefore, none but a transitory effect upon the ray. A short time afterwards the ray, in spite of the new position of the rod, is as straight as ever.

On raising the positively-charged glass rod into its former position, the cathode ray is as strongly attracted as it was previously repelled. A bright surface rises on the side of the discharge tube away from the rod, and urges the chief spot towards the latter. In about 0·2 second it falls back and darkens, leaving the chief spot in its former place. In this case I never saw the chief spot oscillating afterwards. But the conditions are not favourable, since the eye is blinded by the sudden brightening accompanying the attraction.

All electrostatic deflections of the cathode rays take place in the same manner. If the deflecting electrified body is brought from one place to another, or if the difference of potential of two stationary neighbouring conductors is changed—whenever, indeed, the deflecting force is varied—the rays undergo a correspondingly large deflection, which is, however, at once annulled in a damped oscillatory manner. On restoring the conductor to its former place, or the potential to its first value, the rays experience the reverse deflection, which disappears in the same way.

It should be remarked that often, but not always, the oscillation of the direction of the rays is damped aperiodically, as in small deflections, and when the duration of deflection is great, as when the finger is used. Furthermore (when the radiation is not perfectly quiet), the oscillation of the spot is replaced by a more or less irregular flickering. But I have not found it difficult to produce arrangements in which the motion of the spot at each repetition of the deflection bore the well-marked character of a regularly-damped sinusoidal oscillation of short period (0·2 second), so that I cannot avoid putting forward this view of the quivering of the rays before they are completely stretched.

§ 15. *Direction of the Electrostatic Deflection.*—The deflection of the rays has the opposite sense to what I expected. If the discharge tube is introduced between two large parallel condenser plates, leaving 10cm. on each side, and if they are brought to a difference of potential of about 6,000 volts, the ray is attracted for a short time by the negative plate, and stretches again at once. If, now, the condenser plates are discharged the ray is equally strongly attracted by the positive pole, and then stretches again.

If the condenser plates are removed and a rubbed ebonite rod is brought nearer in any direction from a large distance, the rays are attracted for a short time; on withdrawing it, they are repelled. A glass rod has the opposite effect. Positively or negatively-charged conductors in motion act correspondingly. Uninsulated conductors in motion, *e.g.*, the hand, act like positive bodies if the anode is put to earth, as in Fig. 1. They act as negative bodies if the cathode, K, is put to earth, and the anode and all parts of the oil beaker have in consequence a more or less high positive potential.

Since the experiments giving this sense of the deflection were discovered on the basis of the theorem that the cathode rays follow the electrostatic lines of force, I am far from abandoning the theorem in consequence of the wrong sign of the deflection. On the contrary, further conclusions may be drawn from it. Since the negative lines of force in a vacuum are nevertheless probably repelled by an approaching negative body, and since the cathode rays following the lines of force are yet attracted by the negative body, we must conclude that one of the signs of the internal processes is incorrectly assumed. The simplest assumption would be that not negative but positive lines of force should exceptionally issue, which determined the path of the cathode rays.

§ 16. *Brightening and Darkening of the Cathode Rays by Electrostatic Effects.*—Besides the electrostatic deflection a somewhat independent change of intensity of the radiation takes place. It will be seen from the description given in § 14 that the repulsion of the rays is the reverse of the attraction not only as regards direction but also as regards change of brightness. A very strong transitory brightening or darkening of the fluorescent spot accompanies the attraction and repulsion described. With strong repelling forces, such as quick motions of the rubbed rod, the rays producing the spot (also those of the ring figure) may be perfectly extinguished for half a second or a second, as far at least as their fluorescent effect is concerned.

The independence of this electric action upon the intensity of the rays from their deflecting action is exhibited when an uninsulated guard plate 30cm. in diameter, is introduced between the deflecting rod and the oil beaker. This almost completely intercepts the electrostatic deflection, but not the change of brightness by the motion of the rod. Both effects may be intercepted by a metallic enclosure. Further, attraction and brightening on the one hand, and repulsion and darkening on the other, are not always combined. On bringing, for instance, a rubbed ebonite rod in a tangential direction from a long distance up to the beaker, the rays are attracted, but are at the same time strongly darkened or even extinguished. I am further investigating these changes of intensity.

§ 17. *Self-Tension of the Cathode Rays.*—The short duration of the electrostatic deflection and its reversal on removing the deflecting force may be accounted for in two ways. Either the deflection is governed by the rate at which the deflecting force changes, or by the deflecting force itself, so that the short duration of the deflection and its reversal are due to a secondary effect. I believe that in this case the secondary effect may play a greater part than Faraday's "electrotonic condition," which he originally put forward as the basis of his views concerning magnetic induction. Assuming the cathode rays to follow the lines of force, this secondary effect can hardly be anything but the charging of the glass wall. The permanent charge of deflecting power changes the course of the lines of force in the vacuum permanently. Hence a secondary cause must appear after a short time, which neutralises this deflection of the cathode rays. But a cause capable of altering the course of lines of force is either an electric vortex ring or an electric charge. Now it has been known for some time that the cathode rays alter the electric charges. Hence, under any circumstances, they stretch the lines of force and themselves by a corresponding charge of the glass wall. This relation, almost independent of all minor circumstances (shape of the glass wall, position of the anode), must approach all the further towards the essence of the discharge, inasmuch as the stretching is oscillatory. We may now also understand why there may be permanent as well as transient electric deflections of the cathode rays. Many of them may be effected by stationary charges of the glass wall, the effect of the rays upon the charges of the glass wall—which by itself would soon bring about the straightening of the rays—being continuously paralysed by a charge coming from another source. Such permanent deflections may therefore only be brought about by such bodies as are capable of yielding continuous currents, *i.e.*, by electrodes, as is in fact the usual simple case.

It is my pleasant duty to express my thanks to my esteemed colleague, Prof. E. Lecher, who granted me a bench in the Institute under his charge, and to the Society for the Advancement of German Science, Art, and Literature in Bohemia, which placed the means for this work at my disposal.

**Fluid Friction.**—The vexed question in the theory of fluid friction, whether finite slipping does or does not take place at the surface of a solid in contact with a liquid, forms the subject of a contribution, by Dr. Antonio Umani, in a recent number of the *Nuovo Cimento*. The experiments, says *Nature*, were conducted in the physical laboratory of the university of Parma, the apparatus used consisting of a cylindrical box filled with mercury, and suspended by a torsion fibre. In one series of experiments the sides of the box were nickel-plated, so that the mercury did not actually wet the metal; in another series, the mercury was made to bathe the sides of the box by thoroughly amalgamating the latter. In the former case, the presence of a film of air between the mercury and nickel was obviated by filling the box *in vacuo*. The observed values for the logarithmic decrement of the amplitude of the oscillations were found to differ in the two series of experiments by an amount which, Dr. Umani considers, indicates finite slipping between the mercury and the box when the latter is nickel-plated. The author further proceeds to calculate the internal coefficient of viscosity of mercury from the results of his second series of experiments, and obtains the value $\eta = 0\,01577$ C.G.S. units at temperature 10° C. Warburg, employing Poiseuille's method, had previously obtained at temperature 17·2° C. the value 0·01602



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## OLIVER HEAVISIDE.

At last we are permitted to mention the fact that Her Majesty the QUEEN has been pleased to offer a pension to Mr. OLIVER HEAVISIDE from the Civil List, and that he has accepted it. We are informed that certain very distinguished and very enthusiastic men of science threatened to visit the philosopher in his Devonshire retreat—or rather, threatened to picnic for weeks around his retreat, so that he might be compelled to say that he would accept of the pension in case it were offered. His knowledge of the ordinary affairs of life must be as limited as his power of applying mathematics to physical problems is unlimited, if he thinks that this honour—an honour that the Duke of WELLINGTON felt to be an honour after he had been acclaimed as the Saviour of Europe—tends in the slightest degree to tie his hands, to blunt his pen, or to affect his independence. He receives the pension from the executive of the nation, and assuredly there is not one man acquainted with recent work in mathematical physics who does not feel that the giving of this pension is not merely a good deed in Mr. BALFOUR counting for righteousness, but a bargain for the nation made very greatly in the nation's interests. Something has been done that looks very generous; it is simply an act of wisdom, gracefully performed. The English nation is the wealthiest known in history. What sensible man grudges a few thousand pounds spent occasionally on a new work of art or many thousands on a new ironclad? Only the foolish among us judge of such expenditure from the point of view of their own bank balance, their perspective being governed by the line of sight of a parish councillor, which is bounded by the rates. "The delight of diving into a big pile," as it has been coarsely but effectively put, is one of the greatest which Mr. BALFOUR enjoys. No millionaire can enjoy it in quite the same way. We take it that every penny of the surplus wealth of this nation is owing to the nation, and is being spent, wisely or unwisely, by all who command it, in the interests of the nation, having its effect in millions of ways in keeping us fit to lead among the nations. But the money follows accustomed channels, and sometimes fails to reach nooks and corners where even in very small quantity

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it might be greatly productive of good. Here is the chance for our leaders, to watch the operations of the natural flow but to occasionally create a little eddy in a corner.

A man of striking individuality, standing, like SAUL, a head and shoulders above other men, is always to be admired. But, alas! our habits of living, good as they are for men in general, are far too apt to make us all alike. Our great men are caught and anointed and coaxed and threatened until they lose that individuality that so attracted us. Mr. HEAVISIDE has great individuality. We venture to think that a little pension will produce no great difference in his philosophy. If it had been a great one; if he had been knighted or made a Privy Councillor; if he lived in London and had to give and go to dinner parties; if, besides, in spite of a big pension he found it necessary to make money to meet great house expenses, we don't know but what he might come to be like other philosophers in the hands of the social drill sergeant. But we, who know what HEAVISIDE has done, know that he has simply been freed from some petty worries. We ask him to give us what he will, when he will and how he will. No poet ought to be less controlled than he.

His services to the nation, or rather to the world, are already great. In the development of a race the essential thing seems to be the occasional appearance of a "Sport," and that is what he is. He is not a mathematical physicist, he is a physical mathematician. The rules of the Cambridge mathematical game are very rigid, and for many a day Mr. HEAVISIDE had to feel that the man who attempts to change the rules has a hard time of it. Imagine a boy who had no cap, who belonged to no house, a mere day boy, asking to play with the twenty-two, and not only that, but daring to propose a change in the Rugby rules. That is exactly what occurred. Schoolboys are supposed to resent cheeky innovation more than other mortals—but the supposition is wrong. Grown-up schoolboys exercise a much more serious resentment. Mr. HEAVISIDE dared to write about things that even rigorous mathematicians themselves did not understand. But just as schoolboys are the most generous of mortals when they do get over their first prejudices, when they find that an interloper is modest and in earnest, so the acknowledged mathematicians are now willing to admit that Mr. HEAVISIDE has stirred them up a little with his earnestness, and has done service in the temple of Cambridge mathematics which no worshipper could have done, which only an outside unbeliever dare have attempted. It was easy to say that he had invented no new mathematical weapons—everyone of his weapons was invented before. That is true, but how many of them were used, and not only used, but used with learned skill in attacking problems that had never been attacked before?

We would ask our readers to look up a wonderful notice of of Mr. HEAVISIDE'S Papers published in our columns on August 11, 1893. Who could imagine, when reading that appreciative article, that its author is a Fellow of Trinity College, Dublin, and that the mathematical traditions of Dublin are to those of Cambridge as granite is to sandstone? Surely nothing that anyone else can say is to be compared with these words of our modern "very perfect gentle knight":—"MAXWELL, like every other pioneer who does not live to explore the country he opened out, had not had time to investigate the most direct means of access to the country, nor the most systematic way of exploring it. This has been reserved for OLIVER HEAVISIDE to do. MAXWELL'S treatise is cumbered with the *débris* of his brilliant lines of assault, of his entrenched camps, of his battles. OLIVER HEAVISIDE has cleared these away, has opened up a direct route, has made a broad road, and has explored a considerable tract of country. The maze of symbols—electric and magnetic potential, vector potential, electric force, current, displacement, magnetic force and induction—have been practically reduced to two, electric and magnetic force. . . . In the theory of electromagnetic phenomena the author has made great advances. He has extended the theory of wave propagation in complicated media, of waves along wires and into them, and of the effect of the motion of the medium." Prof. FITZGERALD'S article is worthy of the writer, and of his subject; and what praise can be higher? We see that these snippets from it are only misleading, and we again say to our readers that they had better look it up and see for themselves.

It is not merely that since Mr. HEAVISIDE began to write the science of electromagnetism has been entirely altered; he has worked out innumerable problems in practical telegraphy and telephony, and his Papers on such subjects may be looked upon as a quarry from which smaller men will be manufacturing reputations during the next twenty years. Some of us wish he would make his meaning clearer, and so give his future commentators less to do. He seems sometimes to take an impish delight in deluding the poor traveller, in displaying to the thirsty student whole realms of easily-understood theory, and then suddenly, in the twinkling of an eye, the easy road has disappeared, the thirsty student sees again the arid plain as PUCK spreads his wings and turns again into an eagle just visible in the ether. He is a man who can really think, and we might never take the trouble to think for ourselves if we could understand him too easily.

## REVIEWS.

**Argon and Newton: A Realisation.** By Lieut-Colonel W. SEDGWICK, late R.E. (London: W. B. Whittingham and Co., 1896.)

The meaning of the title and text of this strange book entirely passeth our comprehension, though we have done our very best to read religiously through every one of its 258 pages. Argon we know; and Newton we know. But what is this realisation which follows their juxtaposition? And what have they to do with one another, anyway? In vain have we searched these many mystically-worded pages in the hope of solving the riddle. Nor do the pictures help us—the numerous pictures of atoms "enormously enlarged." We only discover in these that, according to Lieut.-Colonel Sedgwick's "realisation," the monovalent metalloid atom is a sphere, in one side of which there is a depressed crater with a flat edge, while a monovalent metal atom looks like a badly blown glass flask. We believe it was one of Mark Twain's jokes to preface his chapters by utterly irrelevant quotations. Lieut.-Colonel Sedgwick has mistaken this species of humour for a branch of serious logic. The masterpiece of quotation is on his title page: its juxtaposition to the title should serve as a species of *pons asinorum* to bar the way to him who is unable to comprehend that Newton knew all about inert atoms and inactive elements. Apparently Lieut.-Colonel Sedgwick's ideas, as set forth in this treatise, are based on the conception of argon and helium as absolutely inert substances. With the falsity of that conception his "realisation" must vanish into illusion. What sort of relationship is conceived by the author to exist between his premises and his conclusions, the reader may best judge from the following quotation, which we extract from the last few pages of the book:—

"Argon, by showing us that the materials for building a universe require shaping, shows us that our universe had a Maker, and shows us one of the quarries, as it were, from which the materials for our universe were obtained. In this way Argon represents the realisation of Newton's views that 'God in the beginning formed matter in solid . . . particles of such sizes and figures . . . as most conduced to the end for which He formed them.' It tells us, too, that Sir John Herschel and Clerk Maxwell were right in holding the molecule to have 'the essential character of a manufactured article.' . . . Argon and Helium, then, have risen

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like stars upon the horizon to give us fuller light, and to show us the way out of the desert of Agnosticism and out of the bogs of Atheism."

Henceforth, then, every missionary to the unregenerate should be equipped with tubes of these interesting new gases, and with wall diagrams showing the exact contours of their atoms "enormously enlarged."

**Electric Wiring Specifications for Incandescent Lighting.** By GEORGE H. KIMBER. (New York: G. H. Irwin and Co., 1896.)

This booklet is one of several recent attempts to enable architects to perform functions which properly speaking belong to electrical engineers, and we do not think that it will assist them much. It consists of a series of general specifications which are intended to give a skeleton outline suitable for ordinary wiring, as obtaining in the United States. As such the book has its uses, and in the hands of a competent engineer would no doubt save time if he has not already a model specification embodying the points which he finds most useful in his practice. In the hands of an architect it is likely to prove a doubtful blessing. It is like expecting an electrical engineer to design and superintend the erection of a house on the strength of an acquaintance with a text book on architecture. We will only suggest the confusion which is likely to arise between the terms feeders, submains, risers, and branch circuits, as used by the author; but we must in the interests of the consumer suggest that some distinction be made between wiring for direct and alternate-current systems when metal-armoured conduits are used. The author states in schedules F and G that when iron-armoured conduits are specified two conductors may be carried in the same tube whether the current be direct or alternating, but with brass-armoured insulated tubing "a *separate* conduit must be provided for each wire." It appears to follow therefore that if an installation were to be carried out in accordance with these instructions, and the supply were from an alternating system, that there would be an excessive drop of pressure on each of the feeders, risers or submains. No doubt the author is fully aware of the need for enclosing lead and return in one conduit when alternate currents are used with the conductors in metal pipes, but he does not tell the trusting architect so. We fear that before now trouble has arisen in connection therewith unless the contractor has exceeded the duties of his position, and has acted as consulting engineer to the architect, as has happened before now in this country.

In the rules of the National Board of Fire Underwriters which is appended to the specifications we find that brass-armoured conduits are allowed for double-tube systems only, while iron-armoured conduits are permitted for single-tube systems. This distinction is amply justified by experience, and apparently forbids the use of brass-armoured tubing for alternate-current systems. The author appears to have missed this important point.

**James Clerk Maxwell and Modern Physics.** By R. T. GLAZEBROOK, F.R S. (London: Cassell and Co., 1896.)

While recollections of the rejoicings over the jubilee of Lord Kelvin's professoriate are still fresh in our memory, there is an appropriateness in turning to read a well-written account of the life of one of Lord Kelvin's compeers, who, unhappily, is not now alive to join in the universal celebration. But, though personally lost to the scientific world of the present day, James Clerk Maxwell, by the influence of his researches and writings, shines with Kelvin as a star of the first magnitude in the firmament of modern physical science. It is not now a fitting time to review in detail the almost countless gems of that all too brief life-work. Most of us are familiar with the lucid, if lengthy, account which Prof. Campbell and Dr. Garnett have supplied in their well-known biography. And for those who do not possess sufficient leisure to read through the numerous pages of that work, Mr. R. T. Glazebrook has written the little book before us. It is well worth reading.

But Mr. Glazebrook's book is in no sense an abridged edition of the larger biography. The author has the advantage of having personally known and worked with Maxwell; and personal recollections of his "most kind friend, as well as revered master," brighten many of the pages, which are nowhere dull. It is not merely the scientific and mathematical Maxwell that Mr. Glazebrook has sketched; it is the complete man—Maxwell the student, the humorist, the poet, the devoted husband, the devout worshipper of nature and nature's God.

## THE HARDIE McLEAN AUTOMATIC TIME-SWITCH.

The automatic time-switch devised by Mr. J. Hardie McLean, and used extensively in Oxford and other places for some 3½ years, has admirably fulfilled the object with which it was originally designed—namely, to encourage economy in the use of electricity. The switching of the public arc lamps in the streets of Oxford, which until recently were connected two in series across the low-pressure network, is effected by this device. The economy that has accrued has been such as to fully warrant the expense of attaching these switches to the arc lamps. In many of the colleges the public lights are switched off at a stated hour each night by means of this arrangement.

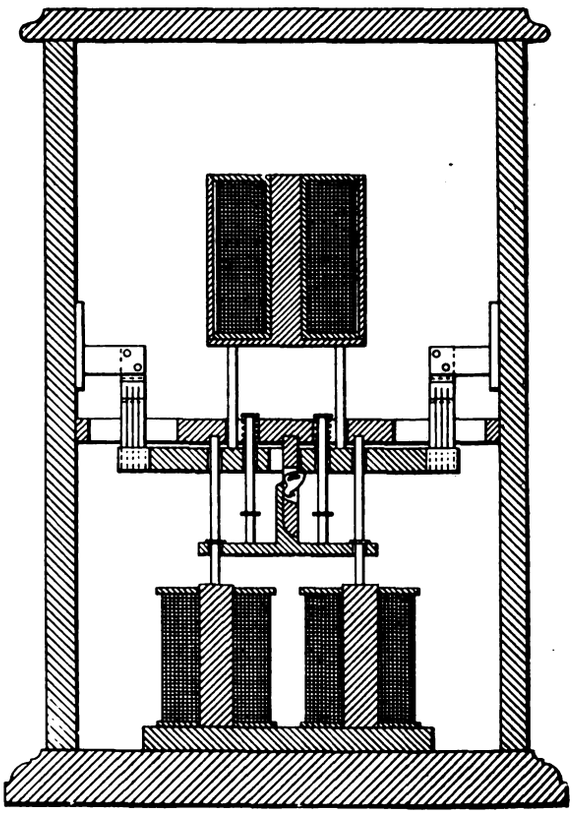

FIG. 1.—Switch On.

The principle of Mr. Hardie McLean's device will be readily understood on reference to the accompanying sketches (Figs. 1 and 2). The contact bar is raised to complete the circuit by means of the solenoid placed above it; the solenoid becoming excited, the moment a clock, which is placed above it, makes electrical contact with the distributing mains at the given hour (Fig. 1). When the time comes for disconnecting, a second contact is made by the clock, which sends the current round the coils of the field magnet, which is placed *underneath* the contact bar. The result is that the switch is pulled off (Fig. 2). By means of an arrangement resembling a cam in the centre with a slotted hole, when the switch is on, the weight of the armature of the magnet, and core of the solenoid, is taken off the contact bar, so that it has no tendency, should the contact bar become slack, to drop out. The current for the solenoid and the magnet is derived from the low-pressure supply. The connections are so arranged that when the switch is on or off the current is disconnected from the operating coils of the switch; these are only in circuit during the moment work is being done. The clock, which is specially made, has a 24-hour face,

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and can be set to switch on or off the current at any time during the 24 hours. The clock can either be wound up electrically from the mains, or by means of a key once a fortnight, and requires no further attention.

These switches should prove useful in public buildings, factories, offices, &c., where the light is only required between given hours.

We may say that a simpler form of switch is used for the purpose of turning the lamps off without the additional

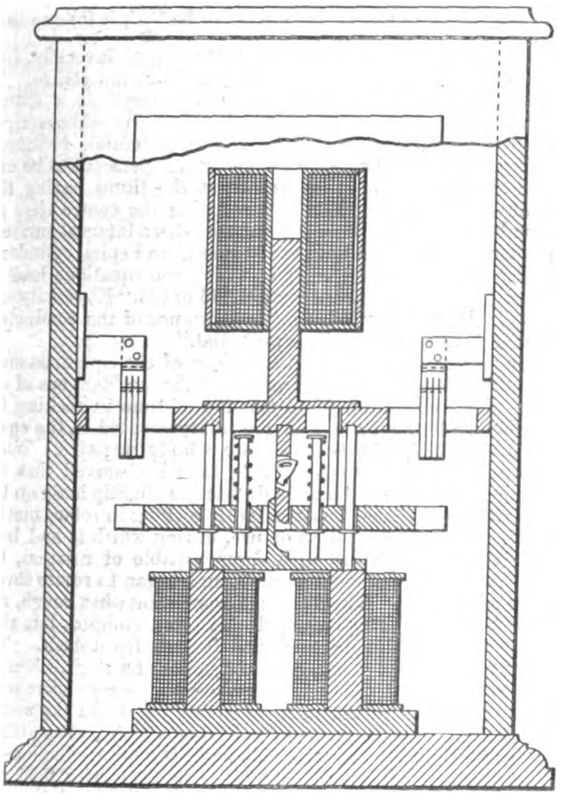

FIG. 2.—Switch Off.

arrangement for switching them in. This is a far less expensive arrangement, and is found in many places to be all that is required. The size and shape of switch is made to suit the various shapes and spaces at disposal in arc lamp posts, &c., the cases being made of cast-iron, for this class of work, as well as wood.

## THE GUILDFORD STREET-MAINS.

At Guildford the street-mains are being laid on what is known as the "Safety Concentric" system, that is to say, each current-carrying cable is composed of a copper core, insulated in one of

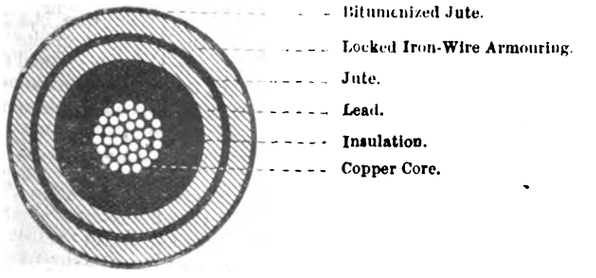


FIG. 1.—Detail of Cable.

the well-known ways, and having served on it an outer conductor of stranded iron wire, which serves for the return current and is not insulated (*see* Fig. 1). The three-wire system is used. The difference of potential between the two "outers" of the three-wire system is 400 volts, and the difference of potential between core wire and the armour which serves as the third wire is 200 volts. Each complete main thus consists of two of these concentric cables laid side by side, the armouring being practically uninsulated and being used as the neutral wire. Although uninsulated the armouring is protected from any possible electrolytic injury by being first served with a light protecting covering of bituminous jute, the cables being then laid together in V-shaped troughs filled in with bitumen, as shown in Fig. 2. Suitable distance pieces are inserted in the trough at short intervals, to prevent the cables sinking through the bitumen to the bare wood of the trough. The particular wire used by Messrs. Sharp and Kent, the contractors for the job, is manufactured by Messrs.

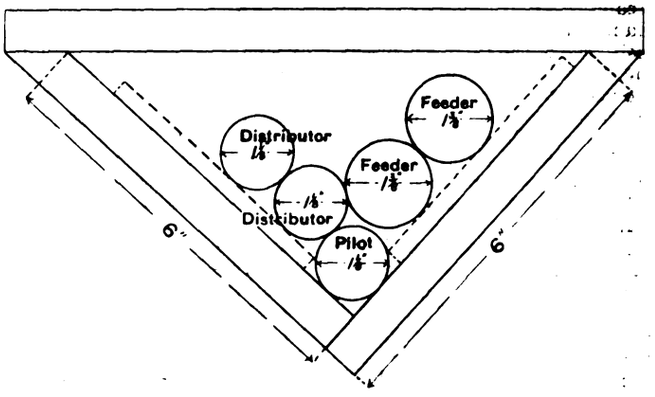


FIG. 2.—Section for Left-Hand Side of North-street, Guildford.

Callender, the armouring being on the lock-coil system, which practically makes the cable watertight. There will be no service boxes, all joints being made direct on to the cable by means of a cast joint and then buried in the ground. The above remarks apply to the distributors. The feeders are insulated throughout their entire length. The design of this "earthed-neutral" three-wire system is due to Mr. Money-Kent.

## THE EFFECTS OF A STRONG MAGNETIC FIELD UPON ELECTRIC DISCHARGES IN VACUO.*

BY A. A. C. SWINTON.

As is well known, when the lines of force of a magnetic field cut the path of the cathode rays in a vacuum tube, the rays are deflected in one direction or another, according to the polarity of the lines of force. If, on the other hand, the relative positions of the vacuum tube and the magnet are such that the lines of force and the cathode rays are parallel, the rays are not sensibly deflected. Under certain circumstances, however, I have found that with the rays and lines of force parallel, other phenomena occur both in regard to the appearance of the discharge and in connection with the internal resistance of the tube.

The apparatus employed consisted of a Crookes tube of the form illustrated,† supported vertically over one pole of a straight electro-magnet. The tube, which was excited by means of a 10in. Ruhmkorff coil, working much below full power, was about 11in. in length. The cathode terminal consisted of an aluminium plate at one end of the tube, and the anode a similar plate at one side. The tube was exhausted to a degree that gave considerable green fluorescence of the glass, with a very slight trace of blue luminescence of the residual gas in the neighbourhood of the cathode and anode. The magnet employed had a soft iron core 12in. in length and 1⅛in. diameter. It was wound with 2,376 turns of No. 18 S.W.G. copper wire, which, when supplied with continuous electric current at 100 volts pressure, allowed from 13 to 14 amperes to pass, and magnetised the iron core practically to saturation.

When the Ruhmkorff discharge passed through the tube, the magnet not being excited, the walls of the tube showed everywhere green fluorescence, which was especially strong all over the rounded end of the tube opposite the cathode. A very small amount of blue luminescence could also be faintly seen just below the cathode, and also in the vicinity of the anode. With the tube and magnet placed with their axes in a line and the cathode terminal at top

* Paper read before the Royal Society.

† Owing to the unsatisfactory nature of the illustrations we have not reproduced them; the meaning of the text, however, is quite clear.—[ED. *E.*]

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away from magnet pole, as soon as the magnet was excited the whole appearance of the discharge in the tube was found to alter immediately. Excepting for a very little at the top of the tube near the cathode, and a very bright spot at the bottom immediately over the magnet pole, all the green fluorescence of the glass disappeared, while extending from near the cathode to the bright spot at the bottom of the tube, a very bright cone of blue luminescence with a still brighter whitish blue core, made its appearance. When under these conditions the tube was slightly moved sideways, the bright spot at the apex of the cone and the cone itself moved, the spot and apex always maintaining a position exactly over the centre of the magnet pole. At the same time the minor blue luminescence proceeding from the anode terminal, due probably to the "make" current of the Ruhmkorff coil, was bent downwards towards the magnet, and deflected sideways one way or another according to the polarity of the magnet, which polarity, however, did not affect in any way the vertical cathode stream. The internal resistance of the tube, as measured by an alternative spark gap on the Ruhmkorff coil, was also found to be very greatly diminished while the magnet was excited. With the magnet not excited, the alternative spark would leap from 1¼in. to 1⅝in., while, when the magnet was excited, the gap had to be reduced to about ⅛in. before the sparks would pass. As soon as the current from the magnet was cut off, the appearance of the tube immediately reverted to what it had been before, and its internal resistance increased to what it had been before.

Experiments were also tried with the tube inverted (with cathode at bottom, near to magnet pole). In this case the internal resistance was affected by the magnet just as it had been previously. The appearance of the tube was also altered by the diminution almost to vanishing point of the green fluorescence, the presence of very bright blue luminescence on the under side of the cathode next the magnet, some less bright blue fluorescence near the anode, and a considerable amount of faint blue luminescence throughout the remainder of the tube. In this case, as in the other, the tube reverted to its normal appearance as soon as the magnet was demagnetised, and the appearance was the same whether the pole of the magnet next the tube was north or south.

Further experiments with the tube placed horizontally so that the magnetic lines cut the cathode rays, produced the usual deflection of the latter, but did not seem to have any appreciable effect on the internal resistance of the tube.

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Since the above Paper was written, further experiments have revealed the following additional facts. With a tube of the same form, exhausted to an extent that gave X-rays plentifully under ordinary conditions, and supported over an electro-magnet as before, the X-rays disappeared as soon as the magnet was excited, but re-appeared the moment the magnet was demagnetised. With another tube of similar form, but furnished with an inclined platinum plate forming the anode placed near the bottom of the tube, similar results were obtained. This tube being kept on the pump was further exhausted to a degree that allowed the electric discharge to pass with difficulty when the magnet was not excited, and under these conditions gave X-rays of a character that penetrated the bones of the hand almost as easily as the flesh with but little contrast. With this exhaustion the excitation of the magnet not only caused the cathode rays to focus on the platinum, thus giving sharper shadows, but at the same time had precisely the same effect as lowering the vacuum, in so far as, the moment the magnet was excited the X-rays became more plentiful, and became of such a character as to penetrate the flesh with much greater ease than the bone, so that the contrast between bone and flesh was exceedingly marked. A photograph of the hand taken with one minute's exposure with the tube in this condition, and with the magnet excited, though considerably over exposed, proved to be a very good one. Further investigations are in progress, but the application of a strong magnetic field in the manner described gives promise of considerable practical utility, not only in so far as it facilitates the accurate focussing of the rays proceeding from a flat cathode upon any desired point of the platinum anode, but also and more especially because by employing a high exhaustion and by varying the intensity of the magnetic field, it is possible to arrive with ease at the exact conditions requisite to produce a maximum of X-rays of exactly the penetrative character that may be best for any given purpose, a result which hitherto has been difficult of attainment.

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**The Rumford Premium of the American Academy of Arts and Sciences.**—The American Academy of Arts and Sciences, after having received the report of its Rumford Committee on the merits of Mr. T. A. Edison, has awarded the Rumford premium with the gold and silver medals to that inventor.

## ON A ROTATIONAL MOTION OF THE CATHODE DISC IN THE CROOKES TUBE.*

BY FRANCIS E. NIPHER.

It is well known that the equations which represent the properties of the magnetic field external to a conductor are inconsistent when applied to points within the body of the conductor. Assuming the total magnetic force within to be tangent to a circle whose centre is at the wire centre, and that the surfaces of equal potential are radial planes; assuming the force due to an element of the conductor of infinite length and of section $d\,s$ to be $\frac{2\,d\,i}{r}$, it follows that the force at any point without the conductor varies inversely, and at an internal point directly, as the distance from the centre. If now within the wire we assume any radial plane as a datum equipotential plane, and determine the locus of any other equipotential surface, such that the difference of potential, measured along the lines of force, is constant, this surface turns out to be one having as a cross-section a spiral known as the lituus having the radius as an external asymptote, and reaching the centre after an infinite number of turns. It is evident that these internal surfaces of equal potential cannot be both radial planes and spiral cylinders. Maxwell disposes of this absurdity to which the equations lead in the single sentence which closes section 606 of his "Electricity and Magnetism." He says: "Within the substance of the conductor, there is no such thing as magnetic potential."

It has long seemed to me that this failure of the equations must be the result of leaving some elements of the problem out of the discussion. I have spent a great amount of time in seeking for some rotational phenomenon hitherto unrepresented in the equations. Until recently the results were wholly negative. While recently experimenting with a Crookes tube I observed that the circular aluminium disc of the cathode became slightly loose on the aluminium wire, and that it was constantly rocking in rotary motion on the wire. After several days of use, during which it had been decided to construct a tube with discs capable of rotation, the cathode disc suddenly became loosened, and began to rotate slowly on the wire as an axis. The bearings were somewhat rough, and the disc was not perfectly balanced. It often stopped, but then began to rock against the obstacle until it again freed itself. The direction of rotation was contrary to the hands of a clock, when the disc was viewed from the point where the cathode wire pierces the wall of the tube. All attempts to accelerate or retard the motion by means of strong bar magnets, as in Barlow's wheel, were without effect. Placing the tube at various distances from the induction-coil and giving the disc all possible positions in the earth's field produced no change in the rotation. A more decided rotation was produced by using the brush-discharge of a 24in. Holtz machine. No rotation has been produced as yet when the leading wires were in metallic contact with the conductors of the Holtz machine, but when the leads consisted of rods having spherical terminals, separated by short spark intervals, the rotation was always seen. When the loose disc was made the anode, no tendency to rotation was observed. Thus far all attempts to produce the effect in air of ordinary pressure have failed, but the work in this direction is not yet concluded.

In the tube used, the tendency to rotation was not observed until by long use the vacuum had become very high, and it has now nearly reached the limit where the sparks pass round the tube, rather than through it. The leading-in wires are at right angles to each other in the tube used. Tubes are now in preparation which will have rotary discs facing each other as well as at right angles to each other, and various other features, by which it is hoped that many questions which at once suggest themselves may be answered. There is much reason to suspect that the gas particles do not shoot off normally from the surface of the disc, but in a vortex the axis of which is in the two dark spots opposite the cathode faces. The fact that the anode does not respond, and that similar experiments in open air have thus far failed, seems to point to the cathode discharge as the direct active agent. This view is not easily reconciled with the result of the experiment made by Crookes with the hemicylindrical cathode (*Nature*, July 3, 1879, p. 229, fig. 3), but the figure shown does not seem to quite agree with the description of it. Experiments are now in preparation which will decide this question. It is possible that the rotation observed is a direct action and reaction between the current in the disc and the external field due to the current. In this case the rotation apparently ought to be producible in open air, and on the anode terminal of the Crookes tube.

Whatever may be the direct agency producing this rotation, it seems apparent that we now have an experimental basis for imposing a term representing a rotation into the equations representing the conditions within a conductor.

* From the *Transactions* of the Academy of Science of St. Louis, Vol. VII., No. 7.

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## ELECTRICITY SUPPLY AT 220 VOLTS.*

BY A. S. BARNARD (HULL).

The question of the most suitable pressure at which to supply current from a central station depends, of course, to a very large extent, on the area of the district to be supplied and the position of the central station. As, however, nearly all systems of supply include networks of distributing mains, which are maintained at about the same pressure as required by the lamps on the consumers' premises, and which networks are fed from sub-stations or generating stations, as the case may be, the writer proposes to deal chiefly with the advantages and disadvantages of the use of 220 volts on the distributing mains, without going very much into the question of whether it is better to have one or more low-tension generating stations to supply current to the network, or a high-tension generating station with a number of sub-stations.

In the first place it should be remembered that it is not to the much-discussed new regulations recently issued by the Board of Trade that we owe the beginning of a new era in which 200 to 220 volts will be the accepted standard of pressure for incandescent lamps as 100 to 110 volts is at present. These regulations did not produce 220-volt lamps, and it is a pure chance that they happened to be under discussion just at the time when electrical engineers were considering the possibility of adopting a higher-voltage lamp and so relieving their overcrowded mains, or reaching out to unexplored fields of action in the suburbs of the town. It naturally followed that engineers who had this in view were anxious to secure liberal clauses in these regulations which should admit of the use of lamps at 220 volts on consumer's premises, and also of three-wire distribution in the streets (involving 440 volts across the outer cables) without being hampered or restricted by unnecessary precautions or expense in laying such cables or in converting existing 110-volt systems to the higher voltage. In the end their efforts were mainly successful, though there are qualifications and conditions introduced which may in some cases prove almost insuperable difficulties in the way of changing over an existing system. It seems probable, however, that many engineers whose stations are at present working at 100 to 110 volts will manage to gradually persuade their customers that it is to their advantage to be supplied at 200 to 220 volts, or, if they are unable to do this, will, by appealing to their public spirit and representing the incalculable benefit of the change to the town, manage to obtain their consent to the change, and so overcome the difficulty of the proviso under Regulation B 6.

Whatever doubt may exist as to the benefits to the consumer of the higher voltage, there can be no question as to the immense gain to the supply works by its adoption. In the first place, should the Westinghouse Company succeed in their application for a renewal of the three-wire patent, some stations having three-wire networks at 110 volts may find it worth while to discard their middle wire and adopt a two-wire 220-volt system, rather than continue to pay royalties on their mains. In the majority of cases, however, the change that will be likely to be made will be the doubling of the pressure throughout, making 400 to 440, or even 460, volts across the outer wires, with 200 to 230 volts at the consumers' terminals.

Briefly the advantages of the change will be as follow :—

1. Existing mains can supply twice as many customers, at the same time reducing the percentage of loss in the cables by one half.

2. Variations and fluctuations due to the switching on or off of motors or large groups of lamps, or carelessness in switching dynamos in or out at the station, are all reduced by at least one half.

3. New customers can be supplied at a much greater distance from the station.

On the first point little need be said. In connection with most stations that have been in operation two or three years it has been found that some at least of the distributing mains were overcrowded, and needed either to be increased themselves or to be supplied by larger feeders. As electric light becomes more and more recognised as a necessity and not a luxury, this increasing of mains will be found to be a very heavy item of expenditure indeed ; and any means by which twice the number of consumers can be supplied, with the further advantage of reducing the percentage of loss, or four times the number of consumers with the same percentage of loss, will be gladly welcomed by the engineers responsible for furnishing a supply at an unvarying pressure to any number of persons who may apply for it.

It has been thought that the same end would be attained by the use of 110-volt lamps, the manufacture of which was to be so improved that they should give the same light with little over half the current they formerly took. Well, at present the best 220-volt lamps in the market take about 3½ watts per candle-power, and the most efficient 110-volt lamps about 2½ watts. That is to say, the 220-volt lamps will consume about 40 per cent. more than the high-efficiency 110-volt lamps. But how many consumers really prefer these high-efficiency lamps? Some do, no doubt, and congratulate themselves vastly on their reduced bills for current ; but others, possibly the majority, prefer to use 3 to 3½ watt lamps, which last longer, and do not cause the annoyance of continually burning out and having to be replaced. Both kinds of lamp are in use at Hull, and while, of course, there are many more of the high-efficiency 110-volt lamps than there are 220-volt, it is a significant fact that there has never yet been a single complaint made of these latter ; whereas it never happens that a consumer complains of his lamps "giving out so quickly" except when he is using some specially recommended highest-efficiency lamp. Moreover, if we *must* have 2½-watt per candle-power lamps, at any rate with 16 c.p. and all larger sizes, we shall in course of time get them, even at 220 volts. Even now it is only with the 8 c.p. and 16 c.p. lamps that there is any difficulty ; and when they do come they will have a far better chance at 220 volts of obtaining the steady pressure, free from fluctuation, necessary for their economical use, than ever they have had at 110.

And now as to the second point—the reduced variations of pressure. Suppose a consumer having a motor or any other appliance taking 40 amperes at 100 volts is situated at the far end of a rather long main. When he switches the motor on or off he will very probably cause a "jump" in the neighbouring lights representing, perhaps, 4 volts, or 4 per cent. of the standard pressure. If, instead, he were supplied at 200 volts, not only would his current be reduced to 20 amperes and the consequent variation in the voltage to 2 volts, but, as 2 volts is only *1 per cent.* of 200 volts, the effect on the lamps would be reduced to one quarter, or, in nine cases out of ten, what was previously an annoying little flicker would become quite unnoticeable. Again, stations where a number of 100-volt machines are run in parallel are dependent upon the switchboard attendant, and perhaps some automatic device, to switch each machine in and out at exactly the right voltage. Now, every attendant has his own "coefficient of personal error"—amounting to perhaps three volts, and even the best automatic switches have a similar margin to a greater or less extent. On a 100 to 110-volt system, a machine being switched in at 103 or 113 volts can be noticed at the lamps, and if, as sometimes happens, it is 105 or 115 volts, the effect is a decided jump in the light. On a 200 to 220 volts system the same errors will probably be made, but their effect will be reduced to one half, as it is the *percentage* of variation in the pressure at a lamp that is noticed. Altogether, it seems to me that doubling the pressure at the lamps will make a marked and decided improvement in the steadiness, and will reduce the variation from the standard pressure at any point in the mains to a very great extent.

With regard to the third point mentioned, the advantages to be derived from changing over to 220 volts are so patent as hardly to need enlarging on. A station distributing at 110 volts on a three-wire system can supply an area of about one square mile, or, say, to a distance of about half a mile on all sides. To supply beyond this distance and maintain a reasonably constant pressure necessitates the use of such heavy copper mains and feeders as to become almost prohibitory, and the point is very soon reached at which it pays better to adopt a high-tension system with transformers. Now, there are a number of low-tension stations throughout the country which have been established in the heart of the busiest quarters of the town, and which are supplying at 110 volts profitably and well. After a time, though, demands arise for current in the residential and outlying districts, and these demands have to be met. How shall it be done? By establishing a number of little low-tension stations all round the outskirts of the town, or by putting down a high-tension station to work independently of the existing station? Well, it seems to me that neither of these plans can compare in efficiency and low cost with that of doubling the pressure at the existing station, and so increasing the area over which its operations can extend. To what distance it is possible to supply economically at 220 volts can hardly be said to be settled as yet. Mr. Addenbrooke, in his recent Paper before the Institution of Electrical Engineers, claimed that a 220-volt three-wire system could cover an area of 25 sq. miles from one station. No doubt it could, if the mains were heavy enough and the limits of variation in the pressure not too stringent. In changes of this sort, made by Local Authorities at any rate, two points should be kept in mind—first, improvement in the lighting service ; second, economy in the capital outlay and working expenses. As regards improvement in regulation—if the present condition of things in most towns having a supply over an area of about 1 sq. mile, from one station, be the best that is obtainable at 110 volts, it would seem that too much loss has been allowed in the distributing mains, and the error should not be repeated when the area is being extended. When doubling the pressure, it will be quite enough to expect to be able to supply to double the distance, with rather smaller mains—calculated to allow the same actual loss to the farthest lamp, as at present allowed to the farthest lamp in the small area—the percentage of variation in the voltage being then reduced to one half of what it is at present.

* Paper read before the Municipal Electrical Association.



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The writer would not care, therefore, to recommend attempting to supply much more than four square miles from one station or sub-station; and this could be done in the case of many existing stations by doubling the pressure, using mains which cost little over half as much as the mains laid in the business parts of the town, and yet reducing the loss and variation of pressure at the lamps to half the percentage obtaining at present. It must be borne in mind, too, that in cases of this kind the new area to be supplied will probably not be nearly equal to the present area in the number of lamps connected per yard of mains laid; and whatever basis is taken in determining the size of distributing mains to be laid in the business part of the town, it should be quite safe to take two-thirds, or even half, of that figure as the basis for mains laid in streets of villas, private houses, &c.

Of course there are many provincial towns—Hull is one of them—where the area of supply laid down by the Provisional Order is much more than 4 sq. miles. In a case of this sort the advantage of being able to reduce the number of generating or of sub-stations holds good as before. At Bradford, as stated by Mr. Gibbings, the new station is designed to supply a distance of 1½ miles, over an area of about 9 sq. miles, on the three-wire system with 230-volt lamps. Districts at a greater distance, in an area of about 17 sq. miles, will be supplied from the same station by means of motor transformers. This arrangement is practically identical with that the writer is recommending to the Hull Corporation, except that it is not proposed to supply more than about four square miles without the use of transformers during the hours of heavy load.

The above remarks have for the most part referred to existing 110-volt systems, and the advantages they would derive from changing over to 220 volts. In the case of new works, not yet laid down, the advantages are much greater. It is well-known what a heavy strain on the first few years' working is the payment of interest on, and redemption of, capital; and if by its means the expenditure in mains can be reduced by one half, and at the same time a steadier and less variable light given to the farthest customers—who is there who would not favour the adoption of the 220-volt lamp?

The next point is, How will the higher pressure affect the wiring and fittings on consumers' premises? As far as present experience goes, there is nothing to fear on the score of increased fire risk. Installations designed for 100 or 110 volts pressure when changed over to 220 volts run very little, if any, extra risk. The current in the wires is reduced to about one half of what it was, and this quite balances the objection to the pressure being doubled. As a rule, it is not the insulation of the wires that is at fault in an old installation so much as the badly made joints and overloaded wires. A badly soldered joint is far less likely to cause trouble under the new conditions, as the heating would be less and the loss of voltage at the joint would be proportionately to the voltage of the lamps less also. Many of the flimsy little switches, cut-outs, and ceiling roses, too, where the insulation is fairly good, are really *safer* with 220 volts and the reduced current than they were with 110 volts. Certain little American switches which are largely in use at Hull, and which get perceptibly warm with a 32 c.p. 110-volt lamp, will keep quite cool, and work with less sparking with a 220-volt lamp of the same candle-power. In most of these little auxiliary appliances the E.M.F. has been amply provided for; but the carrying capacity of the screws, terminals, contact-plates, &c., is sadly over-estimated. In the matter of fuses, given a sufficient length of break, a fuse appears to act more suddenly and certainly at 220 volts than at 110. Single-pole fuses are certainly to be preferred to double-pole, for these latter are seldom constructed with the poles sufficiently separated to be safe from arcing when the fuses melt; also the moisture which often condenses on a porcelain base is more likely to cause serious leakage, and perhaps arcing, with 220 volts than with 110.

In wiring new premises for any considerable number of lamps at the higher voltage, a slight saving may be made in the cost of wires. Even allowing a rather better class of insulation, yet by reducing the main cables to about half the size they would otherwise be, some reduction is made in the expense. This will not apply in the case of small branch wires and the wiring of shops, &c., for two or three lights, for in these cases it is not the current density so much as the mechanical strength of the wire that determines its size. For instance, a solid wire would not be used smaller than No. 18, S.W.G., to supply an 8-c.p. lamp, though at 220 volts this only represents a current density of about 100 amperes to the square inch. The fire offices may not altogether agree with this view; but it should be evident to all that in ordinary house-wiring the danger of fire lies more in excessive currents than excessive pressure, and doubling the pressure at the lamps will certainly mean a reduced current density in the smaller wires. It is the writer's opinion that, with attention to the details of fittings, such as fuses, switches, and ceiling-roses, wiring at 220 volts will be just as cheap and rather safer than at half that pressure.

With regard to the use of arc lamps in shops, &c, some great objections can be urged against the use of 220 volts. The consumer *will* ask to be able to switch off separate lamps, and to use one or two lamps without paying for the current for four. Even now, at 110 volts, there is often trouble through a man who has one lamp only, finding that his current costs him as much as his neighbour pays for two. Until some means can be devised for reducing the pressure to, say, 50 volts without wasting energy in resistances, this will remain a difficulty, though perhaps something may be done by arranging a number of small arcs to burn in series in one globe. Still, this would be a troublesome and expensive arrangement, and the effect would not be the same as with one large arc. Of course, in street lighting from the low-pressure mains the higher pressure would be a great advantage, as it would enable as many as eight or nine lamps to be run in series across the outer wires and to be controlled by one switch, thereby reducing the labour of switching the lamps on and off. With electric motors there need not be any trouble, as these can be wound to work at 220 volts, just as well as at 110, and certainly the reduced current taken by large motors will reduce the cost of the starting resistance, &c., and will also lessen the effect on the lamps in the neighbourhood when the motors are started or stopped.

Now, as to the incandescent lamps that are as yet on the market for use at this pressure. In the first place, of course, where lamps are always used in groups of two or four, the ordinary lamps for 110 volts can be used coupled in series. Some makers have even brought out a little fitting for adapting the ordinary lamp holder to take two lamps like this, the idea being that, where a 16 c.p. lamp was in use, two 8 c.p. lamps should be fitted, and so on. This is very neat, and gets over many of the objections to 220-volt lamps; but it is hardly adapted for universal use, as the two lamps will not go into many of the glass shades, &c., in use, and many people will consider that their appearance is not nearly so æsthetic as that of the single bulb. Other makers have put the two filaments into one bulb, and coupled them together either inside the bulb or just outside the neck in the plaster cap. Several firms have, however, boldly grappled with the question, and have succeeded in making single-filament lamps having bulbs little or no larger than those commonly in use, and these seem to indicate the lamp that will shortly become commonly adopted.

As might naturally be expected, the lamps with single filaments have hardly reached the stage of durability and efficiency that the double-filament lamps have attained. For all that, most excellent results have been obtained from some individual lamps of this type, and equally poor results with samples of double-filament lamps. On this question Mr. Gibbings, the borough electrical engineer of Bradford—where double-filament lamps are mostly in use—writes as follows: "The 230-volt lamps are very much appreciated by our consumers; in fact, we are continually being pressed by those we have not changed over to do so, and we find that the life of these lamps comes out, if anything, better than the ordinary 115-volt lamps." Such favourable and positive testimony as this is rather surprising, but the secret is to be found in the steadier and more even pressure supplied, rather than in the better quality of the lamps. In either case it is most satisfactory and encouraging, and should help to convince any who doubt the possibility of a commercially good 220-volt lamp being made that, at any rate, it is quite possible to equal the 110-volt lamp.

In the lamps under the writer's own observation the average life is quite equal to that of the best makes of 110-volt lamps. With the exception of one maker's samples, the candle-power has been maintained longer, and there has been less blackening of the glass. Several lamps fail through short circuits occurring in the cap, but this fault also is absent from the lamps of several makers. Other lamps have failed through the long filament touching the glass whilst hot, and so cracking it and admitting air; and especially has this been the case when these lamps have been run in any position other than vertical.

In conclusion, the writer would express the belief that the 220-volt lamp will soon be recognised as the most useful advance that has been made in electric lighting in the past year or two. It is on the market now, is being fairly tested and found satisfactory in several towns, and it has "come to stay."

## ALTERNATING-CURRENT STATIONS AND HIGH-VOLTAGE LAMPS.*

BY H. W. COUZENS (TAUNTON).

High-voltage lamps, as known at the present time, are unquestionably the offspring of the low-tension engineer. This may at first seem strange to an outsider, and, indeed, a contradiction in terms, but it is not at all to be wondered at when we consider the limited area which can be served by a 100-volt network. Indeed, this is so extremely restricted that as soon as continuous-current

* Paper read before the Municipal Electrical Association.

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low-tension electricity works of any magnitude came into existence the three-wire system was brought out to extend the area of supply and mar the sweet simplicity of 100 volts all round. As these undertakings have grown and enlarged their borders, they have been driven to seek means to render a further increase of pressure commercially practicable, and this they have done with the aid of a 200-volt lamp. But although the alternating-current engineer is not "cribbed, cabined and confined" in this way, there are, I venture to think, cases in which high-voltage lamps may be of benefit to him, and I will endeavour in a few words to mention one or two such.

The standard practice for high-tension alternate-current work is to employ transformer sub-stations with a low-pressure distribution to consumers, but this hitherto has not been economically practicable in scattered residential districts, and distributed transformers have been the usual means of supply. With a declared pressure of 200 volts at the consumers' terminals, however, we can of course extend our mains four times as far each way, and the saving in capital outlay on the transformers will probably balance the cost of the low-tension network; and the standby losses of a number of small transformers with relatively large magnetising currents will be wiped out. In this way the 200-volt lamp should greatly aid in demonstrating the marked superiority of the alternating current for electricity supply; for by its help, in almost any class of district, the benefits of low-pressure distribution to consumers, combined with the advantages of high-tension transmission, are secured. Furthermore, this low-pressure network is small and isolated, and therefore exceedingly unlikely to give trouble from leakage.

In the second case, where sub-stations are employed, but the distribution is at 100 volts and not on the three-wire system, though such is rarely the case at present. Where it does occur, however, it is a comparatively simple matter to double the pressure at consumers' terminals, thereby diminishing the current density in the mains, and making the same main take a much larger lamp connection.

Thirdly, where the distribution from the sub-stations is on the three-wire system at present, the 200-volt lamp is still of service, and will prove to be of great value if the life of the patent is prolonged. In the case of a Local Authority more especially, side streets in the neighbourhood of the supply main can be lighted with incandescent lamps. Straggling consumers, also, at some distance from the mains, can be picked up; and there are many installations which it would not pay to connect at 100 volts, and yet would be profitable at the higher pressure.

In all instances it should be borne in mind that if by any means the cost in capital outlay be reduced (as I have endeavoured to show), the consumer is bound eventually, though indirectly, to reap the benefit. This is certain to be the case whether the undertakers be a company or the Local Authority, though more especially in the case of the latter, on account of their high standing charges.

Perchance because they are sceptical as to its good qualities, the engineers of alternating-current electricity works appear to have taken comparatively little interest in high-voltage lamps up to the present time. The best known makers of this class of lamp incidentally gave the writer to understand, a short time ago, that their customers and the inquiries they received were at present almost exclusively from direct-current supply stations. Practical experience is the only proper basis of opinion on this question, and my own has been altogether favourable. This has not been due to any special care in arranging for the higher pressure, for the lamps have been affixed and the pressure doubled without touching in any way the wires or fittings, which have been of ordinary pattern. The new M-shaped double-filament Stearn lamp gives a useful and pretty effect when alight, and the 8 c.p. lamp is also a success, though the importance of this size of lamp is, I consider, somewhat overrated at present, for it is very difficult to get the average consumer to be satisfied with anything less than 16 c.p. in these days of increased illumination.

In conclusion, whilst to direct-current low-pressure supply the 200-volt lamp gives a new lease of life, not unattended with trouble in controlling 400 volts instead of 200 (which is anticipated by the ever-vigilant Board of Trade, who are at present content with *not defining it as high-pressure*), the alternating-current engineer can reap its advantages without any additional drawbacks of like character; and the writer will not be slow to do this in the immediate future.

DISCUSSION.

Mr. R. C. JACKSON (Newcastle) thought a 100-volt lamp was in itself a more efficient article than a 200-volt lamp, and a 50-volt more efficient than a 100-volt lamp. His opinion was that the high-voltage lamps would not be anything like so economical to the user as those of more moderate voltage. The only way to fight the gas companies, and beat them, was to use smaller candle-power lamps; he did not see how they were going to get 4-c.p. or 6-c.p. lamps with a 200-volt supply. When they had determined the economy and life of lamps of various voltages, the matter of the pressure on the mains would drop into its place in proper order.

Mr. J. H. RIDER (Plymouth) said that it seemed to him that low-pressure engineers were taking upon themselves burdens which would make them purely incandescent lighting men. Because they could get more lamps upon a certain size main and so on, they were going to give up the advantages of the small consumer with his single arc lamp, and the small motor man; these simply would not go on anything but the so-called low-pressure continuous-current system. He thought the consumer should have the advantage in this matter. If engineers shut their eyes to the man who wanted one arc or two, they were not doing their duty to the customer. A customer wanted to get that which suited him, not them. If he wanted a single arc lamp or two, he was not going to be compelled to pay for four.

Mr. C. H. WORDINGHAM (Manchester) thought he ought to say something on the subject because Manchester was the pioneer of 400 volts across the outers. They had always had it there, and he might say that had it not been for Manchester he did not think that the Board of Trade would have raised the low-pressure standard. That distribution at 400 volts had two difficulties. Concerning wiring in houses, he could not speak from much experience, because very few customers, so far, had 200-volt lamps. They had been asked to supply 200-volt lamps, and, of course, they had been only too delighted to do so. With regard to the idea that they could use ordinary fittings with 200-volt lamps, he thought a few words of warning were necessary. He had made a few experiments, and had used ordinary fittings for 200-volt lamps. The results had been disastrous in every case. One point had not been touched in the Paper—the great advantages of a 400-volt system in combination with the trams.

Mr. C. H. STEARN thought there was little actual risk in the change. There might be a few accidents here and there, and a few short circuits might occur, but nothing very serious. Even at present pressures some precautions would have to be taken, and on the whole he did not think there was much danger. He absolutely disagreed with the idea that a 50-volt lamp was any more efficient than a 100-volt, or that a 200-volt lamp was no less efficient than a 100-volt lamp.

Mr. A. H. GIBBINGS (Bradford) thought the time had not come when a definite opinion should be got with regard to this high-pressure system; the remarks of the previous speakers nicely balanced each other. The arc lamp question was a difficulty, though. In Bradford, however, they had as many high-pressure arc lamps as any town in the kingdom, namely, 379, and had had no complaints. The subject of lamp efficiency might very much better be discussed in twelve months time, when more facts would be able to be brought to bear upon the subject. In Bradford the ratio of 8 c.p. lamps to 16 c.p. was as 180 to 10,490.

Mr. W. ARNOT (Glasgow) said he could not say anything from experience, because they had not touched the 200-volt lamp in Glasgow, though they had been experimenting with them; and he was perfectly sure that in a few years the 200-volt lamp would be just as much used as, if not more than, the 100-volt lamp.

Sir COURTENAY BOYLE said he thought that such discussions must certainly be of benefit to one individual, viz., the consumer, because, after all, they were all working in the interests of the consumer. He did not mean to say that the interests of the producer should be disregarded; on the contrary, they were to be carefully safeguarded, but it was to the consumer they must look for the approval of their actions. He should like to call attention to one point, and that was, could anyone suggest a name for a Board of Trade unit? He had wanted it called a "Kelvin," but Lord Kelvin had some interest in a supply meter, and did not wish his name to appear in connection with a Board of Trade unit. He said there was another point which was still more important. The Board of Trade must look to the gentlemen who were interested in localities to guide them as to the behaviour of supply meters. It was the Board of Trade who had to approve of supply meters, and up to the present they had had a difficulty in discharging that duty. They could see how they behaved in a laboratory, but they wanted to know how they behaved in actual practice.

Mr. BARNARD, in reply, said that with regard to the remarks that the opposition to the 220-volt lamp was dying away, it struck him, with three or four of the speakers, that the opposition was stronger than the support. With regard to fire risks, he said Mr. Wordingham had managed to give a fine show of broken fuses, but he had got a few of the same kind. He thought they could rely upon makers to give them fuses which, with very little alteration, would do for 200 volts.

Mr. COUZENS, in reply, said that one of the most important questions seemed to be that of efficiency raised by Mr. Jackson. He believed that Mr. Jackson was connected with a supply company, and probably had to supply lamps to customers. That was not the custom of Corporations. They left the consumers to get their own lamps, and found they preferred long-lived lamps, not highly-efficient ones; that was precisely what they would get with 200 volts.

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## ELECTRIC TRACTION: A REVIEW OF ITS APPLICATION AND A COMPARISON WITH OTHER METHODS.*

BY R. ST. GEORGE MOORE, M.INST.C.E.

A civil engineer, acting either for a corporation or in general practice, has frequently to advise on matters about which it is an absolute impossibility for him to be conversant with all the details. For instance, in the preparation of a water-works scheme he has to decide upon the type of pumping machinery to be adopted; whereas it would be unwise for him to attempt to design the machinery, knowing, as we do, that all machinery, such as marine engines, pumping engines, &c., has been brought to their present condition by the makers of the various types gradually introducing improvement upon improvement. The same case will apply to traction. It would, in the first instance, probably devolve upon the civil engineer to decide whether electrical or some other method of traction should be adopted, his knowledge of the nature of the traffic to be carried, the nature of the permanent way, the grades and curves being essential to come to a proper decision. When this decision has been arrived at, then the details ought to be put into the hands of one of those who have made the method of traction selected their speciality. The author's object, therefore, in this Paper is to consider electric traction, not from an electrical engineer's point of view, but from a civil engineer's, and to describe a few of the leading and most instructive examples, and analyse their merits or demerits. The following lines have been selected for description as illustrating the distinctive features of electric traction:—(1) The Brighton Electric Railway; (2) The Liverpool Overhead Railway; and (3) Brighton and Rottingdean Seashore Electric Tramroad.

After describing Mr. Magnus Volk's well-known little venture on the Brighton beach and the Liverpool line, the author gave the following particulars with regard to the Seashore line.

The Brighton and Rottingdean Seashore Electric Tramroad is one of the latest and most peculiar applications of electric traction. This line is situated on the foreshore entirely between high and low water, and extends from the Paston Place Groyne, within the borough of Brighton, to Rottingdean, a distance of 2 miles 7 furlongs. At high water of spring tides, at the deepest portion of the line, the car will run in 15ft. of water—that is to say, the rail-level will be 15ft. below water-level. The permanent way consists of four lines of 52lb. steel flange rails, specially rolled, with an additional width of flange and thickness of web to compensate for the corrosion which will take place and thereby equalise the life of these portions with the rail-head, the life of which it is anticipated will be considerable, owing to the comparatively small amount of traffic to which it will be subjected. The rails are laid in pairs to a gauge of 2ft. 8½in., and to a total gauge between the outer rails of 18ft. For the sleepers of ordinary railway practice are substituted concrete blocks and large cast-iron chairs, according to the nature of the ground. Between the rails and the cast-iron chairs and the concrete blocks oak cushions are fixed. Where concrete blocks are used mortises are cut so as to be at least 6in. into the solid chalk, and a box framed round it of the height required, and the block formed by filling the box with concrete. Although some portion of the line has been completed two winters, after the concrete has once had time to set no damage has been done to the blocks, either by the sea or frost. As may readily be understood, a large amount of trouble was caused by rough weather damaging the blocks in their green state. The precedent for the use of concrete sleepers was the favourable results obtained for slow traffic by the Wurtemburg States Railway prior to the general adoption in Germany of steel or iron sleepers. The cast-iron chairs are similarly fixed, with the exception that the mortises are deeper, and where the chair stands more than 2ft. out of the ground a concrete plinth is built round it. The rails and oak cushions are fastened to the concrete blocks by two bolts built into the block during construction. The ruling grade is 1 in 300, and 40 chain curves (with the exception of one very short piece of curve near the Paston Place Station) have been adopted. The stations at Paston Place and Rottingdean are small piers or jetties, constructed in iron, with a deck level with the deck of the car, or about 23ft. above rail-level.

The car is carried on 16 33in. wheels, in four bogeys, two of which occupy each line of road, and are held in position by a strong steel tube framing. On each bogey stands a main steel tube column, from which spring the arched girders supporting the deck. The level of the deck is 23ft. above rail-level, and 46ft. long by 22ft. wide; a deck house, for shelter in wet weather, 25ft. 3in. long and 12ft. 6in. wide, with a promenade deck, is provided. The car, when fully loaded, will weigh about 50 tons, and it would require a wind pressure nearly equal to three times that of a hurricane, or 134·4lb. per square foot of exposed surface, to create an equilibrium of forces; that is to say, if the inner line of rail is taken as the fulcrum and the weight of the car as acting vertically through its centre of gravity, we get $9 \times 60 \times 2{,}240$ units of resistance, taking the centre of pressure at 25·0 above rail, the area exposed 300 sq. ft., and $x$ the pounds per square foot, we get $x \times 25 \times 300 = 9 \times 50 \times 2{,}240 : x = 134{\cdot}4$. This force would only produce an equilibrium; the force therefore required to lift the car round the inner rail as a turning centre and turn it over, would, of course, be very much larger. The margin of stability of the car from overturning from an impediment in the permanent way is very great.

The electrical generating station is at Rottingdean, and the current is conveyed to the car by an overhead copper wire and trolley pole. The motors are placed on the main deck of the car, and are connected with the driving wheels by shafting down two of the steel tube legs and bevel gearing. On the rear bogeys powerful hand-brakes are fixed. The prime mover is one of Sisson's compound high-speed surface condensing engines, indicating 110 H.P., driving a direct coupled dynamo. The two motors have an effective brake horse-power of 30 each, and it is anticipated that they will drive the car at six miles per hour.

The cable tramways and electrical tramways have one very distinctive feature in common, namely, the central generating station, the difference being the form in which the power is transmitted from the prime mover to the car. The two points, therefore, to be considered are the prime cost of the road and efficiency of the transmitter. The cost of the installation of a cable road is very much greater than that for an electrical trolley line, as may readily be understood when a comparison is made between the cost of the pole and wire and the underground conduit furnished with cable and sheaves, even after allowing for the cost of dynamos and motors. The efficiency is also less, that is to say, that with a given horse-power at the generating station, the effective horse-power available in the axle would, with the cable system, be just half that with an electrical system. Further, the electrical system is capable of far greater extension without additional generating stations than the cable system, as the length of a cable is limited, and that of an electric system (by the introduction of transformer stations) is, within reason, practically unlimited.

### DISCUSSION.

Mr. LOBLEY (Hanley) said he could corroborate Mr. Moore Speaking of the comparison between the conduit and the overhead-trolley system, he could quite corroborate the opinion that the poles and wires ceased to be an objection after a very short acquaintance. He went over to America in 1891, and he was certainly prejudiced against the trolley-wire system, but he had not been in Boston 24 hours before he ceased to notice them at all as an objection to be considered against the overwhelming advantages of the system. He admitted they were ugly at the curve where a great number of cross wires were necessary to hold up the trolley cable, but that had been improved, and the unsightliness been gradually removed. With regard to the conduit system he dared say a great many members had seen it at Blackpool, where it had been in operation for many years. He had been frequently on that line, but only on one occasion had he been able to get to the end of the line, owing to the conduit being choked up with sand. In the winter the mud and snow would act in the same way. With regard to the overhead system there was no doubt an appreciable danger from falling wires, and he did not at present see any method of overcoming that danger. Two years ago a good many members saw the system at Brussels, and he had since seen it at Havre. In the latter place where a telephone wire passed over the trolley wire it was insulated. Of course the car had then to depend upon the momentum acquired to carry it over the insulated part of the wire, but they did not find in practice any difficulty about that. The other day the members had an experience in Hanley of what he believed was the steepest gradient for a steam tramcar in England—1 in 13½. Whether it was the weight of the members or not he could not say, but they had to get off the car before it could get to the top of the hill. But there was a long difference between that and 1 in 7, mentioned by Mr. Moore.

Mr. J. T. EAYRS (West Bromwich) said little or no mention was made of cable traction, which was a popular form and one which was not going into obscurity in favour of overhead electric traction. The conduit system was being pushed forward, but up to the present they had had no Paper read at their meetings respecting that system. There was no regular line in operation in this country, except a short trial line, which any of the members could see working. He should like to say with regard to the remark in the papers that the electric poles were made in America, that he was astounded and surprised to find that statement. He thought it a great reflection upon English manufacturers, that they could not supply the poles to be used in this country. He might say there was a manufacturer in his own town who was commencing to make these poles on the American system. There was no difficulty in the construction, and it was surprising there had not been sufficient enterprise hitherto to manufacture these poles in England. The drop test, which was used in America, was a very simple one and caused no difficulty whatever.

Mr. COLLINS (Norwich) said he should like to ask Mr. Moore whether he could express any opinion as to the capability of the Westinghouse system.

Mr. YABBICOM (Bristol) said that as reference had been made to the line at Bristol he might refer to what had been done there, because the line had been open for several months and in successful work. There was

* Abstract of a Paper read before the Incorporated Association of Municipal and County Engineers, at Brighton, June 25th and 26th.

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a considerable amount of opposition on the part of the Council to the adoption of the overhead system, and the Council took the precaution of going to other places before they allowed it to be adopted in Bristol. The result of these visits was they gave consent for the system to be tried on a trial length. That had been working so satisfactorily that the Council had given permission to the company to extend it. The statement that the poles could be made ornamental rather than an eyesore he thought must be taken with a grain of salt; but against any ugliness on the part of the poles must be considered the convenience and the smoothness with which the line was run. The system started in Bristol with a street 80ft. or 90ft. wide, where the double bracket was used, and an arc lamp was placed on the top, the whole occupying no more space than the arc lamp formerly did. In narrow streets the single bracket was used, the arm being of variable length according to the distance from the footpath. Therefore it was impossible to say they did not to a certain extent incommode the public; but the advantage of the system had been so great that the public had asked, and almost demanded the extension which had been granted. Some time ago a deputation from Newcastle visited Bristol. They were brought to bless it, but they cursed it, and said they would not have it at any price in Newcastle, but he attributed that to the fact they were only there for a day and had not time to get accustomed to the poles.

Mr. LEWIS (St. George's, Bristol), said he could support the statement of Mr. Yabbicom as to the success of the electric trolley system in Bristol. Three-fourths of the line was in his district, running on gradients of one in thirteen, and he could promise Mr. Lobley when he came there that he would not have to get down and walk up hill. The public had taken up the system with very great spirit, and an extension of a mile and a half was about to be made in his district and in the city.

Mr. SILCOCK (King's Lynn) said that the effective horse-power available with the cable system was stated by Mr. Moore to be just half that with the electrical system. He should like to know how Mr. Moore arrived at that calculation. Everything depended upon the traffic, and it required something like a minute and a-half service each way to make a cable come in for price at all. The cable had one decided advantage—that there were no poles or wires, or sparking, which occurred with certain conditions of the atmosphere. Then there was no humming or buzzing from the motors, and no danger from falling wires. Then, again, when there was any very heavy traffic to deal with on the cable system extra cars could be put on without further expense. The overhead system had the advantage of no central slot, and two rails instead of three, and cars could be run at different speeds, according to the district. These points were very strongly in favour of the overhead electric, and the probabilities were that it would be largely developed in the near future. A system that was good enough for the Boulevards in Brussels was good enough for the manufacturing towns in England.

Mr. BARBER (Islington) asked with reference to the calculation as to the stability of the car, whether the centre of pressure which was referred to as 25ft. above the rail level was taken from the perspective drawings which he saw before him. If so, the platform or deck was only 23ft. above the rail level, and with the shelter 10ft. or 12ft. high it seemed to him that the centre of pressure should be more than 25ft. If this was so, it would materially alter the calculations. Then, as to the weight—loaded—50 tons he wished to ask whether that was with a portion submerged. They were told that 15ft. would be submerged at times, and that would reduce the weight. The wash of the waves, together with the force of a hurricane, might produce oscillation, and when once oscillation had been started they would require to allow a large margin of safety in order to prevent a catastrophe.

Mr. MOORE, in reply to the points raised in the discussion, said that Mr. Lobley had called attention to the grade of one in seven. He believed his authority for making that statement was reliable, but he begged also to state that he did not recommend that electric tramroads should be laid on grades of one in seven. Mr. Lobley also objected to the title of the Brighton and Rottingdean Tramway. When the Bill was deposited in Parliament it was called a railway, as it undoubtedly was a railway. But they were met with this difficulty. If a railway, then it must be fenced according, to the Railway Department of the Board of Trade; on the other hand, the Harbour Department of the Board of Trade said, under any circumstances they must not fence it in. The consequence was they had to amend it and substitute the word "tramroad." With regard to the Westinghouse system, it had not been adopted to any great extent. Mr. Barber referred to the calculation of stability. The calculation—which was taken pure and simple as an example for the Paper—was for the cars standing and in the dry.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June 26, 1896.*

**An Important Telephone Organisation.**—Telephone circles were stirred last Friday by the announcement of the incorporation at Albany, the capital of this State, of a new telephone company of large proportions. The name of the new concern is the New York Telephone Company, and it has a capital stock of $16,000,000. According to the incorporation papers the object of the new Organisation is to construct, buy or lease lines of electric telegraph and telephone to be operated in New York City and thence to Albany and Boston and the intermediate cities, towns and places in the east, covering the territory from Boston to Philadelphia and including Long Island. The incorporators of this Company are men of prominence in telegraph and telephone circles, and include Thomas T. Eckert, general manager of the Western Union Telegraph Company, John Van Horne, vice-president of the same Company, and James Merrihew and Charles A. Tinker, superintendents of the same; George J. Gould; John E. Hudson, president of the American Bell Telephone Company of Boston, and William Forbes of the same Company. Efforts to ascertain the objects of the Organisation failed to elicit anything definite from those interested, but it is generally understood that the Metropolitan Telephone and Telegraph Company and the New York and New Jersey Telephone Company are to be consolidated, and the business conducted by the new Company. At first the Organisation was looked upon as a possible rival to the American Bell Telephone Company; but from the fact that Mr. Hudson, who is president of the latter company, and Mr. Forbes, another prominent officer, are named among the incorporators, it became at once evident that this could not be the case. In fact this was denied positively by Mr. George Gould himself. The new Company will hold a meeting this week for the purpose of electing officers, when it is stated some public announcement of the intent of the Company will be made.

**Convention of Street Railway Officials.**—On Thursday and Friday of last week, the street lighting officials of various cities in the east met in convention in New Haven, Conn., in response to a call issued by the Lamp Committee of the New Haven City Government, for the purpose of discussing practical and difficult problems in their particular work. Several papers were read, including one on "General Street Lighting," by Hon. Walton Clark of Philadelphia; "Municipal Ownership of Gas and Electric Plants," by Hon. T. B. Perse of Hartford, Conn.; and one on "Welsbach Street Lighting," by F. P. Merrill, manager of the Welsbach Street Lighting Company of America. The sense of the meeting was evidently against the municipal control idea. A permanent organisation was effected, and the next annual meeting will be held at a time and place to be named by the Executive Committee.

## CORRESPONDENCE.

### PUBLIC LIGHTING BY ARC LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been called to a statement in the excellent series of articles on "Public Lighting by Arc Lamps," by André Blondel, translated for *The Electrician*. As the experiments by Messrs. Reidhead and Guthrie, referred to in *The Electrician*, Vol. XXXVI., p. 821, April 17, 1896, were conducted in the electrical engineering laboratories of the University of Minnesota under my supervision, I may be pardoned for defending what M. Blondel characterises as "certainly an error."

The globes used in these experiments were of a pattern quite common in America, having the upper opening considerably wider than that indicated in Fig. 32 on page 821. Part of the curve above the horizontal axis therefore represents light that did not pass through the globe. Such light was not only not diminished by passing through the glass, but was considerably augmented by reflection from the lower part of the globe. This peculiarity was noted and explained in the original paper reporting the experiments, but later notices have overlooked it.

Common experience vindicates the substantial accuracy of these curves, especially Curve IV., upon which doubt was cast. When a room is lighted by arcs with opal globes open at the top, the ceiling directly above each lamp shows an annular zone that is lighted much more strongly than the space beyond, indicating plainly the line where the globe ceases to intervene. Where the globe completely encloses the arc or is surmounted by a tight case, this strengthening of the upward light is of course not manifest.

Hoping that this may be of some interest, I am, yours, &c.,

GEO. D. SHEPARDSON.

The University of Minnesota, Minneapolis,
June 23, 1896.

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TO THE EDITOR OF THE ELECTRICIAN.

SIR: Thanks to your kindness, I have read the interesting observation of Prof. G. D. Shepardson, and regret to have cast accidentally an undeserved doubt upon Curve IV., since it is warranted accurate. The large opening of the globe explains perfectly well the upper maximum of the curve, but I am still puzzled by the maximum in the horizontal plane.—Yours, &c., A. BLONDEL.

## THE NEGATIVE RESISTANCE OF THE ARC.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: When it was first heard of, the negative resistance of the arc was generally supposed to be a joke, and the fun of it was appreciated fully. But the recent discussion before the Physical Society showed that it was not a joke, and that, unlike "aruspices" in ancient Rome, modern worshippers of "Negativity" are really in earnest. Since they do not find any absurdity in the idea of a negative resistance, even after Prof. S. P. Thompson's masterly demonstration, we must be prepared for the worst, and expect to be shown next a body with a negative mass and a light with a negative candle-power. Before this time comes I may be allowed to remark that I had already considered the "instable $d\,V/d\,A$" as an explanation of the condition of stability of the arc, in the manner proposed by Messrs. Frith and Rodgers (*La Lumière Electrique*, December 26, 1891, p. 620), and described in *The Electrician* (December 8, 1893, p. 146), the temporary rise of brilliancy (which necessarily implies a corresponding rise of tension), caused by a sudden diminution of the resistance of the circuit, a phenomenon which, according to the letter published in last week's issue, has been more fully investigated by Mrs. Ayrton in her beautiful researches.

But all these facts have, in my opinion, no bearing on the value of the true resistance of the arc, and do not give any indication about its sign, as the authors believe. To show this clearly, I have only to take again a mode of reasoning already suggested by Prof. S. P. Thompson, and to complete it, in order to account for the distinction between stable and unstable $d\,V/d\,A$.

Let us consider the experiment of Messrs. Frith and Rodgers, and call V the difference of potential between the carbons, E the E.M.F. lost at the surface of the carbons (called, wrongly, I think, "back" E.M.F.), R the resistance of the arc, C the continuous current, A the alternating current. The equation of the arc with the two currents is, adopting the notation of the authors,

$$V = E + R\,(C + A),$$

where C is a constant, R and A variables. We get by differentiating,

$$d\,V = d\,E + R\,d\,A + A\,d\,R.$$

E is accepted as a constant by the authors, and is most probably so, since it represents the work expended in the volatilisation of carbon. Hence the following relation remains:—

$$\frac{d\,V}{d\,A} = R + A\frac{d\,R}{d\,A}.$$

The authors forgot the existence of the last term when dealing with the variable resistance of the arc as with a constant resistance, and wrote $R = d\,V/d\,A$. But in reality this relation is *not* the true resistance of the arc, and consequently all their conclusions are void. That the arc may be cooler than the crater does not prove, moreover, anything in favour of negative resistance, but only shows a loss by radiation. I hope that, when they reconsider the whole matter, the authors will admit that their negative resistance was only the result of a mistake in definition, and will be satisfied with our gratitude for the interesting experiments they brought before the electrical public.—Yours, &c.,

Paris, July 7, 1896. ANDRÉ BLONDEL.

**WIENER ELEKTRICITÄTS GESELLSCHAFT.**—At the recent annual meeting of the shareholders of this Company a dividend at the rate of 5 per cent. for the past year was declared. It was also decided to increase the capital of the Company from £192,750 to £289,125, and to increase the number of shares by making the existing £24. 5s. shares into £19 shares. It was further decided to make a reduction in the price of electric current, this reduction to take effect from May 1st last.

# LEGAL INTELLIGENCE.

### Medhurst v. Kyffin.

The hearing of this case (which was fully reported in our last issue) was resumed and concluded on Friday last week, before Mr. Justice Kennedy and a Special Jury. The case was adjourned on Thursday, after counsel for the parties had reviewed the evidence.

Mr. JUSTICE KENNEDY, in the course of a lengthy summing-up, held that the occasions when the defendant spoke the words complained of were privileged, and that being so, the plaintiff, to maintain his action, must show that the defendant in making the statement was actuated by express malice towards him, as proof of such a state of things would deprive the defendant of his shield of privilege. They would, therefore, find for the defendant unless they thought that the plaintiff had made out that there was express malice.

The JURY, after considering the matter for 25 minutes, found a verdict for the plaintiff, assessing the damages at £400.

The announcement of the verdict was received with applause.

His LORDSHIP gave judgment in accordance with the finding.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the atest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied. price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

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TENDERS INVITED.—The Vestry of St. Mary, Battersea, invite tenders for the supply and erection of boiler house plant, engine house plant, switchboard and connections, accumulators, wiring and fittings, &c., for electrically lighting the municipal buildings and Town Hall. Tenders to Mr. W. Marcus Wilkins, Vestry clerk, Municipal-buildings, Lavender-hill, S.W., by noon, 14th inst.

——— The Commissioners for the Control of Lunatic Asylums (Dublin) require tenders for the supply and erection of an electric light installation at the Armagh District Lunatic Asylum. Tenders must be sent in to the Secretary, Board of Control, Custom House, Dublin, by 10 a.m. of August 3rd. Further particulars are given in our advertisement columns.

——— The Municipal Council of Mexico invite tenders for an electric light installation capable of supplying current to 600 arcs and 150 incandescents. The illuminating power of the arc lamps must be between 1,200 and 2,000 c.p., and of the incandescents 50 c.p. Contractors may tender for a high or low-tension supply system, but plans of the electrical plant and apparatus, lamp pillars, &c., must be submitted to the Council. Tenders must be accompanied with a deposit of £1,000, and be sent in to Señor D. Juan Bribiesca, Secretary, City Council, Mexico, by August 31st. A pamphlet containing further particulars can be seen at the Commercial Department of the Foreign Office, between 11 and 6.

——— The Crewe Corporation invite schemes and tenders for (*a*) the erection of a refuse furnace and boiler upon land adjoining the site of the Isolation Hospital, (*b*) for the supply and erection of an engine and dynamo, laying of electric light mains, and erecting a complete electric lighting installation in the hospital buildings, and (*c*) for the supply of accumulators. Tenders to the Town Clerk, Town Hall, Crewe, by Tuesday next.

——— The Prussian State Railway authorities invite tenders for 21½ tons of telegraph wire. Tenders to the Königliche Eisenbahn Direktion, Altona, by the 21st inst.

——— The Danish State Railway authorities at Aarhus require tenders for 20,000 rolls of telegraph paper. Tenders by the 13th inst.

——— The Cheltenham Town Council require tenders for extending their electricity supply station building. Tenders to the Town Clerk by the 24th inst.

TENDERS ACCEPTED.—The Highways Committee of the Leeds City Council recommend the acceptance of the tender of Messrs. Siemens Bros. and Co. for the supply of trolley wires and attachments in connection with the Leeds electric tramway scheme. This tender is the next lowest to that submitted by Messrs. Crompton and Co. and subsequently withdrawn.

——— The Rochdale Town Council have accepted the tender of Messrs. Fletcher, Hirst and Co., of Burnley, for supplying the electric lighting plant required at the Rochdale Free Public Library.

——— The Colchester Town Council have accepted the tender of Messrs. Christy Bros., of Chelmsford, for wiring and fitting up the new science school for the electric light, at £148. 17s. The contract for supplying the laboratories with technical fittings has been let to Messrs. Illingworth, Ingham and Co., at £297. 10s.

——— In addition to the contract for wiring the George A. Clark Town Hall, Paisley, for £844, the Brush Company have secured an order for the supply of an engine for the installation at £565.

BUSINESS FOR SALE.—Our advertisement columns contain particulars of an electrical engineering business in the north of England for sale. Further particulars may be obtained from Mr. David White, solicitor, 105, Bath-street, Glasgow.

DISPOSAL OF WORKS.—Messrs. Percy Huddleston and Co. inform us that they have, on behalf of the liquidators, privately disposed of the lease of the premises of the Acme and Immisch Electric Works at Ferdinand-street, Chalk Farm.

APPOINTMENTS VACANT.—The Telegraph Department of the Gold Coast Government require a Deputy Superintendent to take charge of the department during the absence of the Director of Telegraphs. The salary is £400 a year, rising to £450 by annual increments of £10. Free quarters are granted, and passage money. The appointment is, we believe, confined to members of the British Telegraph service, who have to send in applications by the 23rd inst. through their superior officers.

——— A mathematical lecturer, qualified to assist in the Physical and Electrical Engineering Departments, is required for the Royal Technical Institute, Salford. Applications to the Town Clerk, Salford, by the 11th inst.

TURBINE INSTALLATION.—We are informed by Mr. Frederic Nell that the Stilwell-Bierce and Smith-Vaile Company have secured the largest contract ever given for a turbine installation, comprising the development of the water-power on the Richelieu river, which forms the outlet of Lake Champlain, U.S.A., amounting to about 21,000 H.P., which is to be transmitted electrically into Montreal, some nine miles distant, where it will be sold for light and power purposes. The contract price for the installation is £124,000. This contract is in addition to the Lachine Rapids installation, to which we briefly referred in a recent issue.

PARTNERSHIP DISSOLVED.—Messrs. William Kilburn and William Sykes, engineers and electricians, of Bishop Auckland, have dissolved partnership.

LIQUIDATIONS.—The first meeting of creditors and the meeting of contributories of Leete, Edwards and Norman, Limited (in liquidation), engineers and electricians, 366 and 368, Euston-road, London, N.W., take place on the 10th inst., at the Bankruptcy Court, Carey-street, W.C.

——— A meeting will be held at Messrs. Sharp, Parsons and Co.'s, 130, Colmore-row, Birmingham, on August 6th, to receive an account of the winding up of Wells, Gallimore and Taylor (Limited), electric bell manufacturers.

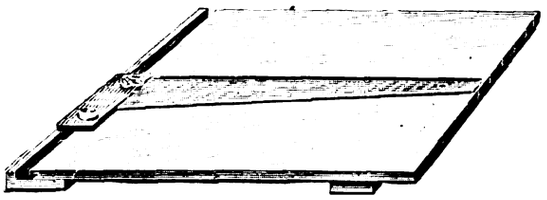
BANKRUPTCIES.—Claims in the failure of Charles Gordon Stewart, electrician, of Edinburgh, must be sent in to the trustee, Mr. R. A. Craig, C.A., Edinburgh, by August 10th. Meeting of creditors at the Court House, Edinburgh, on September 1st.

——— Claims against the estate of A. Whitelaw & Son, electrical engineers and machinists, 16, Sciennes, Edinburgh, must reach Mr. A. L. Kennaway, 122, George-street, or Mr. P. Ronnaldson, C.A., 3A, North St. David-street, Edinburgh, by the 13th inst.

——— At the Bankruptcy Court, Carey-street, W.C., Mr. B. B. Wake, late a partner in Wake & Sanders, mica merchants, &c., 3, Crosby-square, E.C., recently made an application for his discharge. The failure was attributed to liabilities in connection with the Shipowners' Syndicate with which Mr. Wake had been associated. The only offence reported was insufficiency of assets; but Mr. Registrar Gifford held that under the circumstances the bankrupt could not justly be held responsible for that, and granted him an immediate order of discharge.

GÜLCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED) IN LIQUIDATION.—A general meeting of this Company is to be held at 73, Lombard-street, E.C., on Wednesday next at noon, to receive from the liquidator (Mr. C. Fitch Kemp) particulars of the manner in which the winding up has been conducted and the property of the Company disposed of and other business. The statement of receipts and payments issued with the notice shows the manner of the disbursement of £22,781 received from sales of stock and plant, book debts, loans, &c.

IMPROVED COMBINED DRAWING BOARD AND TEE-SQUARE.—The accompanying illustration shows the Stanley-Howard form of drawing board and tee square. It is claimed to greatly facilitate the operations of mechanical or geometrical drawing. The board is made with one end ledge rabbeted over the working edge. This ledge is of hard wood, and carries a groove in which the lower stock of the tee square works. The tee square is made with the stock upon the upper surface of the blade, and extends to the drawing edge only; a second stock of the ordinary form is placed underneath this, and affixed by a centre, so that it may move within



certain limits to set the blade to an angle and clamp in position. Through the centre attaching the two stocks a bolt passes, and affixed to this at its upper end is a lever, and at the lower end a cam. The lower stock runs perfectly free in the groove, and the cam is placed so that the tee square may be used in every way as an ordinary tee square, but by a slight turn of the lever the cam is made to come in contact with the side of the groove farthest from the working edge, thus forcing the stock hard up to the working edge and locking the tee square in position in any part desired. This contrivance is made by the well-known firm of Stanley, of Great Turnstile, London.

THE SILVERTOWN COMPANY.—At the meeting of the shareholders of this Company, on Tuesday, which is reported elsewhere, the alterations in the Articles of Association necessitated by the qualified certificate given with the previous half-year's accounts by the auditor of the Company (a member of the firm of Turquand, Young, Weise, Bishop and Clarke), were discussed, after the interim dividend of 2½ per cent. had been approved. By the proposed alterations in the articles, the Directors are bound to lay before the shareholders a profit and loss account, and a balance sheet containing a summary of the property and liabilities of the Company, which is to be accompanied by a report of the Directors as to the state and condition of the Company. After discussing the matter

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for some time, several prominent members were of opinion that the shareholders had not had sufficient time or opportunity for considering the proposed alterations; and it was therefore decided, on the motion of a shareholder, that the customary method of issuing the old articles side by side with the proposed modifications should be adopted. The shareholders will again meet on the 21st inst. to discuss the matter.

ENGLISH CARBONS.—The English Electric Carbon Company of Brymbo have discovered that they can undertake the manufacture of materials in which graphite and other forms of pure carbon enter; and, therefore, are utilising their extensive plant and machinery for the production of plumbago crucibles, moulders' blackings and similar requisites of the foundry. These are to be manufactured in addition to the Phœbus arc light carbons, which are well known in the market.

TELEPHONE DIRECTORY.—The National Telephone Company has many detractors, and, of course, there are a great many who could—or think they could—conduct the business of the Company very much better than the existing group of officials. We ourselves, who are acquainted with the difficulties which so intricate a system presents, have sometimes felt that there were some things which the Company might unquestionably improve upon. Certainly, one of these was the preparation and publication of a telephone directory embracing the whole of the subscribers to the Company's system. We therefore welcome the bulky volume which the Company have just issued, and which represents an immense amount of clerical work admirably performed. It is not necessary here to point out how very important it is that such a directory should be extremely accurate; but we can say that, so far as we have consulted the new book, it is, in addition to being well arranged and easily referred to, accurate to a degree. Seeing the short time which the printers, Messrs. McCorquodale and Co., have had for completing the work, a share of the merit of the production is due to them. In all the directory contains about 1,380 pages, the entries giving the exchange to which the subscriber belongs, his number, name, trade or profession and address. The Company have decided that the service will be improved if the caller gives the exchange to which the required number belongs, and have accordingly added this to previous particulars given in these lists. What sort of job the little boys who are too frequently entrusted with the calling up of numbers will make of this additional duty remains to be seen, but it will, we fear, lead to a good deal of "language"—spoken and suppressed. Now that the circuit of trunk line telephones is extended to nearly all the principal towns in the kingdom, this book will doubtless prove one of the most important works of reference published in this country. We would suggest to the Company that in future issues sections of the work on coloured paper would prove useful. This refers especially to the list of public call offices, the whole of which could be grouped into one section without destroying the usefulness of the order in which the book is at present arranged. The binding of the directory leaves something to be desired. It scarcely does justice to so important a work of reference. These comparatively unimportant modifications will do much to popularise the directory, and doubtless to add considerably to the Company's subscribers' list.

PRICE LIST.—We have received from Mr. A. Cort, of Camberwell New-road, a new price list of red, grey, or black hard or flexible fibre in sheets, tubes, rods, &c. Mr. Cort claims for his hard or flexible fibre many advantages over other substances used for valves for air and circulating pumps and other purposes.

ELECTRICAL SUPPLIES CATALOGUE.—Mr. F. C. Allsop, of 97, Queen Victoria street, London, has issued a new and attractive catalogue of electrical apparatus, including bells, telephones, and electric light accessories. The list contains particulars relating to a large number of articles, which is grouped in a handy form, so that the requisite information can be seen at a glance. An excellent feature is the printing of the matter and illustrations upon one side of the paper only. It frequently happens that in consulting a trade catalogue it is useful to make notes and memoranda on the pages facing the particular piece of apparatus required.

"GIVEN AWAY WITH A ——."—The author of a book on "Acetylene" has adopted the novel practice of giving away a sample box of calcium carbide with each copy of his book. The author is M. J. Reyval, an electrical engineer in Paris.

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BANGOR.—An unsuccessful attempt was made at Wednesday's meeting of the City Council to rescind the previous resolutions of the Council, authorising an application to be made for a Provisional Electric Lighting Order.

BATH.—The Urban Sanitary Authority have come to an amicable agreement with the City of Bath Electric Lighting and Engineering Company as to the acquisition of the electric light works, the only outstanding point being the date of the actual transfer. The Company have suggested January 1st next, but the Council are anxious to obtain possession of the works before that date.

BELFAST.—The Judicial Committee of the Privy Council have granted the application of the Belfast Street Tramway Company to double certain of their lines outside the borough. For the applicants it was stated that a double line was necessary in order to enable them to introduce the overhead system of electric traction. The present application did not, however, touch the Belfast Corporation (who opposed the application) or the tramways within the City of Belfast.——The Electric Light Committee are in treaty for the acquisition of the quay between the Albert Bridge and the boat-house on the Laganbank-road, to serve as a site for the proposed new electricity works. The electrical engineer has been instructed to arrange for the charging of small batteries, a number of which are now in daily use, at a reduced rate.

BLACKPOOL.—The Local Government Board has sanctioned the borrowing of £30,000 by the Town Council for electric light extension purposes.

BOSTON.—The Paving and Lighting Committee are inquiring into the advisability of erecting an electricity supply station.

BOYLE (IRELAND).—Messrs. J. A. S. and Hugh Stewart have notified the Guardians of their intention to apply for a Provisional Order for this district. A company is to be formed for the purpose of supplying current for lighting and motive power purposes. It has been decided to utilise the water-power of the river Garva.

BRIGHTON.—Sanction for the borrowing of £35,200 for electric light purposes has been granted to the Town Council by the Local Government Board.

BRISTOL.—A new scale of charges for the supply of electric current for motive power purposes is being drawn up by the Motive Power Sub-Committee.

BURY (LANCS.).—The Town Council have fixed the price of electric current at 6d. per unit for lighting and 3d. for motive power purposes.

CHAMOUNIX.—It is stated that the Municipal Council of Chamounix, in the Mont Blanc district, has voted a sum of 100,000fr. for the purpose of introducing the electric light, which is to be ready by the summer of 1897.

CHELTENHAM.—A scheme for the construction of a tramway between Cheltenham and Cleeve Hill, a distance of three miles, has been discussed by the Town Council. The promoters propose to employ electricity as the motive power to equip the line on the overhead trolley system. It is intended to take current from the Municipal works. The arrangement of the details has been left to the Streets Committee.

CHURCH LIGHTING.—Messrs. J. Lomax Kendal and Co., of Manchester, inform us that they have secured the contract for lighting the church of St. Ann and St. Mary, Manchester, by electricity, current being taken from the Corporation mains. This is the first church to be lighted by electricity in Manchester.

COLCHESTER.—The Town Council have approved the plans for the electricity station buildings.

CORK.—The draft Order in Council sanctioning the construction of a system of tramways on the overhead electric system in this city by the Cork Electric Tramways Company has been approved by the City Council, subject to any final amendments that may be suggested by the Public Works Committee, to whom the matter has been referred.

COUNTRY HOUSE LIGHTING.—To the specification of Mr. H. C. Crews, consulting engineer, of Manchester, Messrs. J. Lomax Kendal and Co. are installing the electric light at the residence of Mr. J. H. White, Disley, an oil-engine plant, with accumulators, being used.

DARWEN.—The Electric Lighting Committee recommend the Town Council to appoint Mr. E. M. Lacey consulting engineer for the purpose of preparing a report as to the probable cost of establishing electricity supply works.

DOUGLAS (ISLE OF MAN).—The electric tramway between Douglas Head and Port Soderick will, it is expected, be formally opened to-morrow (Saturday).

EARL'S COURT EXHIBITION.—An addition to the many and popular attractions at the Empire of India Exhibition at Earl's Court, London, has just been made in the form of a miniature Eiffel Tower, 150ft. high. Above the top platform of the tower is fixed a large electric lighthouse light, the tower being itself illuminated by electric lamps on the various platforms, which are furnished with refreshment buffets, all similarly lighted.

EXETER.—The Electric Lighting Committee are going to work in a businesslike fashion. They have offered to supply current for lighting the local hospital at 6d. per unit, with a discount of 25 per cent. if an all-night supply is taken, and have also offered the postal authorities special terms for lighting the post office. The Committee have decided to obtain a 300 I.H.P. boiler, feed pump, steam alternator, and other apparatus, to be purchased at a cost of about £2,100, and various extensions of the mains are to be carried out

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at an expenditure of £1,325. These proposals have been endorsed by the City Council, who are anxious to put their electrical undertaking in a good financial position.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from July 1st to July 7th, with the ports of destination :—

*Argentina*—Buenos Ayres, £500. *Australasia*—Auckland, £50 ; King George's Sound, £38 ; Launceston, £749 ; Melbourne, £720 (including £568 telegraph material) ; Sydney, £922 ; Wellington, £99. *Belgium*—Brussels, £972 ; Ostend, £52. *Canada*—St. John (N.B.), £15. *Ceylon*—Colombo, £26. *Chili*—Loca, £241 (telegraph materials). *China*—Shanghai, £51 ; Tientsin, £48. *Denmark*—Copenhagen, £24 (telegraph material). *Egypt*—Suakim, £14 (telegraph material). *France*—Boulogne, £41. *Germany*—Bremen, £39. *Gibraltar*, £49 (telegraph material). *Holland*—Amsterdam, £138 ; Flushing, £71 ; Rotterdam, £421. *Hong Kong*, £19 (telephone stores). *India*—Bombay, £283 ; Calcutta, £60. *Japan*—Yokohama, £152. *Peru*—Callao, £700 (submarine cable). *South Africa*—Cape Town, £9,912 (including £9,482 telegraph material) ; Durban, £24 ; East London, £2,142 ; Port Elizabeth, £144. *Spain*—Barcelona, £33 (telegraph cable) ; Bilbao, £20 ; Pasages, £1,775 ; Santander, £6. *Straits Settlements*—Penang, £280 (telegraph material) ; Singapore, £414 (including £365 telegraph material). *Sweden*—Gothenburg, £851 (telegraph material). *United States*—Boston, £61 ; New York, £41. *Uruguay*—Paysanda, £800 (telegraph apparatus). *West Indies*—St. Lucia, £25.

*Foreign made electrical apparatus and material.*—Foreign manufactured electrical goods have been exported as follows :—

*Australasia*—Brisbane, £279. *China*—Shanghai, £51 (telegraph accessories). *Japan*—Yokohama, £192 (electrical instruments).

FOLKESTONE.—Dr. Hopkinson's fee of 100 guineas for reporting to the Folkestone Corporation on electric lighting matters has proved too big a pill for that body to swallow. The Mayor has come to the opinion that the Corporation do not require an expert at all, but can leave the matter in the Board of Trade's hands. The citizens of Folkestone are no nearer the electric light than they were when Mr. Baker made his proposal to light the town and district electrically for £16,000.

GARSTON.—Mr. F. H. Medhurst has been appointed by the District Council to prepare a report upon the advisability of establishing electricity supply works, either alone or in conjunction with a refuse destructor station.

HELENSBURGH.—Some time ago Mr. H. A. Mavor prepared a report on the electric lighting question for the Lighting Committee, in which it was stated that without the expenditure of a considerable sum for private lighting purposes, the public lighting could not be entered upon with any reasonable prospect of financial success. The Committee therefore recommended the Police Commissioners not to proceed further in the matter, and this view has now been acquiesced in by the Commission.

ISLINGTON (LONDON).—The County of London and Brush Provincial Co. have notified the Vestry of their intention to apply for a Provisional Order for the district. The Company, who have laid electric light mains in some of the streets in the neighbouring parishes of St. Luke's and Clerkenwell, wish to pass their mains through a portion of the Islington district, in order to connect the two areas where mains have already been laid. The matter is being considered by the Electric Lighting Committee.

KINGSTON (JAMAICA).—At a recent meeting of the Kingston Municipal Council a letter was read from the local Electric Light Company offering to light the city, suburbs and lanes, by means of 80 arc and 300 incandescents, for £2,500 per annum. It is more than likely the Council, who are at present paying £3,003 a year for inferior gas lighting, will accept this offer. A special meeting has been called to deliberate upon the matter.

LEEDS.—The British Thomson-Houston Company have given the City Council a month's notice of their intention to remove their electrical plant and rolling stock from Roundhay-road. The Council are making arrangements to take over and work the undertaking themselves.

LEWISHAM (LONDON).—A notice from the Blackheath and Greenwich District Electric Light Company of intention to apply for electric lighting powers for Lewisham has been received by the District Board of Works.

MANCHESTER.—Mr. Rienzi Walton held a Local Government Board inquiry on the 2nd inst. into the application of the Town Council to borrow £100,000 for electric light extension purposes. In support of the application Alderman Higginbottom, Chairman of the Electric Lighting Sub-Committee, gave figures showing the remarkable demand for electric current in this city. The electricity works were established in 1893, and were designed by Dr. Hopkinson, the system of distribution being the five-wire direct current. All the later extensions had, however, been carried out by the resident engineer, Mr. C. H. Wordingham. The whole of the £250,000 already borrowed had been expended ; but the demand for current had been so great, and was continuing to increase at such a rapid rate, that it was absolutely necessary to make considerable additions to the plant and mains in order to meet the further demand. In 1893 there were 820 consumers, representing an equivalent of 8,000 8-c.p. lamps connected, and in June, 1896, they had 1,216 customers, representing 116,700 8-c.p. lamps. There were, in addition, about 7,100 lamps waiting to be connected. Even with the proposed extensions the capacity of the present station would only be equal to 136,000, or 19,300 8-c.p. lamps beyond the orders in hand, which would exhaust the capacity of the works. The Board of Trade had given their consent to the area of supply being extended to the whole area of the city, 25⅛ sq. miles. It would therefore be necessary to make further large extensions at an early date, or a new station upon another site would have to be erected in order to cope with the ever-growing demand for electric current for lighting, motive power and other purposes. The Borough Electrical Engineer, Mr. C. H. Wordingham, also gave evidence, after which the inquiry closed.

METROPOLITAN ASYLUMS BOARD.—At a fee of 45 guineas the services of Prof. Ayrton have been retained for preparing a specification for and supervising the wiring of the new building about to be erected for the staff of the North-Western Hospital.

PAISLEY.—The Town Council received 61 applications for the post of resident electrical engineer, and this number has been reduced to 15 by the Electrical Committee. The list will be further reduced to a leet of five, but power has been reserved to each member of the Council to add any of the rejected names to those to be finally voted on.

REDDITCH.—The District Council have been notified by the Manchester Edison-Swan Company that they intend to apply for a Provisional Order for the district.

SALISBURY.—The Salisbury Electric Light Company have obtained an extension of three months in which to comply with the terms of their Provisional Order.

SOUTH SHIELDS.—In answer to a complaint as to the progress being made with the electricity works, Alderman Rennoldson, Chairman of the Electric Lighting Committee, said that owing to certain delays by contractors, the Council had decided that the supply of electric current should not be commenced till August 1st. As far as he could tell, the cost of the works would not exceed the original estimate, viz., between £27,000 and £28,000. The plant was practically completed, cables had been tested, and everything was now progressing satisfactorily.

STOCKTON-ON-TEES.—The Board of Trade has granted the Town Council a further period of two years for complying with the terms of their Provisional Electric Lighting Order.

SUNDERLAND.—The Highways Committee recommend the Town Council to give the National Telephone Company permission to put their wires underground.

TERMINAL CHARGES ON TELEPHONE MESSAGES.—In reply to a question in the House of Commons, on Monday, Mr. Hanbury said that terminal charges on telephone messages operated only in a few cases. They were fixed by agreement with the National Company, and there was no power to modify or abolish them without the Company's consent. Such charges were not levied prior to the agreement coming into force. They were, however, fixed with a view to a state of things that did not previously exist.

THE POST OFFICE AND TELEPHONES.—The Post Office has issued tables showing the charges for telephone trunk-wire conversations not exceeding three minutes, and also the places between which direct trunk wires do not exist, but with which telephonic communication is practicable through the trunk centre specified in each case, at the rates of charge for trunk-wire conversations to and from that centre.

WAKEFIELD.—The West Riding of Yorks County Council have decided to introduce the electric light into the new county offices at Wakefield. It was at first proposed to take current from the Corporation's mains, but on the advice of Mr. S. a'Court it has been decided to put down an independent generating plant. The plant (including a battery of accumulators) is to cost £1,805. The insulated iron tube system of wiring is to be adopted, costing £1,450, and a system of telephonic communication at a cost of £270 is to be introduced.

"WESTERN WEEKLY NEWS."—We have received for several years past from Mr. Ernest Croft, the manager of the *Western Morning News*, a copy of the summer number of the *Weekly News*, and certainly the issue for 1896 leaves its predecessors far in the rear. For those who are likely to visit western holiday haunts for the first time, such a publication has, apart from its literary merit, much attraction. Some excellent views are given of Devon and Cornish show places; and the letterpress notes accompanying the illustrations just whet the appetite, and induce a desire to make a closer acquaintance with spots most of which are famous in English history. The 1896 issue is full of light holiday reading, and for twopence can be obtained more than is usually purchaseable for a much larger sum.

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WILMSLOW.—The District Council have decided to apply for a Provisional Order.

WIMBLEDON.—The County of London and Brush Provincial Company have notified the District Council that they propose to apply for a Provisional Order.

WREXHAM.—The Town Council have decided to apply for a Provisional Order. The Council also intend to apply for powers to supply electric current outside the area of the borough, as it is anticipated that the electric light will be introduced into the workhouse, the Great Western Railway station, and Acton Hall, all of which lie outside the borough.

WORKHOUSE LIGHTING.—The North Dublin Union are making inquiries as to the cost of lighting the workhouse buildings electrically. Application has been made to the Corporation to state their terms for supplying current.

OUTING.—The excursion of the men engaged on the Wandsworth contract of the Brush Company took place on Saturday last, the party journeying to Bognor. Mr. G. A. Cowles, in the absence of Mr. P. J. Pringle, resident engineer, presided at the dinner at the Beach Hotel. An enjoyable day was spent.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

June 10, 1896.

12,738. V. PLANQUES. Brussels. System for the indoor distribution of the electric light.

12,746. W. J. HEAD. London. Improvements in two-pin plug for portable electric lamps.

12,755. THE TELEGRAPH MANUFACTURING COMPANY (LIMITED). Helsby. An improvement in the manufacture and insulation of electrical conductors.

June 11, 1896.

12,859. L. B. MILLER. London. Improvements in electric transformers.

12,895. H. R. SMITH. Chicago. Electric elevators.*

June 12, 1896.

12,983. R. N. LUCAS. Woking. An improved grid or plate for secondary batteries.

13,023. H. REASON. London. Improvements in casings for electric conductors.

June 13, 1896.

13,046. F. B. EVANS. London. Improvements in and connected with cleats for electric and other wires and the like.*

13,048. J. RHODES and J. HENDERSON. Wakefield. An electric lamp and oil can combined.

13,074. A. J. MARQUAND and D. LOWDEN. London. Improvements in the manufacture of electrical resistances.*

13,079. W. P. THOMPSON. Liverpool. Improvements in or connected with dry batteries and the like. (C. C. Lesenberg, Germany.)*

13,080. A. LOTZ. Manchester. Improvements in or applicable to electric meters.*

June 15, 1896.

13,145. T. J. BAKER. Birmingham. Improvements in the construction of ammeters and voltmeters.

13,195. W. J. DAVY. London. Improvements in or connected with automatic switches for controlling electric lamps.

13,200. O. G. STROMBERG. Liverpool. Improvements in or applicable to the charging of accumulators.

June 16, 1896.

13,250. C. ADAMS-RANDALL. London. Improvements in telephonic apparatus.

13,263. W. L. PREECE. London. A frictional grip for sliding rods, applicable to holders of electric lamps, carbons, and the like.*

13,264. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED). London. Improvements in regulating induction electric motors. (A. H. Armstrong, United States).*

13,267. W. R. DAGGETT and W. H. HEINZ. London. Improvements in electric switches for street railways and the like.*

13,271. J. B. VERITY. London. Improvements in electric switches.

13,295. W. P. THOMPSON. Liverpool. Improvements in or relating to electrically controlled railway signals. (F. McBrien, J. Wayland and J. H. Fleming, United States).*

13,297. R. PIGNOTTI, F. LORI, S. REGNOLI, M. PANDALEONI and M. BESSO. London. Improvements in and relating to electric furnaces.*

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

10,360. LANCASTER. Electric switches.

10,418. WENDE. Time recording apparatus for consumption of electric currents.

10,647. NEW and MAYNE. Electric propulsion of boats, &c.

11,547. COWPER-COLES GALVANISING SYNDICATE AND OTHERS. Coating strips, wire, &c.

12,404. HOOKHAM. Electricity meters.

12,546. CHAMBERLAIN and HOOKHAM AND HOLDEN. Electricity meters.

12,614. LORRAIN (Esmond). Electric railways.

15,644. SIEMENS BROS. AND CO. (Siemens and Halske). Electric railway signals.

1896.

4,845. ADAMS. Arc lamps.

6,625. FIPPARD. Telephone receivers.

7,854. OTIS ELEVATOR CO. (Otis Bros. and Co.). Regulating electric motors.

7,885. DEVONSHIRE (Henny and another). Incandescent electric lamp bases.

8,228. SIEMENS BROS. AND CO. and LAUCKERT. Electric generators.

8,483. SIEMENS BROS. AND CO. and DIESELHORST. Joints for electric cables.

8,659. SCHNEIDER. Electric accumulators.

8,660. SCHNEIDER. Electric accumulators.

8,695. MAJERT. Electrodes for accumulators.

# COMPANIES' MEETINGS AND REPORTS.

## Consolidated Telephone Construction and Manufacturing Company (Limited).

The fifteenth annual general meeting of this Company was held yesterday at Winchester House, Old Broad-street, under the presidency of Mr. C. L. W. FitzGerald.

The SECRETARY (Mr. Charles Curtoys) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I cannot disguise from you that this year our profit on trading has really reached its lowest limits. This is caused, I think, by three things, the first and most important of all being the decrease in the sale value. That again means—what I am sorry to say I have told you year by year—that our wages keep up, while the value of the goods we sell keeps on decreasing, owing to the very severe competition in the telephone world. We have now four or five very eager competitors, and there is no doubt about it that the moment they know what we are selling a telephone at they undersell us. The second cause of our diminished profit is our having removed the factory. For about three months, in consequence of that proceeding, we were in a very disorganised state, and it was with great difficulty that we could execute orders. I am glad to say, however, that all that is over. As you are aware, you last year authorised us to move the factory from London to the country. We have been most fortunate indeed in getting a splendid factory, and there are photographs of the workshops here for the inspection of any shareholder who wishes to see them. We secured this factory on very advantageous terms, and it is freehold. I anticipate that we shall by this change make a considerable saving in the rent, and, in addition, we expect to save in fuel and rates and taxes. We are using a gas engine instead of steam coal, and we also get our water extremely cheap. With regard to the important question of labour, when we proposed to remove to Coventry we thought that labour would be very much cheaper than it is in London. It is cheaper; but owing to the *boom* in the bicycle trade there is such a demand for workmen that, without doubt, wages have risen. I cannot say whether that will continue, but it is our intention to use female labour as much as possible, and so save on that heading. We have got an office, or rather a whole building, in London at a cheap rate, situated in Shaftesbury-avenue, and it has proved fairly satisfactory in the way of sales. We have sold goods there which we did not sell in the old factory in Farringdon-street. Our total receipts in the year on revenue account amounted to £6,614, of which £3,209 was received as damages in respect of the Edison Gower-Bell Telephone Company of Europe in connection with the Belgian lawsuit. When I met you last year we had just arrived at the point when we had won a certain action, and we had been told to send in our claim for damages. Our legal advisers in Belgium at that time spoke of our receiving a very large sum, but after sending in our claim the judge had to assess the damages. He assessed them at a very low rate, —erroneously, I think for this reason: That this patent action had been fought in England by the National Telephone Company, and it had been upheld that all telephones were covered by the existing Edison patent, which was the patent we held. The judge in Belgium, however, held otherwise, and the result was that, instead of receiving a very large sum, we had to accept a small amount from the Company we had defeated, and then we had to go on with other actions against other companies with a

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view to obtaining damages from them. These actions might have gone on for another nine years, the period which it took us to defeat the other company; but after a time the two largest companies approached us and offered to give us certain damages. Those damages, together with our law costs, which they paid back, amounted to about £13,000, which was paid to the Edison Gower-Bell Telephone Company, and of this, we, the Consolidated Company, have received about £10,400. That is for various items—a loan that was owing to us, stores account, damages for the actions, and also some dividend. You will see from the revenue account that we made a very small trading profit; we received dividends amounting to £3,233, and the profit on the lawsuit was £3,209. The items of transfer fees and income tax returned bring the total up to £6,614. On the debit side there are expenses amounting to £1,991, which is a decrease of about £250, mainly, I think, owing to the reduction in the fees of the Directors —£500 instead of £750. Deducting these expenses there was a balance left of £4,622, and with the balance brought forward and unclaimed dividends we make up a total of £5,870. On the other side we have made great provision in writing off. The large sum of £565 has been written off as the cost of dilapidations. This amount astonished the Board very much, because although we knew that there must be a certain amount of dilapidations after about 14 years in the "life" of a building, we never thought it would amount to so much as that. We called in experts, however, and without our going to law, that was the amount settled on that we must pay. In addition to that there was the depreciation of plant and machinery, £432, and the expenses connected with the removal of the factory and offices, £739. That seems a large amount, but those shareholders who know the extent of the works will, I believe, agree that the change was effected as cheaply as possible. The removing of the factory was carried out under the superintendence of Mr. Menzies, the general manager. Estimates were obtained from other quarters to see what the cost would be, and it was found that it was cheaper to do the work ourselves. There is another item which I must call your attention to—of reserve against loans, £1,025. That is a reserve which our auditor thought we should make for this reason: you will remember that we lent a company called the Capsule Battery Company £1,000 to take out a foreign patent, taking as security the patent for England. The Capsule Company failed to pay the £1,000 back, and we are now taking steps to try and recover it. Deducting these items, we are left with a balance of £3,023, and we propose to take from that a dividend of 1½ per cent., and carry forward a balance of £1,393, which is about £150 more. It is very difficult for me to say anything as to the future of the manufacturing business. At present we are extremely busy, and we have been very busy for the last three months. I do not know whether that state of things will continue; but I can only say that, if we go on as we are at present doing, there is no doubt that our balance-sheet will look very different next year as regards the manufacturing profit. We are endeavouring to do some work for various bicycle firms. From what we heard we imagined that they were all so frightfully busy that they would only be too anxious to get people to manufacture for them; but we do not find that that is actually the case. We have made a little for various companies, but nothing like what we should like to do. I this morning received a letter from a large shareholder, who has again brought up a question which I think we discussed this time last year—namely, the liquidation of the Company. I believe that this gentleman was not present at our last meeting. If he had been I think he would have remembered that, after long discussion, we then decided that it would be wise to allow the Coventry factory to show what it could do. Otherwise we should not have moved there. If we find, having now moved to Coventry, that we cannot make any profit out of it, it will be a question whether the shareholders shall not be approached as to the liquidation of the Company; but it would be rather strange first to authorise the removal to Coventry, and then to decide on liquidation at once, as is suggested by this letter. I may say that we also received another letter on the subject some days ago. Personally I see no reason whatever why the Company should not be liquidated if we cannot make a profit; in fact, in that case, it would be useless to go on. You will see that our subsidiary Company, the Anglo-Portuguese Telephone Company is going on fairly steadily. It does not show any very great increase, but there is this satisfaction—that it is now returning money to us here. The high rate of exchange with Portugal affects us very much; I believe we lost about £2,000 last year on that account. With regard to the balance-sheet the item of creditors stands at £2,098, but nearly all of that has been paid off; and, as regards our debtors the majority of the £4,513 against subsidiary companies has been repaid. There is no change in the securities, except that we have sold about 400 National Telephone Company's shares, with which we bought the freehold land and building at Coventry. I now move—

"*That the annual statement of accounts and balance-sheet, with the report of the Directors and auditor, now submitted, be received and adopted; and that a dividend at the rate of 1½ per cent. per annum be paid, less income-tax, for the year ended March 31, 1896.*"

Sir ALEXANDER ARMSTRONG, K.C.B., seconded the motion.

Mr. CHARLES S. BUCK observed that at their last meeting he maintained that the manufacturing portion of the Company's business was a failure, and he again emphasised that remark. From the working of the past nine months (he would not say twelve months, on account of the difficulties connected with the removal to Coventry) they had derived a trading profit of £127 on their capital of £112,000. Had it not been for the recovery of the amount referred to by the Chairman in the lawsuit mentioned there would have been no dividend. There had been an expenditure of £1,821 in connection with dilapidations and the cost of removing to Coventry, and he held that this money ought never to have been spent at all, and that they ought not to have gone to Coventry. As to the sale of 400 shares in the National Telephone Company, he saw from the accounts that there was plenty of money to pay for the Coventry purchase without parting with what he regarded as an excellent security. He thought the Company ought to be divided into two portions—manufacturing and financial. The manufacturing portion he would wipe out altogether, as it was an utter failure; and as regarded the financial portion, he suggested the formation of a small trust company to nurse their investments and to invest what other capital they had.

Col. WEST said he could not quite agree with the last speaker as to the propriety of doing away with the manufacturing portion of the business after the expense had been incurred of removing to Coventry. He thought they must now wait and see whether the change would have any beneficial effect on them. The Chairman had called attention to three reasons to account for their diminished dividend; but there was another reason which had not been referred to—namely, the expenses for Directors' fees and office management, which he considered enormous. He could see no reason for carrying forward as much as £1,393, and it would be possible to pay a dividend of 2½ per cent. instead of 1½ per cent.

Mr. GOULY acquiesced in these remarks.

A SHAREHOLDER thought they ought to come to terms with the rival companies, so as to get a fair price for what they produced.

The CHAIRMAN, at the close of the discussion, said no dividend has been declared by the Edison Gower-Bell Company since December, 1893, for the reason that they have not made any profit, and it was only through their winning the lawsuit that they were able to pay us this money. With regard to the sale of the National Telephone Company's shares, until the Edison Gower-Bell Company paid up the amount we have received from them we had not a large sum standing to our credit. The balance-sheet is to March last, but we bought the works in October, 1895, and we did not then have the money which the balance-sheet shows. With respect to the manufacturing part of our business, the factory is so busy that we have had to order fresh machinery. I did not think it was wise to mention this before, but there is a possibility of our doing something in motor cars. It was because we were doing so badly that we decided to move from London, and that is why our balance-sheet this time is so bad. If it is as unfavourable next year I think you will find the Directors only too glad to consider a winding up. As to the rival companies you do not suppose that we have not tried to join hands with them, but that is a proceeding which would not pay those companies, who are all foreign, and who simply sell their surplus stock here. As regards the Directors' fees, the Articles of Association entitle them to £1,500 a year, and we did not think in taking the amount we have drawn that we were taking any very large remuneration.

The motion was carried unanimously.

The retiring Director, Sir A. Armstrong, was re-elected, as was also the auditor, Mr. J. G. Griffiths, at a remuneration of 50 guineas.

The proceedings then terminated.

Dividend warrants will be sent out this week.

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The Directors' report states that the total receipts for the year amount to £6,614. 6s. 6d., including £3,209. 0s. 11d. received in respect of the Edison Gower-Bell Telephone Company of Europe (Limited), Belgian lawsuit, and £1,750 transferred from revenue suspense account, being dividend declared payable on 1st July, 1896, by the Edison Gower-Bell Company. Deducting the usual expenses, amounting to £1,991 16s. 11d., leaves a balance of £4,622. 9s. 7d., against which the Directors have decided to write off various items, amounting to £1,821. 16s. 6d., and to reserve £1,025 against loans. Out of the balance of £3,023. 9s. the Directors propose to pay a dividend of £1. 10s. per cent., carrying forward £1,393. 5s. 10d. Competition in the manufacturing business continues very keen. The lease of the factory and offices at Farringdon-road having expired at Christmas last, the Directors decided upon the purchase of some freehold works at Coventry at an advantageous price. There is a considerable area of ground, capable of being built upon in the event of extension of the manufacturing business. The saving in labour, fuel, rent and taxes promises to be favourable, and though the boom in the bicycle trade has somewhat interfered with expectations under the first item, matters are satisfactorily settling down. Offices, &c., in London have also been obtained upon satisfactory terms, and the Directors propose that the subsidiary companies shall be asked to remove to the same building as soon as convenient. The lawsuit in Belgium carried on by the Edison Gower-Bell Telephone Company of Europe has had a satisfactory termination as regards certain of the infringing companies, and a large sum of money has been paid in respect of damages. Further vigorous action has been commenced against other infringing companies. The Anglo-Portuguese Telephone Company continues to show satisfactory progress.

## India-Rubber, Gutta-Percha and Telegraph Works Company (Limited).

The half-yearly meeting of the above Company was held on Tuesday at the Cannon-street Hotel, for the purpose of obtaining the shareholders' sanction to the declaration of an interim dividend of 2½ per cent. Mr. Matthew Gray, Managing Director, presided.

The CHAIRMAN said: Gentlemen, I wish to give you a little explanation of what we have been doing during the past six months. The amount of business that we have done during that time is probably 10 per cent. greater than anything we have hitherto done. Therefore, we have reason to be satisfied on that account. But it has been rather of an unprofitable nature, because the raw material that we are using has increased in price, I daresay, from 10 to 15 per cent., and the competition for orders is so great that we are not able to get all the profit that we should like. Still we have got every reason to be satisfied. Our works are in first-rate order, and we can turn out our work satisfactorily. I have no doubt at all, from what I can see, that our output will go on increasing. In reference

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to submarine cable work you may remember that we had a number of cables to lay in Cuba. We had very little time to do the work in, but we managed to get through with it in time, and we obtained payment. Since then we have had an order to lay a cable between Germany and England for the German and English Governments. It was a very difficult job, in consequence of the shallow water in which we were obliged to lay the cable; but we got that done also. Well, that is the bulk of submarine work that we have done. Since the death of Mr. Henderson and Mr. Jarvis we have been rather short of Directors. We have agreed with Major Darwin to join the Board. He concluded by moving a resolution.

Mr. SILVER seconded the motion.

Mr. GRANT asked whether the Company was involved, or was likely to be involved, in any legal dispute with one or more of the cycle companies.

The CHAIRMAN: Yes; we have been advised that two of the pneumatic tyre companies are entrenching on two of our patents, and we have entered a suit against them. It will no doubt take some time before it is heard.

Mr. LAMONT assumed that the dividend now proposed to be paid was merely a matter of convenient arrangement.

The CHAIRMAN: We do not balance in the middle of the year—at the end of the first six months. Our stock is so large and multifarious that we are obliged to stop our works for three days for the purpose of getting the stock properly taken, and this is attended with much loss.

Mr. LAMONT asked whether there was any truth in various recent rumours to the effect that both loss and profit had been made by the Company on rubber in speculations with tyre companies or in connection with them.

The CHAIRMAN: We have neither made nor lost money in speculating in rubber. We have been obliged to buy it at a price higher than that at which we usually do buy it. The price has risen by about 15 per cent., but there has been no undue purchase.

The resolution was carried.

The meeting was then made extraordinary for the purpose of passing certain resolutions as special resolutions, in effect substituting a number of new Articles of Association for existing ones.

The SOLICITOR to the Company explained the nature of the proposed alterations, particulars of which in the form of a circular were before the meeting.

Mr. W. B. COCHRAN said that he did not see that there was any necessity for altering the Articles at all, especially as the Solicitor had not made it quite clear that there was any advantage to be gained.

Mr. GRANT gathered that by reason of the proposed changes the reports of the Company in future would contain a list of the securities held by the Company.

The SECRETARY: Merely a summary of the property and the liabilities, not a detailed statement.

Mr. JOSEPH PRICE said that if they entered too much into detail they might be giving themselves away to their competitors.

Mr. COCHRAN asked whether, in view of the importance of the issues involved, the Auditor who suggested the proposed changes was present to give an explanation of his reasons why.

The SECRETARY was understood to reply in the negative.

Mr. LAMONT suggested whether it would not be better to postpone the consideration of the matter till the next meeting. Very few of the shareholders knew the Articles of Association, and it was impossible for them to carry in their memories the proposed alterations as they were read out by the Solicitor. The original Articles and the proposed alterations should be printed side by side, and sent to the shareholders for their careful consideration and discussion at the next meeting.

A motion to this effect was proposed and seconded.

The SOLICITOR said that would necessitate another meeting, because all the accounts were made up before the date of the ordinary meeting.

Mr. COCHRAN suggested a special meeting should be called a month hence; and finally, after a good deal of discussion on both sides of the table as to the date of the meeting, a motion proposing that the consideration of the resolutions be postponed till the 21st inst., at the same time and place, and that copies of the Articles proposed to be changed should be furnished to the shareholders beforehand, was agreed to; and the meeting ended.

## Rochester, Chatham and District Electric Lighting Company (Limited).

The annual meeting of the shareholders of this Company was held last week at Chatham, the Chairman (Mr. H. Jasper) presiding. The report states that the net profit for the past year to December 31, 1895, amounted to £224. 5s. Having to provide for interest on an increasing loan, and allow increased discounts, the Directors do not propose to pay any dividend, but to carry forward £638. 7s. 11d. Owing to the demand for arc lighting it has been deemed advisable to put down an arc light plant for 50 lamps. The Directors desire to make arrangements with the Chairman for carrying out the terms of the Company's Provisional Order for the Brompton District.

In moving the adoption of the report and accounts the CHAIRMAN regretted that they were not in a position to declare a dividend. That showed that, as far as their output was concerned, they had been selling the current a little too cheap. The local authorities had compelled them to put their cables underground; they had had unfair competition to contend with, and they were hampered in other ways, consequently they were not able to make much progress during the past year. He had, however, no fear of the ultimate success of the Company. The Chairman then referred to certain negotiations which were in progress for the lighting of streets in the Gillingham district for the District Council. The necessary capital for putting the wires under ground in the New Brompton district had been advanced by the Chairman. As to the proposal for extending their system in the district, he had offered to put down the necessary plant at an expenditure of £10,000, and when they were supplying current he would ask them to allot him 200 £5 shares for him to carry out the scheme; after the undertaking was in a position to pay 6 per cent. net profit he would then divide any surplus profit with the parent company. He would also want power to sell to the Gillingham Council, and he would receive 75 per cent. of the purchase money, and the Company 25 per cent. After a long discussion the report and accounts were adopted, and a committee, consisting of the Mayor, Messrs. Wingent, Geo. Church, E. Smith, Massey, and J. S. Benton, was appointed to confer with the Directors as to the best means for improving the financial condition of the Company.

## United River Plate Telephone Company (Limited).

The report of the Directors for the year ended March 31st last, to be presented at the meeting to be held at Winchester House, Old Broad-street, London, on Tuesday next, at 12 o'clock, states that the receipts and expenses have been taken at the actual sterling value each month, thus obviating the necessity for the item "loss on exchange" which has appeared in the accounts in past years. The gross receipts for the year in the River Plate were £48,744. 10s., against £36,673 for the year before, and the working expenses in the River Plate £24,967. 2s. 2d., against £17,555, leaving a profit, after deduction of debenture interest and all London charges, of £14,504. 13s. 7d., against £9,901. 15s., to which has to be added £4,619. 12s. 4d., brought forward from the previous year, making a total of £19,124. 5s. 11d. Out of this sum the Directors propose to transfer £5,000 to depreciation and renewal fund, and recommend that a dividend of 4 per cent. (free of income tax) be paid upon the Ordinary share capital of the Company, and £4,524. 5s. 11d. carried forward. The capital outlay was £2,682. 3s. 9d., against £2,661. 16s. last year. The Directors further state that there is every prospect that the improvement in the business of the Company will continue. The retiring Directors are Messrs. J. Irving Courtenay and Frederick Green, who, however, offer themselves for re-election.

## Electrical Power Storage Company (Limited).

The annual report of the Directors of this Company, to be presented to the shareholders at the general meeting to be held on Thursday next, the 16th instant, at the Offices, 4, Great Winchester-street, London, E.C., at 2.30 p.m., states that the net profit for the year ended May 30th was £4,416. 5s. 3d., which, with a balance from last year, makes £4,587. 3s. 5d., out of which the Directors recommend the payment of a dividend of 5 per cent. on the Ordinary share capital, absorbing £4,243. 3s. 10d., leaving £343. 19s. 7d. to be carried forward. Provision has been made for the maintenance of buildings, plant, tools, &c., at a cost of £2,272 16s. 8d. The quantity of the Company's manufactures sold during the past year shows a satisfactory increase. The Company has acquired, after long and exhaustive experiment, the patents for the United Kingdom and an interest in certain foreign patents covering a new storage cell, in which considerable reduction in weight and space is obtained without increase of cost. The retiring Director, Sir Daniel Cooper, Bart., G.C.M.G., and the auditors (Messrs. James Meston and Co.) offer themselves for re-election.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**DEUTSCHE SEE TELEGRAPHEN GESELLSCHAFT.**—This new Cable Company has been registered in Germany, with a capital of 3,560,000 marks, in shares of 1,000 marks each. The object of the Company is to establish cable communication between Germany and Spain, with an ultimate extension to the United States. The Company has offices at Cologne and in London at Winchester House, E.C. Messrs. C. W. Guilleaume and W. Hibberdine are joint Secretaries of the Company.

**MORLEY FLETCHER WAVE POWER SYSTEM (LIMITED).**—This Company was registered on July 4th, with a capital of £20,000, in £10 shares, to enter into an agreement with Mr. B. Morley Fletcher for the acquisition of certain patents, patent rights, licences, and inventions, relating to any system for employing or utilising sea or other wave power for the generation of electricity, and to carry on the business of an electric light and power company in all or any of its branches. The first subscribers, with one share each, are: B. Morley Fletcher, civil engineer, W. Tomlinson, M.A., W. B. Worsfold, W. Statham, A. Morley Fletcher, B. Willson, and H. E. Montgomery. Mr. B. Morley Fletcher is to be Chairman, Managing Director, and Engineer of the Company.

**SOUTH MANCHESTER ELECTRIC SUPPLY COMPANY (LIMITED).**—This Company was registered on June 30th, with a capital of £5,000, in £1 shares, to carry on at Withington, and elsewhere in the neighbourhood of Manchester, the business of electric light company in all its branches; to construct, lay down, and fix all necessary mains, cables, lines, wires, accumulators and works; and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity and manufacturers of electrical apparatus. The first subscribers, with one share each, are: J. G. Groves, N. Bradley, E. E. Johnson, R. G. Lawson, W. P. James Fawcus, F. I. Astbury, and H. Cardwell.

**WHITEHOUSE AND THOMAS (LIMITED).**—This Company was registered on June 27th, with a capital of £3,000, in £1 shares, to acquire and take over the business of electrical engineers and metal workers, carried on by Messrs. Whitehouse and Thomas, at Drummond-road, Hampstead-road, London, N.W.; and to carry on the business of electricians, electrical and

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mechanical engineers, suppliers of electricity and electrical apparatus manufacturers. The subscribers include: J. R. Whitehouse, electrical engineer; F. Thomas, electrical engineer; and C. E. Lowndes, electrical engineer.

**COWPER-COLES GALVANISING SYNDICATE (LIMITED).**—The annual return to February 17th has been filed. The capital of £2,000 is divided into 500 "A" and 1,500 "B" shares of £1 each. All the shares have been taken up, and 500 of each class have been issued as fully paid. The full amount has been called and paid on the remaining 1,000 shares.

**CRUTO INCANDESCENT LAMP AGENCY (LIMITED).**—The annual return to January has been filed. 132 shares have been taken up out of a capital of £5,000 in £1 shares, and 25 have been issued as fully paid. The full amount has been called on the remainder.

**CUTTRISS, WALLIS AND CO. (LIMITED).**—The annual return to May 22nd has been filed. 651 shares have been taken up out of a capital of £10,000, in £5 shares, and 300 of these have been issued as fully paid. The full amount has been called and paid on the remainder, and 120 shares have been cancelled.

**ELECTRIC LAMP COMPANY (LIMITED).**—This Company is to be struck off the register.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31½d. per oz. (July 9th). Consols (2¾ per cent.) 113⅝—113⅞ for money, 113½—113⅝ for account; 2½ per cent. 107⅛—108¼ (July 9th). Stock Exchange Settling Days: Consols, Aug. 4th; Stocks and Shares Continuation Days, July 13th and 28th; Ticket Days, July 14th and 29th; Pay Days, July 15th and 30th; Mining Share Carry-over Days, July 11th and 27th.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended July 5th were £881, against £915 in the corresponding week of 1895, a decrease of £34.

**DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for June, 1896, are £1,960.

**EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).**—The interest on this Company's Four per Cent. Mortgage Debenture Stock for the half-year ending July 31st will be paid by warrant on August 1st next. The Four per Cent. Mortgage Debenture Stock register will be closed from the 28th to the 31st inst. inclusive.

**ELECTRIC CONSTRUCTION COMPANY (LIMITED).**—The transfer books of the First Mortgage Debentures of this Company are closed from the 8th to the 14th inst. inclusive.

**EVERED AND CO. (LIMITED).**—Letters of allotment and regret in the recent issue of capital in this Company have been posted.

**GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).**—We understand from a contemporary that the Directors of this Company recommend the payment of a final dividend of 3s. per share on the Preference shares and 3s. 9d. on the Ordinary, carrying forward about £1,000.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company in June were £25,600, and the total receipts from January 1st to June 30th £139,600, against £129,800 and £149,200 in the corresponding months of 1894 and 1895 respectively.

**W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).**—An interim dividend on the Ordinary shares of this Company for the half-year ended June 30th, at the rate of 6 per cent. per annum, free of income tax, and on the Preference shares at the rate of 7 per cent. per annum, less income tax, both payable on September 1st, has been declared. The transfer books will be closed from August 21st to 28th inclusive.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 5th inst. amounted to £1,286. The amount for the corresponding week last year was £1,250; increase, £36.

**METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).**—This Company invite subscriptions for 12,500 Ordinary shares of £10, at a premium of £2 per share, payable £1 on application, £2 on allotment, and £3 on each of the following dates:—October 31, 1896; March 1, 1897; June 30, 1897, the instalments (exclusive of premium), carrying interest at the rate of £4 per cent. per annum from the dates of payment until June 30th next. The prospectus states that the Company have upwards of 3,800 customers, and that an agreement has recently been concluded with the Marylebone Vestry for the public lighting of the northern part of Regent-street, which is expected to shortly form an important branch of the Company's business. The authorised capital of the Company has been recently increased from £500,000 to £1,000,000, and the present issue is to be expended upon an extension of mains, additions to machinery and plant, and the formation of transformer sub-stations, whereby a considerable economy in working is estimated. Further issues of capital will be made from time to time to keep pace with the development of the Company's business. The subscription list was originally opened on Tuesday and announced to close this day (Friday) at 4 p.m., but owing to the number of applications received the list was closed earlier than the date fixed.

**NATIONAL TELEPHONE COMPANY (LIMITED).**—At the Directors' meeting yesterday it was resolved, subject to final audit, to recommend to the forthcoming general meeting of shareholders the following dividends for the half-year ended June 30th:—At the rate of 6 per cent. per annum, less income-tax, on the amounts paid up on the First and Second Preference shares; at the rate of 5 per cent. per annum, less income-tax, on the amounts paid up on the Third Preference shares; at the rate of 5 per cent. per annum, free of income-tax, on the amounts paid up on the Ordinary shares, being the same dividend as was paid in respect to the corresponding half-year of 1895, carrying the same amount to reserve—viz., £35,000, and about £17,000 forward, as against £3,907 last year. The transfer books will be closed from the 17th to 30th inst. inclusive. The dividend warrants will be posted on the 30th inst.

**RIVER PLATE ELECTRIC LIGHT AND TRACTION COMPANY (LIMITED).** The River Plate Trust, Loan and Agency Company (Limited) invite, on behalf of this Company, applications for £125,000 Five per Cent. First Debenture Stock at 97½, payable £5 per cent. on application, £20 per cent. on allotment, £40 per cent. on September 30th, and £32. 10s. on December 31st next. From the abridged prospectus appearing elsewhere it will be seen that the authorised share capital of the Company is £300,000, divided into 30,000 Six per Cent. Cumulative Preference shares and 30,000 Ordinary shares, both of £5 each. The Company, which is the successor of a pioneer company (the River Plate Electricity Company) owns electricity stations in La Plata and Rosario, and another station is being erected in Tucuman. The present issue, which forms part of an authorised issue of £150,000, and is repayable at six months' notice at 107½, is made for the purpose of providing capital for the erection of an electricity station in Buenos Ayres. The lists opened yesterday (Thursday), and close to-day (Friday) at 4 p.m. Prospectuses can be had of the River Plate Trust, Loan and Agency Co., 52, Moorgate-street, E.C.; Messrs. Snell & Swaffield, 9 and 10, Tokenhouse-yard, E.C.; and of Messrs. Ashurst, Morris, Crisp & Co., 17, Throgmorton-avenue, E.C.

**ROLLER-BEARINGS COMPANY (LIMITED).**—In our advertisement columns will be found an abridged prospectus of this Company, inviting subscriptions to an issue of 30,000 Six per Cent. Cumulative Preference shares and 30,000 Ordinary shares of £1 each, payable 5s. on application, 5s. on allotment, 5s. one month after allotment, and the balance at an interval of not less than two months. The authorised capital of the Company is £150,000, divided equally into Preference and Ordinary shares. Of the present issue £20,000 is reserved for working capital. The Company is formed to purchase all rights and title to a roller-bearings invention patented by Messrs. Purdon, Walters and Woodcock, and any further improvements thereto, and for developing and working the same. Patent rights have already been secured for Great Britain, America, Germany, Austria-Hungary, France, Belgium, Italy, Russia, Canada, New South Wales, the Argentine Republic, Brazil, and Uruguay; and negotiations are in progress to dispose of these patent rights for France, Belgium, and South America. It is claimed for the bearings manufactured under these patents that they are especially adapted for electric motors and dynamos, railway carriages and waggons, vehicles, shafting, stationary engines, &c. The object of the invention is to economise the cost of traction, whether in fuel, electric current, or horseflesh, as friction due to sliding or rubbing action is greatly reduced, and considerable economy is effected in oil and other lubricants. The Liverpool Overhead Company have one of their trains fitted with these bearings for trial purposes, and the Corporation of Blackpool have for more than two years had electric cars fitted and running, the consulting engineer to the Corporation certifying that over 30 per cent. of energy is saved by the use of these bearings. Further cars on this line have recently been fitted. The Lancaster Carriage and Waggon Company has for some time past tested the value of these bearings on the shaft of a heavy dynamo and the countershaft of a circular saw, no oil or other lubricant having been used for 18 months, except for the purpose of preventing rust. The patentees claim that, owing to the remarkably small effort necessary to start vehicles fitted with these bearings, they are peculiarly adapted to electric traction and for railway, tramway and general vehicular traffic. The complete prospectus gives full information regarding the invention, and copies of these can be obtained from the National Bank of Scotland, 37, Nicholas-lane, E.C.; Messrs. Ashurst, Morris, Crisp and Co., 37, Throgmorton-avenue, solicitors to the Company; or from Messrs. Marshall and Marshall, 3 and 4, Lincoln's Inn-fields, solicitors for the vendors; and also from the secretary, Mr. T. W. How, 1, Delahay-street, Westminster.

**ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).**—An interim dividend on the Preference shares at the rate of 7 per cent. per annum, and on the Ordinary shares at the rate of 5 per cent. per annum for the half-year ended June 30th, has been declared. The sale of electricity for the quarter ended June 24th, representing the supply at 6d. per unit, amounted to £10,657, against (at the same rate per unit) £8,598 for the corresponding period of 1895.

**STOCK EXCHANGE NOTICES.**—Tuesday, the 14th inst., has been appointed a special settling day in the further issue of 12,000 Ordinary shares (Nos. 20,501 to 32,500) of the Chelsea Electricity Supply Company (Limited). The Stock Exchange Committee have ordered the further issue of 10,000 Cumulative Six per Cent. Preference shares (Nos. 10,001 to 20,000) of the County of London and Brush Provincial Electric Lighting Company (Limited), and £50,000 Four per Cent. Debenture Stock of the St. James and Pall Mall Electric Lighting Company (Limited), to be quoted in the Official List.

**SUBMARINE CABLES TRUST.**—Notice is given that on and after the 15th inst. the sum of £1, balance of the coupon due April 15, 1896, will be paid by Messrs. Glyn, Mills and Co., 67, Lombard-street, E.C. Coupons should be left four clear days for examination.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended July 3rd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,855.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half-month ended June 30th are £2,382, against £1,868 in the corresponding period of 1895. The February receipts (estimated at £5,379) realised £5,443.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, July 1. | Price Wednesday, July 8. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending July 4. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 48 50 | 49 51 | 5 2 0 | Jan., Apr., July, Oct. | 49½ | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 92½ 93½ | 92½ 93½ | 5 6 11 | " " | 93¼ | 92 |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 9 9½ | .. | .. .. | .. | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer)..xd | 100 104 | 100 104 | 3 16 11 | January and July .. | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 9 10 | 9 10 | .. | .. .. | 9⅜ | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine ..xd | 15 15½ | 15 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15⅛ | 15⅛ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) ..xd | 111 115 | 111 115 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock ..xd | 160 170 | 160 170 | 4 2 4 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ 13½ | 12½ 13½ | 5 18 6 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 19½ 20½ | 19½ 20½ | 4 17 7 | " " | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ 4 | 3½ 4½ | 5 0 0 | April and October .. | 40½ | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each ..xd | 106⅞ 109⅞ | 106⅞ 109⅞ | 4 2 7 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10½ | 9½ 10½ | 4 3 0 | Jan., Apr., July, Oct. | 10⅛ | 10 |
| 400,000 | 10 | 2/6 | Eastern | 17 17½ | 17 17½ | 3 14 4 | " " | 17⅜ | 17⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 18¾ | 18½ 19 | 3 3 2 | " " | 18⅝ | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock .... | 131 134 | 131 134 | 2 19 10 | May and November | 132½ | 131 |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 109 | 106 109 | 4 13 6 | February & August | .. | .. |
| 250,000 | 10 | 6/6 | Eastern Extension | 17½ 18 | 17 17½ | 4 0 0 | Jan., Apr., July, Oct. | 18 | 17⅝ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 132 135 | 132 135 | 3 0 0 | February & August | 134 | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 ..xd | 101 104 | 101 104 | 4 16 2 | January and July .. | 103 | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900xd | 101 104 | 101 104 | 4 16 2 | " " | 102½ | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 109 | 106 109 | 3 13 11 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111⅞ 114⅞ | 111⅞ 114⅞ | 3 10 8 | May and November | 113½ | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust | 10½ 11 | 10½ 11 | 4 1 10 | Jan., Apr., July, Oct. | 10⅝ | 10⅝ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17 17½ | 17½ 17⅝ | 3 7 7 | " " | 17⅛ | 17⅛ |
| 150,000 | 10 | 5/0 | Great Northern | 23½ 24½ | 23 24 | 4 3 4 | Jan., April, and July | .. | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 15 0 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 52 55 | 52 55 | 4 10 11 | May and November | 54 | 57½ |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 111 113 | 111 114 | 5 7 2 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1947xd | 106 109 | 105 109 | 3 13 5 | .. .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 6½ 7½ | 6½ 7½ | 5 8 1 | April and October .. | .. | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. | 136 141 | 136 141 | 4 5 1 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph xd | 7 8 | 7 8 | .. | January and July .. | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 103 105 | 103 106 | 4 15 11 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. | January and July .. | 1⅛ | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 ..xd | 93 103 | 98 103 | 7 15 4 | June and December | 102 | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1 1½ | 1⅛ 1⅜ | .. | .. .. | .. | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11¼ 11½ | 11½ 11⅝ | 5 2 2 | May and November | 11⅜ | .. |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £30,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) ..xd | 107 110 | 107 110 | 4 10 11 | June and December | .. | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8¾ 9¼ | 8¾ 9¼ | 4 17 7 | May and November | .. | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6¾ 7¼ | 6¾ 7¼ | 5 3 8 | " " | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2¼ 2¾ | 2¼ 2¾ | .. | .. .. | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 105 109 | 105 109 | 5 12 11 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 105 109 | 105 109 | 5 12 11 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds.... | 110 115 | 110 115 | 6 2 10 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 102 105 | 102 105 | 5 16 6 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3½ 3¾ | 3½ 3¾ | .. | .. .. | .. | .. |
| 224,850 | 10/0 | 1¼d. | Consolidated Telephone Const. & Manufacturing.. | ⅛ ⅜ | ⅛ ⅜ | .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | Yearly | 1⅜ | .. |
| 484,597 | 5 | 3/0 | National | 7⅞ 8⅛ | 7⅞ 8⅛ | 3 9 10 | June and December | 7⅞ | 7¼ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid).... | 16½ 17½ | 13⅛ 17⅛ | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6¾ 7 | 6¾ 7 | 3 11 5 | .. .. | 6⅜ | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) ..xd | 105 108 | 105 108 | 3 4 10 | January and July .. | 107⅛ | 105 |
| 58,000 | 5 | 3/0 | United River Plate | 3½ 4 | 3¾ 4¼ | .. | " " | 3⅝ | .. |
| £116,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) ....xd | 99 104 | 101 106 | 4 14 4 | " " | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ 15½ | 14½ 15½ | 3 4 6 | .. | 15½ | .. |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ 17 | 16½ 17½ | 3 9 7 | .. | 17 | .. |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) ..xd | 132 135 | 133 137 | 3 13 0 | June and December | 135½ | 134 |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain.. | .. .. | .. .. | .. | .. .. | .. | .. |
| £30,000 | £5 | 3 0 | Charing Cross & Strand Electricity Supply Corp. .. | 8½ 8¾ | 8½ 8¾ | .. | .. .. | .. | .. |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | .. | .. .. | .. | .. |
| 24,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid). | 8½ 9½ | 8½ 9½ | .. | .. .. | .. | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) | 13½ 13¾ | 13½ 13¾ | 4 7 3 | .. .. | 13⅞ | .. |
| 8,322 | £5 | .. | House-to-House Electric | .. .. | .. .. | .. | .. .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid). | .. .. | .. .. | .. | .. .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. | January and July .. | .. | .. |
| 45,000 | £5 | .. | Liverpool Electric Supply (fully paid) | .. .. | .. .. | .. | .. .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | .. .. | 1 1½ | .. | .. .. | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13½ 14½ | 13 14 | 2 17 2 | .. | 14 | 13½ |
| £100,000 | Stock | 4½% | * Do. 4½% Debs. xd | 119 121 | 119 121 | 3 14 5 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 9½ 10 | 10 10½ | .. | .. .. | .. | .. |
| .. | .. | .. | Rand Electric | 1⅜ 1½ prem. | 1½ 1⅝ prem. | .. | .. .. | .. | .. |
| 14,930 | £5 | 5/3 | St. James and Pall Mall | 11½ 11⅝ | 11⅝ 12½ | .. | .. .. | 11⅝ | 11¼ |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 9½ 10½ | 9½ 10½ | 3 6 8 | .. .. | 10⅝ | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 10½ 10¾ | 10½ 10¾ | 3 5 1 | .. .. | 10½ | 10⅝ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1⅛ 1⅜ | 1⅛ 1⅜ | 5 8 8 | .. | 1⅜ | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅛ 1⅜ | 1⅛ 1⅜ | 6 17 2 | .. | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 112 115 | 112 115 | 3 19 8 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref.. | 2 2½ | 2 2½ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) .. | 1½ 1⅝ | 1½ 2 | 7 10 6 | February & August | .. | .. |
| £1 0,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock ..xd | 103 106 | 103 106 | 4 4 11 | January and July .. | 104 | .. |
| £ 0,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) .. | .. .. | .. .. | .. | .. .. | .. | .. |
| 110,000 | 2 | .. | Electric Construction | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | .. .. | 1⅜ | .. |
| 12,845 | 2 | 2 2⅜ | Do. 7 per Cent. Cumulative Pref. | 2⅜ 3 | 2⅜ 3 | 4 13 4 | September | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ ¾ | ⅝ ¾ | .. | .. .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. | .. .. | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works | 21 23 | 21 23 | 4 6 11 | February & August | 23½ | 21½ |
| £2 0,000 | 100 | .. | * Do. 4 per Cent. Debentures | 105 108 | 105 108 | 5 14 1 | March & September | .. | .. |
| 15,995 | £10 | .. | International Okonite Ordinary | .. .. | .. .. | .. | .. .. | .. | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. .. | .. .. | .. | December and June | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ⅜ ⅝ | ⅜ ⅝ | .. | .. .. | .. | .. |
| 37,350 | 12 | 24/0 | Telegraph Construction and Maintenance | 38 41 | 38 41 | 4 7 10 | March and July | 40½ | 39½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds xd | 102 105 | 102 105 | 4 15 3 | January and July | .. | .. |
| 37,514 | £5 | .. | Woolhouse and Rawson Ordinary (£3 15s. paid).. | .. .. | .. .. | .. | .. .. | .. | .. |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. .. | .. .. | .. | .. .. | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 17 18 | 17 18 | 4 8 11 | March & September | 18 | 17⅝ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 17 18 | 17 18 | 3 17 9 | .. .. | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 114 | 109 114 | 4 0 0 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 43 45 | 43 45 | 2 15 7 | January and July .. | 44½ | 43 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15½ | 14½ 15½ | 3 6 5 | .. .. | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 135 137 | 135 137 | 2 18 5 | May and November | .. | .. |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway | 13⅛ 14⅛ | 13⅞ 14 | 2 2 6 | .. .. | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 17⅛ 17⅝ | 17⅛ 17⅝ | 2 16 10 | .. .. | .. | .. |
| 115,000 | Stock | 4% | Do 4% Debenture xd | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest but *not* for redemption.

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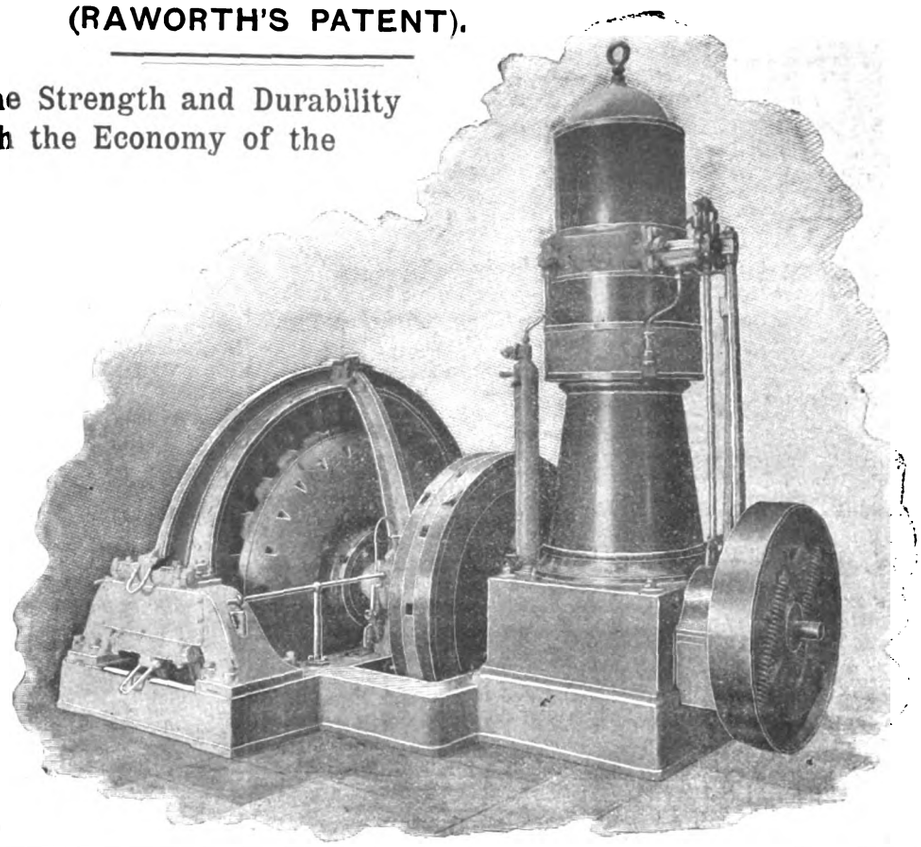
# THE UNIVERSAL ENGINE

(RAWORTH'S PATENT).



This Engine combines the Strength and Durability of the Corliss Engine with the Economy of the High Speed Engine.

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## PORTABLE & STATIONARY BATTERIES.

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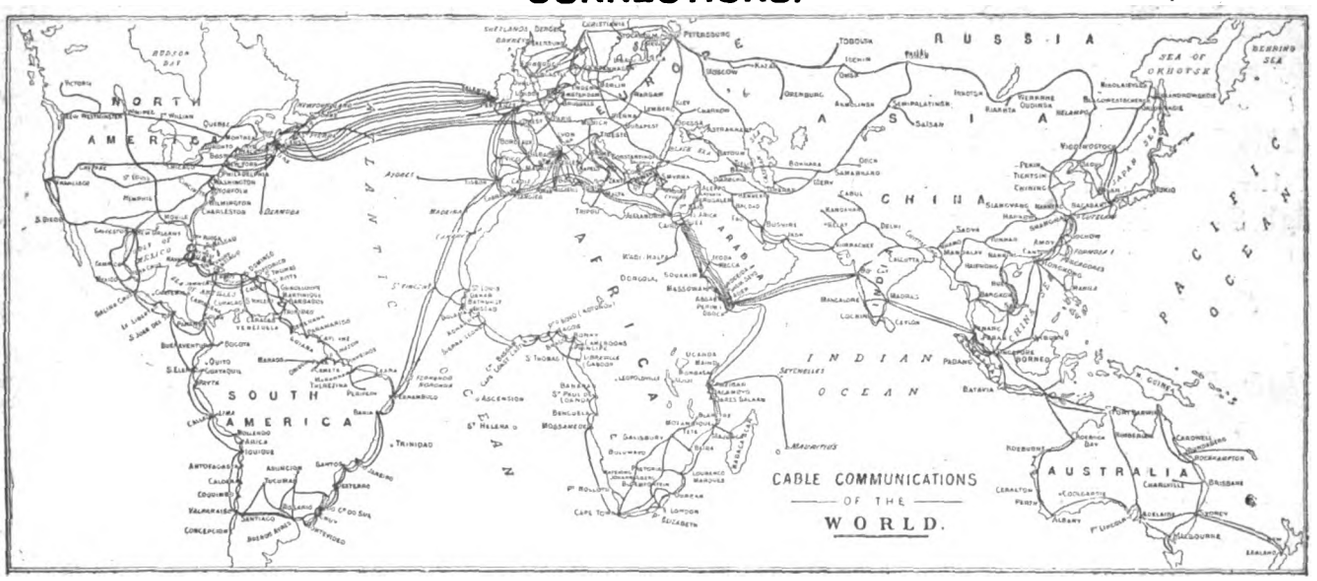
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

# EASTERN TELEGRAPH COMPANY

IN CONNECTION WITH THE (LIMITED),

EASTERN EXTENSION (AUSTRALASIA AND CHINA), BRAZILIAN SUBMARINE, EASTERN AND SOUTH AFRICAN, EUROPE AND AZORES, WEST AFRICAN AND AFRICAN DIRECT TELEGRAPH COMPANIES.

By DIRECT TRIPLICATE CABLES, to Spain, Portugal, Gibraltar, Malta, Egypt, Aden, and India.

By DIRECT DUPLICATE CABLE ROUTES to Madeira, St. Vincent, Brazil, Argentine Republic, Uruguay, also to Peru, Chili, and other parts of South America; and to Suakin, Perim, Penang, Malacca, Singapore, Labuan, Java, Australia, New Zealand, Tasmania, New Caledonia, Bangkok, Cambodia, Saigon, Tonquin, Hainan, China.

By ALTERNATIVE CABLES to Zanzibar, Mombasa, Mozambique (duplicate), Lourenço Marques (Delagoa Bay), Durban and Capetown; Bathurst, Sierra Leone, Accra, Lagos, Bonny, Bolama, Bissao, Cameroons, St. Thome, Principe, Loanda, Benguella, Mossamedes, Conakry, Grand Bassam, and Gaboon.

By SINGLE CABLE to the Azores, Tangier, Tripoli, Cyprus, Seychelles, Mauritius, and Manila.

Telegrams should be sent from the Company's Stations—

**LONDON**—11, OLD BROAD STREET, E.C.; 8, LEADENHALL STREET; 3, CREAT TOWER STREET; 42, PARLIAMENT STREET, S.W.; 206a, WINCHESTER HOUSE, E.C.; 37, HOLBORN VIADUCT, E.C.; FOREIGN AUCTION HALL, COVENT GARDEN MARKET, W.C., and 449, STRAND, W.C.

**MANCHESTER**—20, Brown Street. **LIVERPOOL**—K13, Exchange Buildings.

**GLASGOW**—141, BUCHANAN STREET.

COMPANY'S LEVANT SYSTEM:

Odessa, Constantinople, Dardanelles, Tenedos, Salonica, Smyrna, Chio, Syra, Candia, Rettimo, Canea, Sitia, Rhodes, Trieste, Corfu, Zante, Patras, Corinth, Athens, Cephalonia, Santa Maura, Tinos, Andros, Zea, and all the Greek Islands.

The Company's Cables are worked by Muirhead's DUPLEX principle upon all its Main Sections.

In sending Telegrams from Postal Stations care should be taken to mark them— "VIA EASTERN," these words being signalled gratuitously by the Postal Authorities.

Books of Forms and Tariffs forwarded post free on application at the Company's Chief Offices as above, or at

37, RUE CAUMARTIN, PARIS; and HOTEL DES POSTES ET TELEGRAPHES, MARSEILLES.

Winchester House, 50, Old Broad Street, E.C. By Order, GEORGE DRAPER, *Secretary*.

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TELEPHONE No. 15,077 TELEGRAMS: "INDICES LONDON."

**WHEATLEY KIRK, PRICE & COULTY**

*(ESTABLISHED 1850),*

**Electrical Auctioneers, Valuers, AND ARBITRATORS.**

**Average Annual Valuations exceed £1,500,000 Sterling.**

**49, QUEEN VICTORIA STREET, LONDON, E.C.**

## THE EASTERN TELEGRAPH COMPANY (Limited).

NOTICE is Hereby Given, that the FORTY-EIGHTH HALF-YEARLY ORDINARY GENERAL MEETING of the Eastern Telegraph Company (Limited), will be HELD on THURSDAY, the 23rd of July, 1896, at One o'clock in the afternoon, at WINCHESTER HOUSE, 50, Old Broad-street, London, when the Directors' Report and Accounts for the half year ended 31st March, 1896, will be presented, a Dividend and Bonus declared, and the ordinary business of the Company transacted.

Notice is also given that the REGISTER of TRANSFERS will be CLOSED from the 16th to the 23rd July, both days inclusive.

By order of the Board,
GEORGE DRAPER, Secretary.

London, 14th July, 1896.

## TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (Limited).

NOTICE is Hereby Given that the TRANSFER BOOKS of this Company will be CLOSED from the 13th inst. to the 21st inst., both days inclusive, preparatory to the payment of an ad interim Dividend of 12s. per share to all Shareholders on the Register on the 13th instant.

By Order,
E. DICKENS, Secretary.

38, Old Broad-street, E.C., July 10, 1896.

## COUNTY OF LONDON AND BRUSH PROVINCIAL ELECTRIC LIGHTING COMPANY (Limited).

NOTICE is Hereby Given that the TRANSFER BOOKS of the Company will be CLOSED from July 14th to July 21st, both days inclusive, for the purpose of preparing the Warrants in payment of the interim dividend on the first and second issues of Preference Shares for the half-year to June 30, 1896.

By order of the Board,
H. B. RENWICK, Secretary.

Registered Offices: Moorgate-court, Moorgate-place, London, E.C., July 13, 1896.

## CITY AND GUILDS OF LONDON INSTITUTE.

SESSION 1896-97.

THE COURSES OF INSTRUCTION IN ENGINEERING AND CHEMISTRY at the Institute's Colleges commence in October, and cover a period of two to three years. The MATRICULATION EXAMINATION of the **Central Technical College** will be held on September 21st to 24th and the ENTRANCE EXAMINATION of the Day Department of the **Technical College, Finsbury**, on September 22nd.

**CITY AND GUILDS CENTRAL TECHNICAL COLLEGE**

(Exhibition-road, S.W.), a College for Higher Technical Instruction for Students not under 16 years of age preparing to become Civil, Mechanical or Electrical Engineers, Chemical and other Manufacturers, and Teachers.

THE MATRICULATION EXAMINATION will be held on September 21st to 24th, and the new Session will commence on October 1st.

Professors:—O. Henrici, LL.D., F.R.S. (Mathematics); W. C. Unwin, F.R.S., M.I.C.E. (Civil and Mechanical Engineering); W. E. Ayrton, F.R.S. (Physics and Electrical Engineering); H. E. Armstrong, Ph.D., F.R.S. (Chemistry).

**CITY AND GUILDS TECHNICAL COLLEGE, FINSBURY**

(Leonard-street, City-road, E.C.). The DAY DEPARTMENT provides Courses of Intermediate Instruction for Students not under 14 years of age, preparing to enter Mechanical or Electrical Engineering and Chemical Industries.

THE ENTRANCE EXAMINATION will be held on September 22nd, and the new Session will commence on October 6th.

Professors:—S. P. Thompson, D.Sc., F.R.S. (Electrical Engineering); R. Meldola, F.R.S. (Chemistry).

JOHN WATNEY, Hon. Secretary

City and Guilds of London Institute, Gresham College, Basinghall-street, E.C.

## OWENS COLLEGE, VICTORIA UNIVERSITY, MANCHESTER.

PHYSICS DEPARTMENT.

COMPLETE INSTRUCTION is given to Students preparing for the Electrical Profession. The Dynamo House is fully equipped with Direct and Alternate-Current Dynamos, Motors, Transformers, &c. Special courses of lectures are delivered, including one on Dynamo Design.

Full particulars of the courses of instruction qualifying for the degrees of the Victoria University will be forwarded on application.

The SESSION commences on Tuesday, OCTOBER 6th.

S. CHAFFERS, Registrar.

## UNIVERSITY COLLEGE OF NORTH WALES, BANGOR.

ELECTRICAL ENGINEERING.

Professor ANDREW GRAY, LL.D., F.R.S., will begin in October next a systematic COURSE of INSTRUCTION in ELECTRICAL MEASUREMENT and PRACTICAL ELECTRICITY.

The Physical Laboratory is fully equipped with a Compound Steam Engine, Dynamos, Transformer, Secondary Battery, and the most approved modern Measuring Instruments for all branches of Electrical Engineering.

Laboratory fees at the rate of £1. 1s. per term for six hours per week.

Composition fee for all College Lectures for the Session, £10.

Applications for Calendar, Prospectus, and general information to be made to J. E. LLOYD, M.A., Secretary and Registrar.

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All the above appointments will date from 1st October, 1896, but the successful candidates will be required in the meantime to advise the Principal with respect to equipment and organisation.

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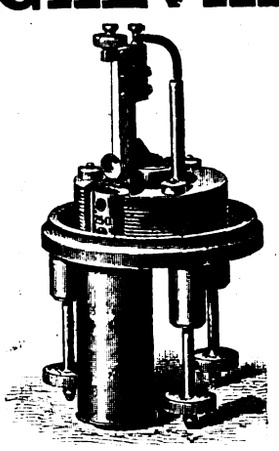
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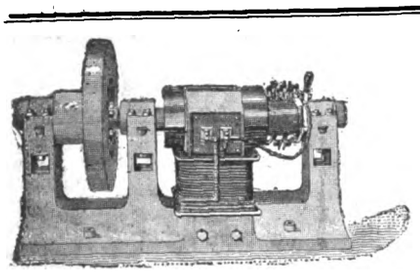
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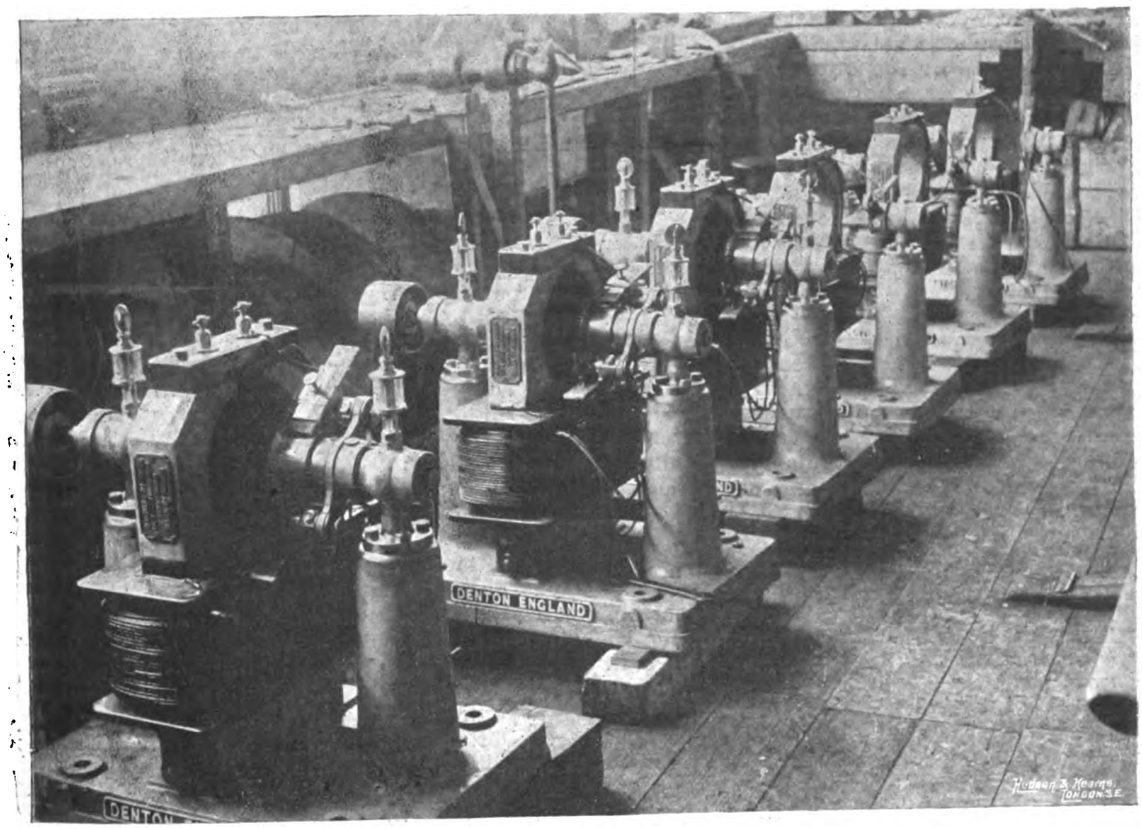


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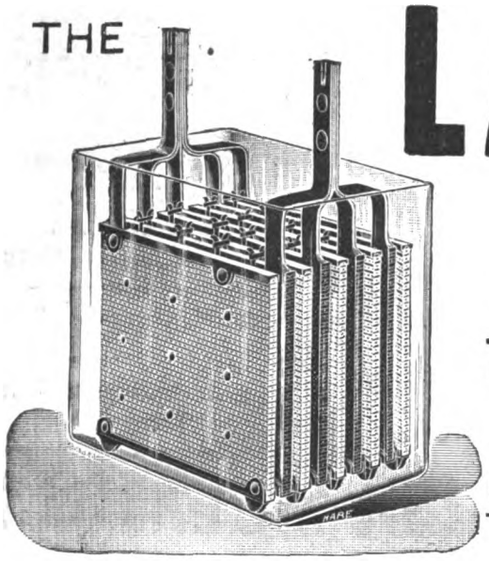

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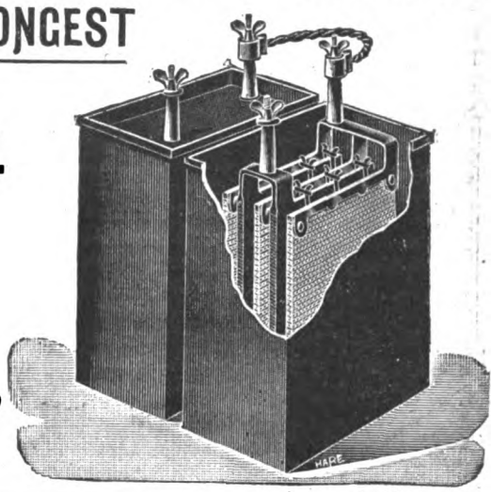

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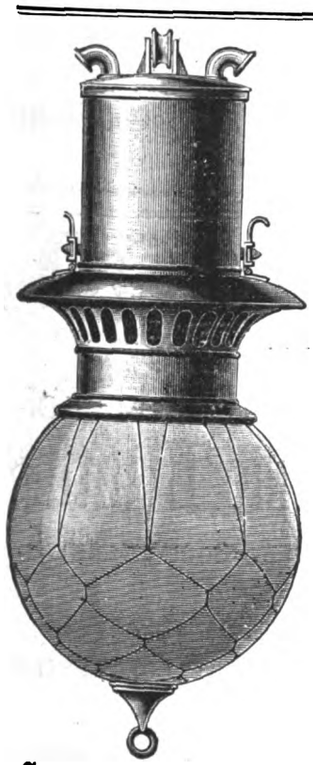

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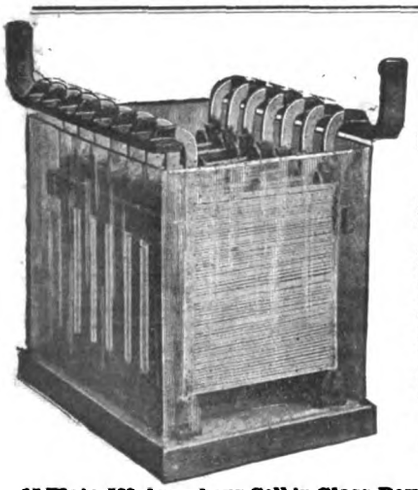

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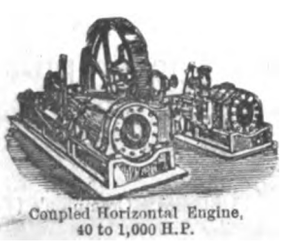

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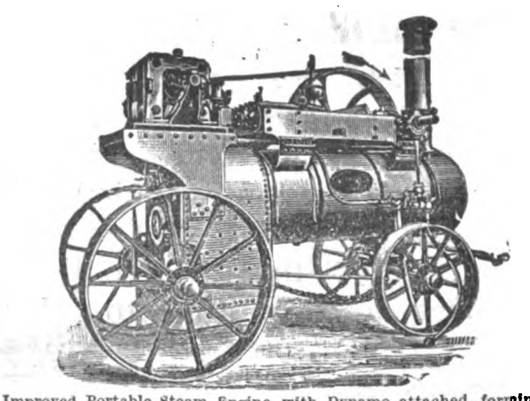

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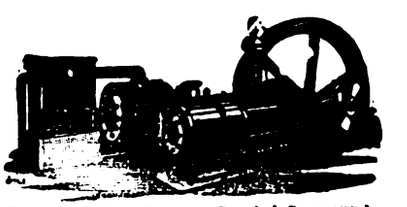

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## NOTES.

WITH the death of Sir JOHN PENDER, following so soon after that of Sir JAMES ANDERSON and Mr. CYRUS FIELD, the three foremost pioneers of long-distance submarine telegraphy have passed away, leaving Lord KELVIN to represent the scientific side of that signal achievement. If this great event in the wonderful history of the nineteenth century is to be commemorated, as it deserves to be, by a national memorial, now is emphatically the time; and we cannot doubt that the Press, the commercial world, the shareholders in the various cable companies, and indeed the community, will adequately support a fitting memorial of an enterprise which has benefited the world at large, and redounds to the credit of the English race.

WE print in another column an article from the pen of Dr. OLIVER LODGE. It is mainly devoted to a delightfully lucid exposition of the meaning and bearing of a marvellous piece of mathematical prediction due to HELMHOLTZ, and dating back to the early part of 1893. Taking for basis the electromagnetic theory of light, the great German physicist worked out the properties of electromagnetic waves of various lengths, with the result that, three years and more ago, before even the peculiar properties of LENARD rays, the immediate forerunners of RÖNTGEN rays, were known, HELMHOLTZ accurately described, as regards reflection and refraction, the behaviour of the numerous varieties of X-rays now known.

THE second law of thermodynamics acts as an efficient policeman in certain branches of physical speculation. CLERK MAXWELL has shown us the one and only way in which that policeman may be bribed, but even this can only be successfully done by (sorting) demonic agency. Prof. FITZGERALD, in a valuable letter which we publish this week, has put the vigilant officer of the "law" upon the track of Prof. AYRTON and his negative resistance. "What do you mean by your negative resistance?" demands the policeman. "Does it transform heat into electric energy without a temperature gradient? If so it breaks the law. And if not, wherein does it differ from an adjuvant THOMSON effect?" But the out and out believer in negative resistance, we apprehend, will find no difficulty in answering these questions. Indeed, the answer is supplied him by the earlier part of Prof. FITZGERALD'S letter. No violation of the law is contemplated. Who shall say what temperature gradients occur within and about the arc? And, with these in view, as Prof. FITZGERALD remarks, "it seems almost impossible but that the very negative resistance Prof. SILVANUS THOMPSON so objects to should exist in some part of the arc." The question arises, however, whether the time has not arrived when the term *electrical resistance* should be more accurately defined, so as either to cover or to exclude effects arising from a temperature gradient. The British Association might tackle the problem next September.

IN a short series of articles commencing this week Mr. G. J. BURCH gives to the world the main results of ten years of hard work upon most unpromising material. Since its invention by LIPPMANN more than twenty years ago, the capillary electrometer has been sadly neglected. Physicists have practically made no use of it at all, and physiologists have not made as much use of it as they might have done. Mr. BURCH describes minutely how to make a capillary electrometer; it is, as he enthusiastically points out, "the cheapest form of electrometer that can be made . . . . essentially the instrument for those who have to think twice before spending a shilling." He then discusses the law of the capillary electrometer, gives full directions for producing photographic records, and describes his ingenious method of analysing them and expressing the excursions of the meniscus in volts, concluding with a brief account of some exceedingly interesting applications of his apparatus. An instrument capable of recording changes in the *quality* of a tone, and capable of extraordinarily rapid response to minute variations of potential difference, is one that has distinct qualities of its own, which should render it valuable alike to the physiological and to the physical investigator.

AT this time of day the announcement of the discovery of a new source of energy loss in dynamo armatures is naturally met with a certain degree of respectful scepticism. It is, however, an announcement of this kind that M. OTTO T. BLÁTHY, of Budapest, apparently makes elsewhere in our issue of to-day. He runs a machine on open circuit at normal speed and giving the standard electromotive force; and he finds the loss due to friction, fan-action, eddy currents and hysteresis equals $L_0$. On loading the machine until a current, I, is passing through the armature, he finds that the total loss $L_i$ instead of equalling $L_0 + I^2 R$ is equal to $L_0 + c\, I^2 R$, $c$ being a constant having any value from about 1·8 to about 2·6. We do not know that this result, when so stated, is either very startling or very new.

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Assuming, as a matter of course, that the effect of temperature in increasing the copper losses has been allowed for, as well as the alteration in the open-circuit core-losses which arises where there is a current in the armature coils, it still seems possible that the implied mystery is capable of a simple explanation, Nothing is said about the position of the brushes. If commutation takes place under such conditions that the coils are short-circuited for an appreciable time, then there will be a loss which is certainly greater as the load increases, and the armature will act as though the resistance rose with the load. Again, if eddy currents are inducible, either in the armature core or the armature coils by the mutual induction of the currents in the coils short-circuited under the brushes, there must be losses that will increase with the load. In short, we are in a state of "animated suspense" pending the advent of further particulars.

An American electrical contemporary states that in a test of a Cornish boiler fired with petroleum "46lb. of water were evaporated per pound of oil consumed," and that another test, made on a 100-H.P. marine boiler, showed an evaporation of "41lb. of water per pound of oil." We have heard many preposterous claims advanced for oil fuel, but never before anything so absurd as this. The feat in either of these cases would be miraculous—to get over 40lb. of steam by burning 1lb. of oil. The pity is that engineers can be found to credit, and editors to print, such utterly misleading reports. No branch of engineering, probably, is so frequently undertaken by incompetent persons as boiler testing, a fact which accounts for the ridiculously high efficiencies often claimed. It only requires that the boiler be nearly empty at the beginning, and nearly full at the end of the trial, that it prime badly, and that the trial be sufficiently short, for a miraculous evaporative efficiency to be obtained. Oil fuel is not requisite, old newspapers (preferably technical) or dustbin refuse will give equally phenomenal results. As to the evaporative power of petroleum, its theoretically highest possible value does not exceed 30lb., even when the lightest and most refined oil is used. Ordinary petroleum has a theoretical evaporative power not generally exceeding 27lb.

Not without considerable justification are the often-expressed fears of purists that the Anglo-Saxon tongue will one day be buried beneath an accumulation of barbaric terms "communicated from abroad." But this much may, at any rate, be said for our own importations; uncouth as they are they usually bear some resemblance to English. We are afraid the same cannot be said for the terms imported from abroad into France. Two extremely interesting electro-physiological communications have recently been made to the Académie des Sciences (*Comptes Rendus*, Vol. CXXIII., No. 1) by that veteran investigator M. d'Arsonval, and in one of them are to be found some remarks about "une résistance dépourvue de self." Now, resistance with self induction we know, and resistance without self-induction we know; but what is this? Resistance "deprived of self" must surely be that perfect conductor we have all been waiting for; although it would appear to have emanated from the Theosophical or some such Society, instead of from the Royal Institution absolute-zero room, as was expected.

**Honorary Degree.**—Harvard University has conferred the honorary degree of LL.D. upon Prof. Alexander Graham Bell.

**Honour for Lord Kelvin.**—The Queen has conferred the Knight Grand Cross of the Royal Victorian Order on Lord Kelvin.

**Personal.**—We are pleased to learn that Mr. Léon Husson, the Eastern Extension Company's representative at Haiphong, Tonkin, has been appointed by the French Government a Chevalier de la Légion d'Honneur.

**The Giffard Prize of the Société des Ingenieurs Civils.**—This prize, of the value of 3,000fr., together with the Giffard gold medal, has been awarded to M. Louis Golchot, of Montceau-les-Mines, for his essay on "The Electrical Distribution of Power in Mines."

**The Willans Patent.**—Yesterday the Judicial Committee of the Privy Council fixed the 29th inst. for hearing the petition which Messrs. Willans and Robinson have presented for the prolongation of their patent, No. 4,901 of 1892, for improvements in high-speed engines.

**The Fastnet Lighthouse.**—In reply to Sir J. Leng, it was stated in the House of Commons last week, that the amount already spent in telegraphically connecting the Fastnet Lighthouse with the mainland was about £2,600, and the estimate for further expenditure was £850.

**The University College of North Wales, Bangor.**—Prof. Andrew Gray will begin in October next a systematic course of instruction in electrical measurements and practical electricity. The physical laboratory at the college is fully equipped for instruction in all branches of electrical engineering work.

**Cable Interruptions and Repairs:—**

| | Date of Interruption. | | Date of Repair. |
|---|---|---|---|
| Puerto Plata—Martinique..... | Dec. 19, 1895 | ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 | ... | — |
| Cadiz—Teneriffe ..... | June 6, 1896 | ... | July 16, 1896. |
| Para—Maranham ..... | July 9, 1896 | ... | July 16, 1896. |
| Lourenco Marques—Durban ... | July 13, 1896 | ... | — |

**Owens College, Victoria University, Manchester.**—The complete instruction given at this college to students preparing for the electrical profession includes a special course of lectures on dynamo design. The dynamo house is now fully equipped with both direct and alternate-current machines. The Winter Session commences on October 6th.

**Nomenclature.**—It has been suggested that "*ne plus ultra* light" would be a more appropriate term than "ultra-ultra violet light" for the waves of less than atomic dimensions referred to this week by Dr. Lodge. When we get down to waves of such a diminutive size that atoms are to them as forest trees are to sound waves, we have some reason for thinking there is nothing more beyond.

**Eastern Telegraph Company.**—At the meeting of the Board of Directors on Tuesday, the Most Hon. the Marquis of Tweeddale, who has been Vice-Chairman since 1874, was elected Chairman, in the place of the late Sir John Pender. Mr. J. Denison Pender was appointed Vice-Chairman, in addition to his position as Managing Director, and Mr. Charles William Earle was appointed to a seat on the Board.

**Patent Amendment.**—Notice is given that J. S. Gisborne, of Belitha Villas, Barnsbury, N., has applied for leave to amend the specification of the letters patent No. 8,210 of 1895, for "A method of and means for increasing the directive force of magnetic needles." Particulars of the propcsed amendments were set forth in the Illustrated Official Journal (Patents) issued on July 1st.

**The State and the Telegraphs.**—In reply to Mr. Henniker Heaton, Mr. Hanbury stated in the House of Commons on Tuesday night that the total telegraph deficit to March 31, 1895, was £5,847,110. 3s. 6d. The proportion chargeable to

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telegraph account of the expenditure to the same date on sites and buildings amounted to £1,241,774. The whole cost of acquiring sites and erecting buildings had been defrayed out of the sums voted for the purpose by Parliament from year to year.

**An Historical Patent.**—To morrow, the 18th inst., the full period of 14 years will terminate for patent No. 3,419, of 1882, which was granted to Sebastian Ziani de Ferranti and Alfred Thompson, for "IMPROVEMENTS IN DYNAMO-ELECTRIC MACHINES OR ELECTRIC GENERATORS." This patent was granted for, among other things, an "improved double zigzag method of winding the field magnets of dynamo-electric machines; also for a zigzag method of winding the armature." This patent has been void for some time.

**The Charges and Electric Figures on the Surface of a Crookes Tube.**—In a recent communication to the Academia dei Lincei, Prof. E. Villari describes some experiments carried out by him with Crookes tubes. He blew a mixture of sulphur and minium on to the glass of a tube at work. Generally there was a patch of minium coinciding with the fluorescent spot, the sulphur spreading uniformly over the rest of the tube. If the cathode rays were stopped by a sheet of platinum there was no red patch. The glass is thus negatively electrified just where the cathode rays impinge upon it, and is positively electrified everywhere else.

**Central London Railway.**—The work of construction in connection with this line has now actively commenced. The houses on the sites of the Marble Arch and Chancery Lane stations are being demolished, and the greater part of the open space in front of the Royal Exchange is being boarded in preparatory to the excavation of subsoil lying between the Mansion House, the Bank and the Royal Exchange, where the great central station is to be made. It is expected that the six and a-half miles of boring which is necessary will be accomplished by December 1, 1897, and that two and a-half years from now will witness the opening of the line.

**Physiological Investigations.**—In a recent communication to the Académie des Sciences, MM. H. Beauregard and E. Dupuy described some experiments carried out by them "On the Electric Variation caused in the Acoustic Nerve by Sound." These investigators find that whenever a sound falls upon the tympanum, an electric current traverses the acoustic nerve and is proportional to the pitch of the note, though they have not as yet established the connection between the current and the volume of the sound. They point out that this discovery places in the hands of physiological investigators what they consider to be a very certain method of determining the limits of audibility in different animals.

**A Submarine Torpedo Boat.**—On Monday evening last an exhibition was made of a model submarine torpedo boat, some 6ft. or 7ft. long, at the St. George's Swimming Bath, Buckingham Palace-road. The model represents a vessel of some 90ft. in length, and proportionate depth and beam, divided into several water-tight compartments, and provided with an under-keel equal in weight to the water which might be let in by shot or otherwise. The propelling power of this craft is electricity, which, it is stated, is supplied from storage cells specially designed for the purpose by Mr. Edward Manville. The air supply has been the special subject of investigation by Mr. Purcell, who has devised a reliable means for making good the loss of oxygen. On Monday night the model was worked from a dynamo. The details have been carefully worked out, and the main ideas are due to Mr. C. Seymour Allan.

**King's College.**—On Thursday, last week, at King's College, Strand, Lord Cranborne distributed the prizes gained during the past year by the students. The following are amongst the winners of some of the chief scholarships and prizes:—Engineering scholarship given by the Clothworkers' Company, C. L. Cartwright; the scholarships of the Clothworkers' Company for natural science, F. C. Mott and C. H. Gompertz; the Sambrooke engineering scholarship, T. R. Renfree. The proceedings were opened by the Rev. Dr. Wace, the Principal, who stated that the ceremony of that evening was something in the nature of a new departure, as it had previously been the custom to distribute the prizes in the various departments on different occasions, but those departments had now become so numerous that a combined distribution had been decided upon. At the close of the distribution Lord Cranborne gave a short address. The distribution was followed by a *conversazione*, which was very largely attended, the guests being received by the Principal and members of the staff. The various laboratories, museums, and studios of the college were thrown open, and demonstrations were given by members of the staff during the evening.

**A Detector of Electromagnetic Waves.**—In a recent communication to the Royal Society, intituled "A Magnetic Detector of Electrical Waves and some of its Applications," Mr. E. Rutherford investigates the effect of Leyden jar discharges on the magnetisation of steel needles, and shows that the demagnetisation of strongly magnetised steel needles offers a simple and convenient means for detecting and comparing currents of great rapidity of alternation. The partial demagnetisation of fine steel wires, over which is wound a small solenoid, was found to be a very sensitive means of detecting electrical waves at long distances from the vibrator. Quite a marked effect was found at a distance of over half a mile from the vibrator. Detectors made of very fine steel wire may be used to investigate waves along wires and free vibrating circuits of short wave-length. Fine wire detectors are of the same order of sensitiveness as the bolometer for showing electrical oscillations in a conductor. This detector also has the property of distinguishing between the first and second half oscillations of a discharge, and may be used for determining the damping of electrical vibrations and the resistances of the discharge circuit.

**The Kelvin Jubilee.**—The reply of the students of Moscow to the invitation of the students of Glasgow University to take part in the Kelvin Jubilee has not, says an evening paper, received the attention from the Press that it deserved, especially as the Russian youths requested their Glasgow would-be hosts "to do our letter as much as possible notorious." The communication is very quaint. Here, for instance, is a passage which shows the conditions under which learning is acquired in Moscow:—"It [the 'common administration'] raises against us the less civilised classes of the population as against men evil-minded and rioters, it surrounds us by spies, unseldom concealed under our 'academic dress,' sometimes even it sends in our middle provocators. We are even subjected to searches, the most active from us undergo administrative chastisements—they lose their liberty and sometimes for some years are send out from the cities having a university, what for many attracts the impossibility of ending their education and following the chosen career. Many intelligent and energetic men are perished by this police regime with all his discretion. . . . You see now, it is for us quite impossible to send any delegates; every person, sended by us, would undergo a too hard punishment. We salute nevertheless your professor, whose scientific merits are known to all the world, and we express our profound regret that we have no possibility of taking a more active part in the life of the Western intelligency, sympathy of which and the greatest possible connexion with which cannot but be to us very desirable." The letter, which had been sent under cover to Berlin, and there registered before being posted, is signed by the "Moscow Federative Council of the 45 United Zemljachestva of Moscow."

**Products of the Electric Arc.**—In a recent communication to the Académie des Sciences (*Comptes Rendus*, Vol. CXXIII., No. 1, p. 13) M. Henri Moissan states that pure tungsten can be obtained direct from the electric furnace by heating a mixture of tungstic acid and sugar carbon in the proportion of 800 grammes of acid to 80 grammes of carbon, and heating for 10 minutes with a current of 900 amperes at 50 volts. Tungsten prepared by means of the electric furnace can be obtained absolutely free from carbon, and when it is in the porous state it is capable of being welded to itself by hammering long before it reaches the point of fusion. It can easily be filed, and when free from carbon does not scratch glass. Pure tungsten also "cements" with ease, and when it has absorbed a certain amount of carbon it can scratch the ruby. The density of pure tungsten is 18·7, and it does not influence the

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magnetic needle. Heated in the electric furnace with silicium and boron, tungsten gives metallic compounds having a crystalline appearance and of great hardness. At a temperature of 1,200°C. carbonic acid is reduced by tungsten with a formation of blue oxide, but without any deposit of carbon. In the presence of excess of carbon, tungsten furnishes a definite carbide, $CTu_2$. This carbide is of iron-grey colour and very hard, and can scratch corundum. Its density at 18°C. is 16·06, and it gives rise to almost the same reactions as the metal itself, although it is more easily attacked by acids than the latter. This carbide ignites spontaneously in fluorine, and burns in oxygen at about 500°C., producing tungstic acid and carbonic acid, and in the liquid state it absorbs carbon, which it gives up again, on cooling, in the graphitic form. The fusing point of pure tungsten is higher than that of chromium or molybdenum. M. Moissan has further found that platinum, rhodium, palladium and iridium easily dissolve carbon at the temperature of the electric furnace and then give it up on solidifying, in the graphitic form. These metals do not combine with carbon and form carbides.

**The City and Guilds of London Institute.**—A brief history of this Institute has recently been compiled and published. It details how, exactly 20 years ago, a meeting of representatives of Livery Companies was held at the Mansion House, when the following resolution was adopted:—That it is desirable that the attention of the Livery Companies be directed to the promotion of Education not only in the Metropolis but throughout the country, and especially to technical education, with the view of educating young artizans and others in the scientific and artistic branches of their trades. Early in 1877 a Provisional Committee was formed to consider how best to apply the funds which some of the City Companies were willing to contribute towards the improvement of the technical knowledge of those engaged in the manufactures of the country. It was subsequently decided to establish a central technical college, technological examinations, and to encourage the establishment of local schools for workmen. From this have sprung the Central Technical College in Exhibition-road, the Finsbury Technical College, the South London Technical Art School, the Leather Trades' School in the Bethnal Green-road, and a system of technological examinations, to which in 1895 nearly 25,000 students submitted. The total amount subscribed by the Companies during the past 18 years is in round figures £480,000. The net cost to the Companies of their various technical education undertakings amounted last year to £21,838. The Finsbury Technical College started in the present building in 1883; there are now some 200 day and some 900 evening students; it costs £9,551 annually, and receives from students and similar sources £3,225. The Central Technical College was opened by the Prince of Wales in 1884, and the first complete course of instruction commenced in January, 1885; its day students now number some 200, and its evening and occasional students more than 500; the annual outlay amounts to £11,683, and its receipts, from sources other than the City Companies, amount to £4,993.

**The Rotary Converters at the Pittsburg Reduction Company's Niagara Works.**—The work that is being done by the Pittsburg Reduction Company at Niagara Falls is, says our Niagara Falls correspondent, attracting as much attention as anything in the electrical field here. Their fine new building on the lands of the Niagara Falls Hydraulic Power and Manufacturing Company, at the edge of the high bank, has been enclosed and will be ready for occupation and operation before many weeks. In addition to this it is announced that they will erect another large building. Should they decide to do this their facilities at the Falls will be very materially increased. The General Electric Company are now erecting the new rotary converters. These converters are the largest machines of this kind which have been built. They will be five in number, each designed to deliver 600 kilowatts in direct current at a voltage of 160. These machines have 16 poles and are operated at a speed of 188 revolutions per minute. Their commutators are of very large size, 3,750 amperes being delivered from each with carbon brushes. The General Electric Company have adopted a novel method of construction in these machines, by which the commutator is very effectively kept cool by ventilation. Through the commutator spider air is drawn, and, after passing over an extended surface inside the commutator, it passes out between the laminations of the armature and around the leads from the windings to the commutator. With each of the machines two 300 kilowatt transformers are used. The rotary converters are operated in pairs, each pair supplying one of the Pittsburg Reduction Company's circuits. So far two of these pairs, also one spare machine, have been put in, and there is still room for another pair. When the full equipment has been laid down, the capacity of the electrical plant will be 4,500 H.P., not counting in this the spare 750 H.P. unit. In the electrical plant of the Pittsburg Reduction Company, the transformers are built on iron floor plates over a trench having brick retaining walls. In this trench a forced atmosphere is maintained by a small blower, and the air from the trench passes upward through the transformers, and in its passage carries off the heat generated in them. All the conductors used, except the heavy current "bus" bars, are placed below the floor, many being in the trench below the transformers.

**Municipal Electric Lighting and Depreciation Funds.**—At the fortnightly meeting of the Finance Committee of the Hull Corporation last Friday, the question of the estimates for the electric light extension was again raised by Alderman Massey. The Chairman of the Finance Committee suggested that the Electric Lighting Committee should again consider the matter, and report to the next meeting of the Finance Committee. He had asked with regard to the depreciation, and he was informed that it was looked upon as part of the working expenses. Mr. Skinner (Chairman of the Electric Light Committee) said that they had charged the cost of *repairs* to the revenue account. Alderman Seaton said he felt convinced that with the basis he had to work on, the Borough Treasurer had made a very fair and proper report. He did not think the Finance Committee should challenge what the Electric Lighting Committee had agreed upon. Alderman Rayment thought it was a fair argument to say the estimate did not show anything on account of depreciation. The estimate also did not include anything for rating. It was true that the Committee did not at present pay anything for rating, but there was no doubt it would be heavily assessed in the future; therefore the financial statement from the Electric Lighting Committee was scarcely perfect. The Borough Treasurer asked Alderman Massey whether, in addition to the sinking fund, he thought there should be a depreciation fund, seeing that the Committee was bound to maintain the plant in good working order. Alderman Massey: "Certainly. You borrow money which you have to repay, and you try to get out of your position by saying the sinking fund is to cover depreciation. It is all rubbish and nonsense." Alderman Hall: "That means 8 per cent." Alderman Massey: "I don't care what it means." The Borough Treasurer said that a trading company had a depreciation account because the capital was found by shareholders, and there was no sinking fund to repay them. He did not know of any Act of Parliament which required the Corporation to set aside a sinking fund and a reserve fund. Alderman Massey said that, in addition to Acts of Parliament, they were governed by common sense. After some further discussion Mr. Skinner promised to discuss the matter with the Borough Treasurer.—The same point was raised on Monday at Edinburgh where the Electric Lighting Committee, under a recommitted report as to establishing a depreciation fund, reported adherence to their former recommendation that a renewal fund should be instituted. Sir James Russell said that the Council would be in an unsafe position in regard to certain parts of the electric light undertaking, if it did not go in for the proposed fund. Mr. Auldjo Jamieson argued that the Committee had stepped entirely beyond its functions. The business of the Committee, he held, was to make and sell electricity; the business of the Council was to administer the undertaking after the electric light had been manufactured and sold. He moved that the whole matter should be remitted jointly to the Treasurer's and Electric Light Committees. He asked the Council to make the statutory provision for contingencies by establishing a reserve fund, but he did not want to do that in a hurry. The House was counted out.

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## ELECTROMAGNETIC THEORY.—LXXXVIII.*

BY OLIVER HEAVISIDE.

(*Continued from page 282.*)

[*The following is supplementary to* § 349.]

§ 349A. When formulæ become somewhat intricate, there is a natural tendency to treat them mathematically only, so that the avoidance of error rests upon the mechanical accuracy of working, which can only be effectively confirmed by repetition and by the harmony of results obtained in varied ways. Under these circumstances it is satisfactory to be able to utilise some simple physical property of wide generality to test the formulæ. Such a property can be applied to the preceding formulæ with advantage.

When a simple coil, whose time-constant is L/R, has a current in it, say $C_0$ at time $t=0$, and is left to itself on short circuit without impressed force, the current subsides in such a way that $C=C_0\epsilon^{-Rt/L}$ is its value at time $t$. It is the elementary case of the destruction of momentum by a resisting force varying as the velocity. Any number of coils of different R and L, but with the same time-constant, will behave in the same way when on short circuit separately, and without mutual influence. The same is true when they are all connected in series to make a closed circuit. If the initial current is $C_0$ in the same sense in all, then the current in all subsides as if they were short circuited. There is no difference of potential generated between any of the terminals. There is, it is true, usually some difference of potential between parts of any one coil; but that is a residual effect, arising from the inductance not being quite the same for every turn of wire. This residual effect does not occur in the application to be made. Anyway, the terminals are at the same potential. They may therefore be joined together through any unenergised arrangement of coils and condensers (without introducing mutual influence across the air), and the current in the original circuit will behave in the same way as before described. Every coil wastes its energy against its own resistance independently of the rest. (It is also possible for the external combination to be energised in special ways without interference, but we do not want that at present.)

The above being a purely magnetic property there is a similar one concerning electric displacement. A leaky condenser (or a condenser with a shunt), if initially charged to potential $V_0$, and then left to itself, discharges itself so that $V=V_0\epsilon^{-Kt/S}$ is the potential at time $t$. Here S/K is the time-constant of subsidence, the ratio of the permittance of the condenser to its conductance. The same is true of any number of condensers separately: if they have the same time-constant, the discharges will be alike. They may be put in parallel without any alteration if their potentials are the same, and no difference will be made by joining the various positive terminals together through any (usually unenergised) electrical arrangements, and also the negative terminals. Every condenser will still discharge itself through its own conductance, and waste its energy therein.

The two properties may be co-existent in one combination in many ways. The particular way we want now is this. First, have a long series of coils of any resistances, but all with the same time-constant L/R. Then put their junctions to earth through condensers of any permittances, but all with the same time-constant S/K. The result is a generalised telegraph circuit, in which the resistance, inductance, permittance, and leakance are collected in lumps, so to speak. But the actual distribution may be continuous, if we like, and is, in any case, quite arbitrary, subject to the constancy of the magnetic and electric time-constants.

Two rows of similar coils may be employed. Then the condensers are to be joined across from one row to the other. But this somewhat complicates the description. One series is enough.

By the preceding, it follows that if the initial state is $V=V_0$, constant, and $C_0=0$, where $V_0$ is the voltage of the condensers, and $C_0$ the current in the conductor consisting of the series of coils, then the state at time $t$ later is simply $V=V_0\epsilon^{-Kt/S}$, and $C=0$. The waste of energy is in the leakage conductance, and is quite local. There is no development of magnetic force. The true current (in Maxwell's sense) is the sum of the conduction and displacement current, and this is zero for every condenser, little or big.

The circuit may be infinitely long. But if it be only of finite length, we must take care that the terminal arrangements obey the same law. Either the ends must be insulated, making $C=0$, or we may put the ends to earth through condensers having the same time-constant S/K, and have them initially charged to the same voltage $V_0$.

Similarly, if the initial state is $C=C_0$, a constant current, and $V_0=0$, the state at time $t$ will be $C=C_0\epsilon^{-Rt/L}$, and $V=0$. The energy starts magnetic and remains magnetic. The waste of energy is in the conductor of the circuit, and is quite local. In order to complete the analogy as regards "true current" in a physical manner, that is, by making a possible case of electromagnetic wave propagation in a conducting medium, we require to introduce the idea of magnetic conductance to replace the real electric resistance of the circuit, as explained in Chapter IV. In default of that, the analogy is partly only a mathematical one. Leaving out the completion of the analogy physically, it is to be further noted that if the circuit is not infinitely long, the terminal arrangements must be suitably chosen. We require either a dead earth at the ends, making $V=0$, or else terminal coils possessing the same time-constant L/R, and initially charged with the same current as the rest of the circuit.

It follows further, that if in the first case, where the initial energy is wholly electric, the initial state be not one of constant $V_0$, there must still usually be a term involving the time factor $\epsilon^{-Kt/S}$ in the resulting potential, unless the mean value of the initial potential should be exactly zero. Also, in the second case, concerning magnetic energy only initially, there must be a term involving $\epsilon^{-Rt/L}$ in the resulting current when $C_0$ is not constant to begin with, unless its mean value should also be zero. How to reckon the mean values will appear presently. Moreover, the determinantal equation must contain the isolated factor Y or $K+Sp$ in one case, and Z or $R+Lp$ in the other, when the above conditions are complied with.

§ 349 B. The Bessel results previously given come under the last Section, because they involve constancy of the electric and magnetic time-constants in spite of the variation of the resistance, &c., per unit length of circuit. We may therefore test the results, and exhibit the solitary terms concerned. If the source is $h=pQ$ at $y$, that is, a charge Q initially at $y$, we may write the operational solution for the potential which results thus,

$$V=\phi^{-1}pQ, \tag{118}$$

and the values of $p$ which make $\phi^{-1}p$ infinite are the constants $p$ in the time factor $\epsilon^{pt}$. If $v$ is the partial solution for any $p$, then

$$v=\frac{Q}{\phi'}\epsilon^{pt}, \tag{119}$$

where $\phi'$ means $d\phi/dp$. Now, if we know that $Y=0$ gives an isolated root of $\phi=0$, we can write $\phi=Y\theta$, where $\theta$ does not vanish with Y. Then

$$\phi'=Y'\theta+\theta'Y=Y'\theta_0=S\theta_0, \tag{120}$$

if $\theta_0$ is the value of $\theta$ when $Y=0$. So

$$v=\frac{Q}{S\theta_0}\epsilon^{-Kt/S} \tag{121}$$

is the partial solution. The denominator $S\theta_0$ is evidently the permittance concerned.

The full operational solution in this case is (61), § 342, in terms of J and G functions, but it is easier to evaluate $\theta_0$ in terms of $J_m$ and $J_{-m}$. So use the equivalent form (59), § 342, or

$$V_1=\frac{\frac{1}{2}\pi Zh}{(xy)^m}\frac{(J_m-\rho J_{-m})_x(J_m-\sigma J_{-m})_y}{(\rho-\sigma)\sin m\pi}, \tag{122}$$

where

$$\rho=\frac{J_m+A'J_{m+1}}{J_{-m}-A'J_{-m-1}}(\lambda), \qquad A'=\frac{\lambda^n sZ_n}{Z}, \tag{123}$$

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and $\sigma$ is got by turning $\lambda$ to $l$ and A′ to $-$B′ in $\rho$; B′ also containing $l$ instead of $\lambda$ and $Z_1$ instead of $Z_0$.

It does not look as if $Y=0$ were involved in (122). But then it has to be remembered that $J_m$ has the factor $s^m$. So, put $J_m=s^mP_m$, and balance the powers of $s$ in the numerator against those in the denominator of (122), on the understanding that

$$Y_0=Z_0^{-1}=m_0(K+Sp), \qquad Y_1=m_1(K+Sp), \qquad (124)$$

where $m_0$ and $m_1$ are positive constants, so that there are terminal condensers with the proper time-constant. We shall then obtain, not the factor Z shown in (122), but $Z/s^2$; that is, $-Y^{-1}$, as required, making $Y=0$ give a root of the determinantal equation. Remember that $x^nY$ and $x^{-n}Z$ are the leakance, and the resistance operators of the circuit per unit length.

The evaluation of $\theta_0$ is now easy, because $Y=0$ makes $s=0$, and reduces the J functions to their first terms, or the P functions to constants free from $s$. The result is that (121) becomes

$$v=\frac{Q\epsilon^{-Kt/S}}{S\left(m_0+m_1+\dfrac{l^{n+1}-\lambda^{n+1}}{n+1}\right)}, \qquad (125)$$

showing that the mean value of the potential—that is, the charge divided by the total permittance of the circuit, including the terminal condensers—subsides in the proper way.

In case of terminal insulation, $m_0=0$, or $m_1=0$, or both. These are included in (125), and give finite $v$. At the other extreme we have $m_0=\infty$, or $m_1=\infty$, or both, and $v=0$. But the term $v$ will still exist finitely if the initial state includes charge of one of the terminal condensers to a finite potential, for then the mean potential will be finite. Practically, however, a short circuit will mean simply $K_0=\infty$ at the terminal, and no condenser. Then $v=0$. The special term does not exist.

Observe that if $m_0$ and $m_1$ are defined to be $Y_0/Y$ and $Y/Y$, and if it be assumed (with or without warrant) that $Y=0$ gives a root, we shall obtain $v=0$ usually, because $m_0$ and $m_1$ are made infinite. The exception is when $Y_0$ and $Y_1$ vanish when Y does; the above case, in fact. Then $Y=0$ really gives a root.

In the other case, if the source is $e=p$P, or the momentum P initially at $y$, we may write

$$C=\phi^{-1}p\mathrm{P}, \qquad (126)$$

using the proper $\phi$, not the same as before, of course. Then if we know that $Z=0$ gives a root of $\phi=0$, we have $\phi=Z\theta$, not the same $\theta$ as the last. Also, if $c$ is the partial solution depending upon $Z=0$, we have

$$c=\frac{\mathrm{P}}{\phi'}\epsilon^{pt}=\frac{\mathrm{P}}{\mathrm{L}\theta_0}\epsilon^{-Rt/L}, \qquad (127)$$

and now we have only to evaluate $\theta_0$, the value of $\theta$ or $\phi/p$ when $s=0$, because $Z=0$ makes $s=0$.

The potential and current solutions are (111), (113). In terms of $J_m$ and $J_{-m}$ and the previous $\rho$ and $\sigma$, they are

$$V_1=-\tfrac{1}{2}s\pi e\frac{y^{m+1}}{x^m}\frac{(J_m-\rho J_{-m})_x(J_{m+1}+\sigma J_{-m-1})_y}{(\rho-\sigma)\sin m\pi} \qquad (128)$$

$$C_1=\tfrac{1}{2}\pi Ye(xy)^{m+1}\frac{(J_{m+1}+\rho J_{-m-1})_x(J_{m+1}+\sigma J_{-m-1})_y}{(\rho-\sigma)\sin m\pi}. \qquad (129)$$

This is on the left of $y$. The $C_2$ on the right side is got by interchanging $x$ and $y$ in $C_1$. The $V_2$ is got by interchanging $\rho$ and $\sigma$ in the numerator only of (128). The signs of $\rho$ and $\sigma$ have to be carefully attended to. The formula of derivation used is the first of (114) for $J_m$ in $V_1$. But it is different with $J_{-m}$. The companion formulæ to (114) are

$$\frac{1}{s}\frac{d}{dx}\frac{J_{-m}\text{ or }G_{-m}}{x^m}=+\frac{J_{-m-1}\text{ or }G_{-m-1}}{x^m}. \qquad (130)$$

Applying (127) to (129), we see first that $Z^{-1}$ does not show itself. But as before, put $J_m=s^mP_m$. The factor Y then becomes $Ys^{-2}$, that is, $-Z^{-1}$, showing that $Z=0$ gives a root, provided

$$Z_0=R_0+L_0p=n_0(R+Lp), \qquad Z_1=R_1+L_1p=n_1(R+Lp), \qquad (131)$$

so that there are terminal coils having the proper time-constant.

Lastly, evaluating $\theta_0$ by the first terms of the J functions as before, we obtain

$$c=\frac{P\epsilon^{-Rt/L}}{L\left(n_0+n_1+\dfrac{\lambda^{-2m}-l^{-2m}}{2m}\right)}, \qquad (132)$$

where $2m=n-1$. The denominator is the total inductance of the circuit, including that of the terminal coils, and $c$ expresses the mean value of the current throughout the whole circuit at every moment.

When $n_0=0$, or $n_1=0$, or both, we have one or more terminal earths or short circuits. If either of $n_0$ or $n_1$ is infinite, it expresses more than a disconnection, for $L_0$ (for instance) is also infinite. The result is $c=0$, but $c$ can be finite if the initial state includes a finite current in the terminal coil. Practically, a disconnection produces $c=0$ in another way. There is no terminal coil as a reservoir for magnetic energy, and the special term involving $Z=0$ does not exist.

It will be observed in the above evaluations that the quantities A′ and B′ which occur in $\rho$ and $\sigma$, equation (123), are reduced to $s\times$ constant or $s^{-1}\times$ constant by the special terminal conditions. This makes $\rho-\sigma$, (apart from the special factor Z or Y above considered), become a function of $s^2$. In general it is not a function of $s^2$ but of $p$. So now in concluding this part of the subject it may appropriately be pointed out that this property can be generalised in many ways by appropriate terminal conditions involving electric and magnetic energy. We have merely to make $Z_0/Z$ and $Z_1/Z$ be functions of $s^2$. It is sufficient to illustrate by an easy example. Let

$$Z_0=R_0+L_0p+(K_0+S_0p)^{-1}, \qquad (134)$$

This says that $Z_0$ is a coil and a condenser in sequence between the terminal and earth. Divide by Z; then, if $R_0+L_0p=n_0Z$ and $K_0+S_0p=m_0Y$, we obtain

$$\frac{Z_0}{Z}=n_0-\frac{1}{m_0s^2}. \qquad (135)$$

To be a function of $s^2$, $n_0$ and $m_0$ must be constants, that is, $n_0=R_0/R=L_0/L$, and $m_0=K_0/K=S_0/S$. Similarly we may make $Z_1/Z$ a function of $s^2$.

In all such cases $\rho$ $\sigma$ is made a function of $s^2$ (with the possible extra factor), and its roots are calculable by tables of Bessel functions. Then there are two $p$'s to every $s^2$ in a known manner, so that the time functions are known, and a complete development can be obtained.

[Corrections.—§ 347, equation (94), *for* $J_{m+1}$ *read* $J_{-m-1}$. § 348, *for* (90) *read* (88); twice. § 349, equation (109), for $q$ read $q^2$; and correspondingly in (113), for $s$ read $s^2$; and in equation (112) interchange $)_x$ and $)_y$.]

*(To be continued.)*

## THE SURVIVING HYPOTHESIS CONCERNING THE X-RAYS.

BY DR. OLIVER LODGE, F.R.S.

Referring to an article by the writer which appeared some months ago (*The Electrician*, Feb. 7), under a title akin to the above, in which the present state of our knowledge concerning the radiation experimented on by Lenard and discovered as such by Röntgen was summarised, and an account given of the various hypotheses which had suggested themselves, it may be not inappropriate to state the present aspect of the matter, now that there has been further experimental progress.

The remarkable discovery of MM. Henry, Niewenglowski, and Becquerel that salts of zinc, of calcium, and especially of uranium exposed to strong light acquire the power of emitting, both then and afterwards, an invisible radiation which can penetrate aluminium and act on a photographic plate, has greatly strengthened the position of those philosophers who maintained that the X-rays were of the nature of ultra-ultra-violet light; and it has done this in the following way:—

The Becquerel rays are capable of some amount of polarisation, and hence are certainly transverse disturbances, like

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light; they can also be reflected and refracted to a small extent, whereas the X-rays can be hardly at all reflected and not at all appreciably refracted. Neither kind can be deflected by a magnet, not even in a vacuum according to the experiments of M. Lagrange; and an assertion that the X-rays could be magnetically deflected after passage through an electrified plate has not been substantiated by careful experiments, made by the writer among others. Taking all these things together, and looking at them in the light of a notable dispersion theory of Von Helmholtz, to which Prof. J. J. Thomson called attention in the Rede Lecture at Cambridge this year (June 10), it has become almost certain that the X-rays are simply an extraordinary extension of the spectrum—far beyond the ordinary ultra-violet—and that the Becquerel rays are a less extreme extension in the same direction.

As a matter of scientific history it may be worth recording that in an article on Röntgen's discovery, published in the *Revue Générale des Sciences* for January 30th, Prof. Poincaré hazarded the suggestion, "that all bodies which fluoresce strongly enough may perhaps emit X-rays in addition to ordinary light, *no matter how the fluorescence is caused.*" He goes on to say that although this is not very probable yet that it is possible, and should be easy to verify; and that, if true, the X-rays would no longer be producible by electrical means alone. In attempting the verification of this surmise, M. Charles Henry found and published on February 10th that sulphide of zinc emitted something which could affect a photographic plate after penetrating black paper, or even a sheet of aluminium 6mm. thick; and M. Niewenglowski, February 17th, found the same thing for calcic sulphide. Then M. Becquerel, February 24th, repeating Niewenglowski's experiments, discovered the remarkably persistent ray-emitting power of the double sulphate of uranium and potassium. Moreover, it is noteworthy that, at a meeting of the French Physical Society held on February 7th, M. Raveau called attention to the fact that several existing theories of dispersion led to the value unity for the index of refraction of substances for very short waves, and hence argued that it was quite possible for the non-refrangible X-rays to be a variety of ordinary transverse ether waves of extremely short period.

To us at the present time the dispersion theory of Helmholtz is by far the most interesting, because it was worked out entirely on the basis of the electromagnetic theory of light. It is contained in Vol. XLVIII. of *Wiedemann's Annalen*. Helmholtz there shows, on electromagnetic principles, that ethereal radiation of smaller and smaller wave lengths should become more and more refrangible, by matter in the molecular form, up to a certain maximum; and this, of course, is ordinary dispersion; but that for waves which are shorter still, the refrangibility—*i.e.*, the refractive index of substances for such very short waves—should rapidly, indeed almost suddenly, drop nearly or quite to zero, thus doubling the spectrum back upon itself, and giving an anomalous dispersion so great that the rays might be bent by a prism in the wrong direction (the direction beloved of examination candidates) for a certain size of wave. This state of things would be accompanied by extreme opacity, or absorption of the vibrations by the material molecules. If, however, waves existed of a kind still smaller, then the opacity would become less obtrusive; the refractivity would likewise remain very small—either positive or negative, perhaps—but probably negative; and ultimately, for extremely small waves of atomic dimensions, the refractivity $(\mu - 1)$ would become nothing and the opacity very small.

In a general way it may be said that material atoms act as if they loaded the ether, so that coarse ether waves large enough to affect some dozens or some hundreds of molecules in a row, such as are the waves of visible light, would by reason of this loading be retarded, and therefore both reflected and refracted. All very coarse waves would be refracted about the same amount, but for smaller waves a new phenomenon would appear; as they got smaller the period of the waves might synchronise with some of the periods of atomic vibration, such vibration as enables atoms to emit light, and whenever that occurred a violent absorption might be expected, owing to the syntonic response or sympathetic resonance between the matter and the ether. This would have the effect at first of retarding the waves rather more, and of giving the well-known effects of ordinary dispersion, or the sorting out of waves roughly according to size, which we get in the prismatic spectrum. Or if the syntony is strongly marked, fluorescent and phosphorescent effects are to be expected from the jangled atoms; and if for this or any other reason absorption is rapid, the dispersion will be what is called "anomalous," which in this connection—indeed in all possible connections—only means unexpectedly complicated.

Push the matter further, however; assume the existence of waves smaller still, so small that they cease to evoke any vibratory response from the material atoms among which they now make their way; the ether of the interstices can hardly be appreciably loaded by the great blocks of immovable substance which now represent the appearance of the atoms, and accordingly retardation and refraction abruptly disappear together, and true absorption also nearly ceases.

To waves penetrating ethereal interstices, matter, even conducting matter, is fairly transparent; for ordinary notions of conductivity do not apply to these intermolecular spaces; electric displacements no longer excite necessary conduction currents, even in bodies which in the gross are conductors, and accordingly there is little or no dissipation of energy, and any obstruction that exists to the passage of light of this kind is of the ground-glass or turbid-medium type, a certain percentage of the energy being scattered at each obstacle in all directions, instead of being able to excite the material vibrations which we know as heat.

This is a very bare account of the matter, but it may suffice to indicate the sort of view which is now coming to be almost universally held regarding the nature of these no longer quite *x* rays. The proof is not complete, and will not be till their length has been measured, but in all probability they are ordinary transverse ethereal waves, moving with the customary velocity of light, of various grades of wave length down to $10^{-8}$cm. in length, vibrating therefore some trillions of times in a second (a trillion being $10^{18}$); and by the aid of this highest type of X-ray we may hope in the future to gain some diffractional insight into the actual structure and appearance of the material molecules among which they go.

In all probability they are excited by Hertz vibrations in the atoms themselves. Ordinary light may be due to mechanical or acoustic atomic vibrations; but this X kind of light is more likely due to electric vibrations, *i.e.*, to surgings of the atomic charges. A globe of steel vibrating mechanically might excite ether waves a hundred thousand times the sphere in size, if it could excite them at all; but, vibrating electrically, its radiated ethereal waves would be not much bigger than the sphere itself. In other words, its vibration frequency would be multiplied nearly a hundred-thousand fold. The mechanical vibration of an atom may emit ordinary light. Its electrical vibration may quite possibly emit X-rays.

There is not lacking indirect evidence to show that what we call atomic weight is approximately proportional to atomic bulk, *i.e.*, that the heaviest atoms are the biggest atoms, and that the actual substance of all matter may be much more nearly of one uniform density than is commonly supposed. Grant this hypothesis, and it is plain why platinum or other dense material appears to be the easiest substance in which to excite the necessary electric atomic oscillations, by the impact of charged and excessively rapidly moving gaseous particles. It also suggests that the gas with the most rapidly moving atoms, viz., hydrogen, may be the best substance for the vacuum bulbs to contain; for these would impart their charges to the large platinum atoms in the most sudden manner. It would also be plain why dense bodies should be more turbid than rare, and it is not unnatural for the turbidity to be largely a matter of atomic weight, *i.e.*, bulk, than anything else, because the ethereal interstices required for the passage of the waves would in such substances be considerably filled up.

Calculate the speed of a hydrogen atom in a vacuum tube between two electrodes, kept oppositely electrified with a difference of potential corresponding to a two-inch spark between flat plates, *i.e.*, 150,000 volts. The atomic monad charge is

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$10^{-11}$ electrostatic unit, so the force acting on an atom is 0·8 millionths of a dyne, over a range of, say, 5 cm. The mass of the atom is $10^{-26}$ gramme; so its acceleration is $8 \times 10^{19}$ C.G.S. units, and hence the speed that may be got up in 5 cm. of free path approaches very near the velocity of light, say $1{\cdot}5 \times 10^{10}$cm. per second. If there are collisions the speed will be reduced, hence it is probably desirable that the gas should be pure, and the necessity for high vacuum is obvious. Too high a vacuum reduces the number of impinging molecules, and so weakens the intensity, but it permits the emission of the most penetrating rays, *i.e.*, those with the greatest frequency number, or highest up in the spectrum.

Unless a charge is imparted to a molecule with something approaching the above estimated rapidity, it would not be likely to have electrical oscillations excited in it; just as it is only possible to excite Hertz vibrations in ordinary small pieces of matter by some very rapid means of communicating the electricity; otherwise the disturbed electric equilibrium restores itself in a dead-beat manner.

It is likely that the amount of energy thus consumed in the production of Röntgen radiation is extremely feeble, and that the rays themselves are of low intensity. All that they do is consistent with the supposition that their activity depends more upon synchronism than upon violence,—which is indeed the case with ultra-violet radiation of every kind.

It is worth while to attempt to give rather a better account of the most immediately obvious results of Helmholtz's new dispersion theory—one of the last grand pieces of work before his bootless journey to Chicago. But it is to be hoped that a translation of the Paper may make it more widely known to English readers.

*Results of Helmholtz's Theory.*

Helmholtz's electromagnetic theory of dispersion gives as the refractive index of a quite transparent substance to radiation of frequency $n$ (that is $n \sim$ per second) the following simple expression:—

$$\mu^2 = \frac{a^2 - n^2}{b^2 - n^2},$$

where $a$ and $b$ are two constants depending on the material, and to be determined by experiment.

For very long waves the refractive index is accordingly $a/b$; for shorter waves it increases at first slowly and then rapidly up to infinity, which it reaches when $n = b$; it then becomes imaginary until $n = a$, after which it increases steadily from zero, until for very large values of $n$, that is for extremely short waves, it approaches the value *unity*.

So long as the substance is really transparent, it is not physically possible for $n$ to equal $b$, and accordingly in such a substance, if such a substance exist, the refractive index merely increases as the waves get shorter. But perhaps a better way of stating this is to say that when $n$ approach $b$ it is impossible for the medium to be thoroughly transparent; and the effect of an absorption or opacity term is to pull down the infinite value of $\mu$ to a large maximum value, attained when $n = b$; and after this, instead of becoming imaginary, it rapidly drops down towards zero, which it attains, or nearly attains, before $n = a$, and it then increases again, and goes on increasing, up to the definite limit 1, which it only actually reaches when $n$ is infinite. In the region of the maximum $\mu$, the opacity of the medium for waves of that frequency is great, but on either side of it the opacity is moderate, and at some distance on either side is zero. In other words, a medium is transparent both for very long and for very short electromagnetic waves; but while the long waves are definitely refracted, the very short waves are not refracted at all.

Between these two frequencies there is a region of opacity and of anomalous dispersion, and in this region the refractivity may be negative, *i.e.* the refractive index may be less than 1, as has been actually observed by Kundt to be the case for some metals. Waves of high but not ultra-high frequency may be reflected and refracted a little, and these correspond with the recent discovery of Becquerel and others; but waves of exceedingly high frequency are barely refracted or reflected at all, and these are the waves of Röntgen.

The writer suggests that a first estimate of the frequency, and therefore of the wave length, could be got by measuring the percentage of X-ray reflected from a substance of known dispersive power; still better by measuring the deviation, if any perceptible deviation can be got. Observed deviation, introduced into Helmholtz's formula, would give only a lower limit for the range of frequency, and that only by extreme extrapolation, but it would be better than nothing.

Such is a rough account of the theory prepared by the extraordinary genius of von Helmholtz, on purely mathematical and Maxwellian grounds, in 1893! before even the experiments of Lenard, and indeed without any likelihood of an idea that the waves whose theoretical niche was thus provided were so soon to be practically displayed in the laboratory as an accomplished fact.

*Addendum.*

It is interesting to look back now to the beginning of the present year, and see how near the early speculators on the subject of Röntgen's discovery approached to what is now in all probability something like the true view of the nature of X-rays. One of the earliest published letters was from Prof. Schuster, in *Nature*, Vol. LIII. (No. 1369), which may now be referred to; and an unpublished letter received by the writer from Prof. FitzGerald in the month of January is so remarkable as closely anticipating the course of discovery along several lines that the writer thinks he is not acting wrongly in printing it here without permission.

"January 24, 1896.

"About those curious photographs which you have sent me. After a variety of notions: including a suggestion that they are a new form of wave-propagation in the ether by a distortion of the *section* of vortices, which may exist all the same and remains for discovery; and a consideration of the possibilities of long waves acting on silver molecular groups, as the shorter ones act on the atoms, and their possible shaking being like the rearrangement of iron molecules, when jarred enabling them to be magnetised; and [after considering also] the action of coherers, I have discarded all these in favour of *very* short waves, ultra-ultra-violet radiations of a wave-length comparable with what would be produced by the Hertzian oscillations of electrical charges on atoms. Such ought to exist, and I think these are they.

"Objection No. I. *Transparency.*—Gold leaf is already too transparent for its conductivity for light waves; and waves that could go along in the interstices between molecules, for which matter was a sort of grove of trees with a sound going through it, a sort of turbulent [turbid] medium,—for such a material for such short waves we might naturally expect a transparency depending rather on density than on any electrical or chemical properties of the medium.

"Objection No. II. *No Refraction or Reflection.*—These, of course, go together. If there is no rapid change of medium there is neither of them, nor polarisation. The velocity of propagation in the interstices between molecules is probably the same as in free ether, and we could any way only expect an effect of the same kind as Cauchy's term in $\frac{b}{\lambda^2}$ for the dispersion that is added on to a specific refraction; and this added effect would be all that would exist, and might probably be very small, so that there would be neither refraction nor reflection.

"I would suggest trying some experiments with two slits of the diffraction kind; to look for a wave-length, though the fuzziness of the photos does not give much hope of success in this at present; for, if I am right, the diffraction effects should be on a *very* small scale.

"Maybe we may yet learn how to photograph molecules themselves by means of these very short waves. This seems to me a very hopeful hypothesis, even though only a few hours old.

"These ultra-ultra-violet waves may also be the means by which cathode rays are projected from the outer surface of windows. Ultra-violet vibrations discharge surfaces, ultra-ultra ones may throw off cathode rays, as Lenard has observed."

Postcard Next Day.—"Since writing to you I have seen Schuster's letter in last week's *Nature*. It quite expresses my

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views. Ramsay has got a beautiful hand photograph. Is the effect reversible? Cathode rays make ultra-ultra-violet radiation—does the radiation reproduce cathode rays? Is this the same as discharging surfaces by light? G. F. F.G."

Part of these suggestions remain still unverified, but there is a good deal to be said for them. The discharge of surfaces by light is due, according to the writer's experiments, to convection by gaseous particles; and what are regularly moving charged gaseous particles but a variety of cathode ray?

## SOME EXPERIMENTS WITH RÖNTGEN RAYS.

BY JOHN BURKE, B.A.

The following is an account of some experiments which for a few months past I have been carrying out at Owens College, the details of which will appear later on.

I have been led to them by a research on a subject closely related to, or perhaps identical with, the phenomenon of X-rays, namely fluorescence, or the lengthening of the period of vibration of light. The experiments of Becquerel seemed to show that many substances in which this process was produced also gave rise to the inverse one of shortening the period, and thereby suggested the correlativeness of both. In either case the processes do not appear to be directly related to temperature, and thus may be styled phenomena of luminescence.*

Some experiments on the diselectrifying power of the X-rays for the purpose of measuring their intensity have led to those

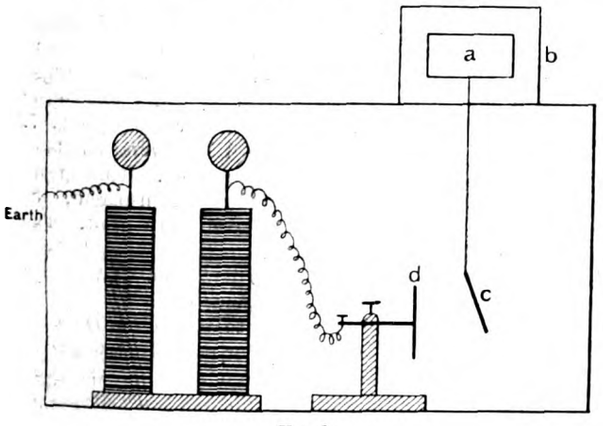


FIG. 1.

on luminescence, to be described later on, and which for the present may be regarded as illustrating the method of measuring the radiation here given.

§ 1. On account of the varying intensity of the rays from the vacuum tube, a method of determining the total radiation in the form of X-rays falling on an electrified metal disc was essential when the conditions were such that the rate of discharge was necessarily slow; and for this purpose a radiometer, if we may so call it, has been employed, the principle of which is illustrated in Fig. 1. Its position relatively to the tube was fixed, and its indications taken as the standard, so that the radiation by which a single to-and-fro movement was effected was taken as the unit given out by the tube of the aluminium-penetrating diselectrifying radiation.

A zinc plate $a$ surrounded by an aluminium cylinder $b$ is connected to a brass rod, to the lower end of which an aluminium leaf $c$ is fastened. The metal plate $d$ is charged to a potential of about 200 volts by the dry piles shown in the figure. The whole apparatus, with the exception of $a\,b$, is enclosed in a wooden box lined with tinfoil. Thus, when the charge on $a$ is removed the leaf $c$ is drawn towards the plate $d$, and on touching it, if the position of the latter has been properly adjusted, it is instantly repelled until the charge on $a$ is again dissipated, when the same process is repeated, and so on. The leaf is thus automatically attracted and repelled, the number of times this takes place being a measure of the total radiation emitted by the tube during the time that another electroscope is discharged through a certain number of divisions on the scale of the latter, which was so placed that its time of discharge had to be necessarily long. A thin sheet of aluminium of the same thickness as $b$ was interposed in the path of the rays reaching B (Fig. 2).

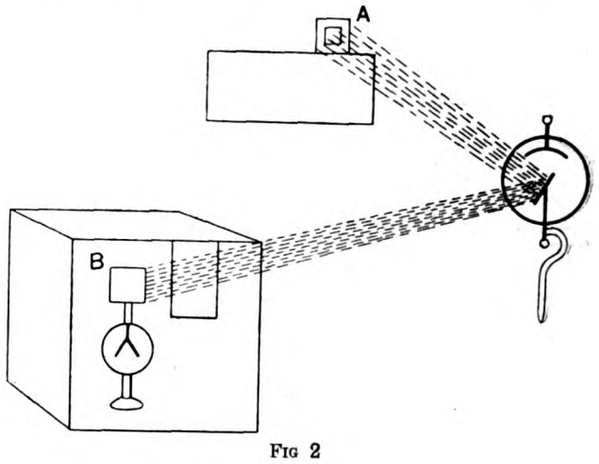


FIG 2

We shall call the automatic electroscope A and the other B. Fractions of a discharge when necessary were taken with a microscope and suitably graduated scale. The position of A being fixed relatively to the tube and the direction of the other, the ratio of the radiation received by A to that given out by the tube, and to that given out in any particular direction, is constant and independent of the intensity or nature of the rays, in other words of the vacuum in the tube (*see* Fig. 2). A method is now being tried by which the radiations on A are registered, which avoids the labour of attending to both electroscopes at once. One discharge of A corresponded to a collapse of the leaves from 18 to 6 divisions on the scale B.

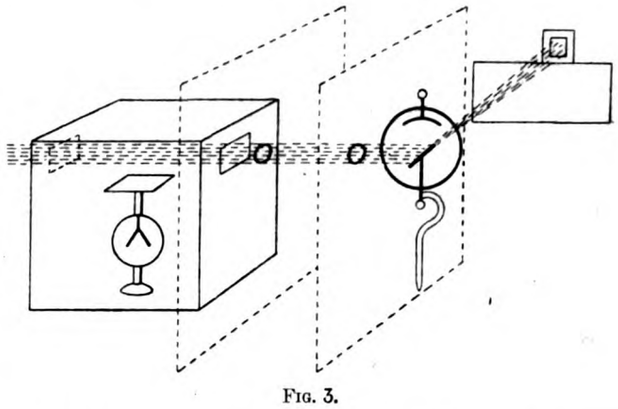

FIG. 3.

If, now, by screening or otherwise of B the same discharge from 18 to 6 required $n$ of A, then the radiation received by B is $1/n$th of the original.

§ 2. The electroscope B retained its charge for about two hours, and when enclosed in a tinned-iron box, well earthed and air-tight, and a parallel beam of X-rays was sent through two ebonite windows in the box, opposite each other, so that it did not fall on the electrified plate of the electroscope, but passed between it and the top of the box (*see* Fig. 3), the electroscope was slowly discharged from 18 to 6 divisions in about five minutes corresponding on the average to about 22 discharges of A. The effect, however, did not take place when

* By *luminescence* is here understood not necessarily the emission of luminous rays, but (1) change in wave-length, as in fluorescence, by an increase, or, as in many substances, by the diminution of wave-length, such as Becquerel has found to take place in many bodies in which fluorescence lasts for some time, and are called phosphorescent substances. (2) No change in wave-length, but the process still of an intermolecular kind, and, therefore, the emission dependent upon the absorption of the incident rays, so that the emitted light differs from the diffused light scattered by reflection.

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the coil alone was working, nor when the vacuum was below or above that necessary for the production of the X-rays.

§ 3. Raising the electroscope B so that the charged plate was in the path of the rays made little difference, but the amount of radiation required to discharge B was somewhat diminished when the plate was vertical and in the path of the rays. It was found that paraffin placed over the electrified plate and in the path of the rays also increased the rate of discharge.

§ 4. The rays were then sent as in Fig. 4. The rate of discharge was less than before, but still very marked, and blowing into the box with a bellows produced a more marked effect when the tube was working that when it was not. By interposing, however, a lead screen in the path of the rays the beams still collapsed, though far more slowly.

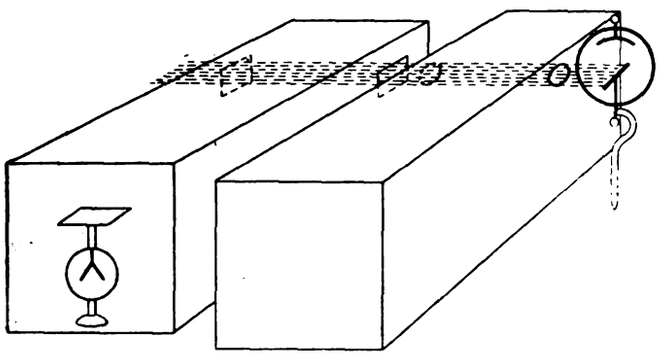

FIG. 4.

§ 5. A brass sphere embedded in paraffin was then connected to the electroscope, as in Fig. 5. The rays, after passing through an aluminium window in the side of the box and traversing the block of paraffin in which the sphere was embedded, were stopped by a thick lead screen in contact with the paraffin, and consequently prevented from entering the surrounding air inside the box. The paraffin was also covered with lead on all sides except where the rays entered, lest by scattering or otherwise they might get at the air, which, if it became conducting, would cause the charge on the electroscope to be drawn altogether away to the sphere by putting the outer surface of the paraffin to earth. The rate of discharge was almost the same when the electroscope stood by itself before it was connected to the sphere as afterwards. In either case the leakage was slow, and required about 40 discharges of A in about 10 minutes.

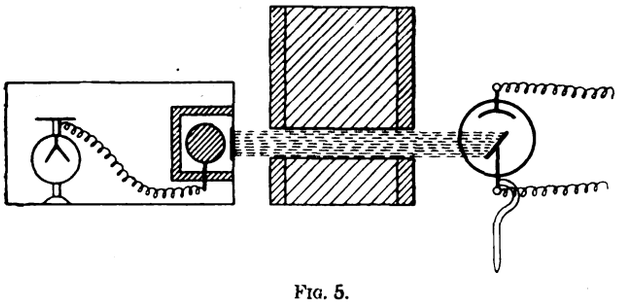

FIG. 5.

The question as to the dielectrification in paraffin was deferred, and the investigation turned upon the cause of the discharge of the electroscope itself under such circumstances, when apparently it had been screened from all radiations.

§ 6. When a lead screen 2mm. thick was interposed in the path of the small parallel beam of rays the rate of discharge was not appreciably affected, nor did the addition of three or four such screens make any perceptible difference. But when the tube, the axis of which was horizontal, was turned round it through an angle of 180deg., so that the side of the platinum from which the rays emanated was away from the electroscope, the duration of the discharge was increased, though not more than 30 per cent. The direct radiations being clearly screened off, the effect was probably due to luminescence of the air, or possibly to scattering, if it was due to rays at all.

§ 7. Removing the lead screens and wooden block shown in Fig. 5 made no difference in the time of discharge, but when the tube was turned round to its original position a very great difference was caused by this large block, notwithstanding the presence of the brass sphere and the small lead screen behind it. These were enough to stop the small parallel beam of rays, but their influence was not so marked when the rays came at a larger angle, and consequently were able to enter the box through the tinned iron. When the block was replaced it was found that if a wooden box 1cm. thick was put over the metal box the time of discharge was practically the same as when the former was removed, but the discharge was almost stopped when the metal box was completely surrounded with lead.

§ 8. These experiments were repeated with a thick glass vessel instead of the metal box, as in Fig. 6, with very similar results, the radiations appearing to come from all directions, but more especially, of course, from the direction of the tube. When the stopper was removed a slight increase in the rate of discharge was produced.

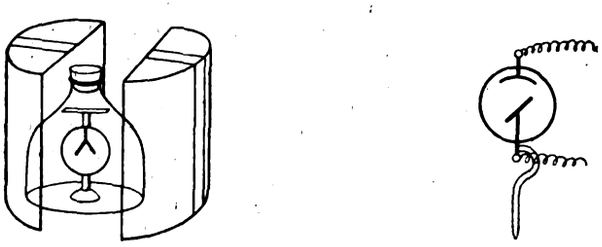

FIG. 6.

§ 9. I then tried whether, the air being rendered luminescent by the passage of these rays through it, it would be possible to photograph round a corner, as it were. And after prolonged exposures of several hours, shadows of shillings and other objects were obtained by the method illustrated in Fig. 7. The photographic plate was well wrapped in several sheets of black paper, and the objects laid over the paper. Thin sheets of copper, tin, and aluminium were somewhat transparent, but lead very opaque. Paraffin gave better results than air. The experiment is being repeated *in vacuo*.

§ 11. Attempts are also being made to detect polarisation with tourmaline plates by comparing their shadows when parallel and crossed. If this should be found to take place, it would prove *conclusively* that air, or the dust, or possibly, though not probably, the micro-organisms in it, are rendered luminescent by

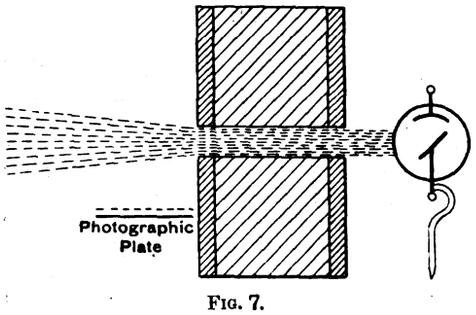


FIG. 7.

the passage of these rays through them. In other words, that the air, &c., is fluorescent to them. There appears also to be evidence that the fluorescence lasts for a short time, since when a lead screen was placed over the photographic plate, Fig. 7, and an exposure of 12 hours given, the rays were found to have entered sidewise all round to a short distance of about half a centimetre between the lead sheet and the plate. This was probably due to the movement of the excited molecules rather than to scattering by reflection, see § 6.

§ 12. The effect of scattering from surrounding objects was studied. In the first place, it had been shown by Joly, and I obtained results similar to his from needles and other metallic objects, that reflection of Röntgen rays only took place to a marked degree at grazing incidences. It followed, therefore, that if the lead screen shown in Fig. 7 affected the

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plate by deflection of rays scattered by the air, the portion of the plate nearer the screen should have been more affected than that farther away from it, chiefly on account of the grazing reflection from its surface, but no such effect was found. Then a wooden screen was placed vertically on one side near the plate, but no increased effect was produced on the side of the plate nearer the screen.

§ 13. It is hardly likely, I think, that the effects above described were due to scattering or reflection from very minute particles of dust or air, though in the absence of polarisation effects or something to distinguish conclusively the properties of rays which produced these effects from the original X-rays, such a view, notwithstanding much that may appear to be opposed to it, must nevertheless be held as something more than a pious doctrine.

Scattering may, and probably does, take place in air, perhaps even from the molecules themselves, on account of the minute wave-length; but it is difficult to conceive that such diffused light would spread to so large an extent as to produce the photographic, and more especially the electrical effects observed.

§ 14. It has been found by Frankland and MacGregor that the hologen compounds are most opaque to the X-rays, and J. J. Thomson and McClelland have shown that the rate of discharge is also most rapid in the hologens and mercury vapour, which harmonises with the view that the discharge in gases is due largely to rays other than the original on account of the marked influence of the absorptive power of the gas, which probably luminesces and thus affects the rate of discharge in it.

There is, I think, much evidence for believing that the process of fluorescence, or lengthening of wave-length and period of the vibration of light, is accompanied by or perhaps dependent upon ionisation or some sort of partial dissociation of the molecules of the fluorescent substance; and some experiments on fluorescence, to be described when complete, have led to somewhat interesting results from this point of view of the subject.

§ 15. By sending a parallel beam of X-rays between two electrified metal plates without falling directly on either, it has been found that the rate of discharge in gases is roughly proportional to the square-root of the pressure, that is, proportional to the number of ions. It may be, then, that it is to this ionisation that the luminescence owes its origin, and by it, though possibly independently of it, diselectrification occurs. The point, however, that gases which absorb most are those in which diselectrification is most rapid, suggests more than that the two are merely concomitant phenomena, and seems to indicate a closer relationship between them. If the effect were due to scattering by the molecules, it ought to have been proportional to their number, rather than to the number of ions.

I am indebted to Prof. Schuster for much valuable advice throughout this research, as also for the use of his own apparatus, and to Prof. FitzGerald for the criticisms that from time to time he has given me, from which, it is needless to say, I have derived great benefit.

## ON THE DISSIPATION OF ENERGY CAUSED BY THE ARMATURE CURRENTS IN ELECTRICAL MACHINERY.

BY OTTO T. BLÁTHY.

It is generally assumed that the total loss in a dynamo electric machine when under load can be pretty closely approximated by determining the loss when running at normal speed and normal E.M.F., but without any current in the armature, and adding to this the energy dissipated in consequence of the ohmic resistance of the armature by the current flowing through it (in this article as well as in all researches giving the data for it, no consideration is given to the energy used for exciting the fields, this being always supplied by an external source of current). If $L_o$ be the amount of power necessary for driving a dynamo at normal speed and standard E.M.F., this power being used to overcome the frictional resistances and that caused by fan action, and for supplying the energy dissipated by hysteresis and eddy currents; R, the resistance of the armature; and I, the armature current, then it is usually supposed that $L_i$ the energy dissipated in the dynamo when the current I is flowing through the armature, is pretty closely represented by the formula—

$$L_i = L_o + R\,I^2.$$

A series of researches carried on for the last 15 months in the shops of Messrs. Ganz and Co., of Budapest, and which on account of the pressure of current business could not be brought to a satisfactory conclusion, has shown that the generally accepted supposition is *very far* from the truth. With very few exceptions it was found that the loss in a dynamo under load is considerably larger than the amount resulting from the above given formula.

Generally the experiment was made by coupling directly a dynamo to another of identical design, or by driving the one from the other by a fast running belt. One of the machines was used as a motor and the other one as generator, while in a second series of tests the rôle of motor and generator between the two machines was reversed. The energy supplied to the motor, as well as that furnished by the generator, were controlled by volt, ampere, and watt meters; and the latter instruments, whose indications were mainly relied upon, were changed over from the motor to the dynamo, and *vice versâ*. In this way errors due to the unequal behaviour of a dynamo when used as a motor and as generator, and to small differences in the calibration of the watt meters was eliminated. The loss caused by the change in the condition of the belt (when such was used) when running light or under load was also taken into consideration, but the influence of this factor was found quite insignificant.

First, the ordinary types of direct-current dynamos manufactured by Messrs. Ganz and Co. were tested. These are the two-poled Delta dynamos, from 5 to 60 H.P., and the four to eight-poled C dynamos, from 25 to 160 H.P. All these dynamos embody in their design the most approved and latest ideas. The armature conductors are wound in the slots of cores made of the very best charcoal-iron sheet. The loss due to armature resistance is generally from 2 to 3 per cent. of the nominal load of the machine. The direction of the magnetic flux in the armature is reversed from 900 to 2,600 times per minute. The result of all these numerous tests can be given by the formula—

$$L_i = L_o + c\,R\,I^2.$$

In all these dynamos the coefficient $c$ was from 1·8 to 2·6.

In a machine of 110 H.P. built for experimental purposes, having 8 poles, running at 650 revolutions per minute, normal speed, provided with a field-magnet built up of thin sheet-iron, and the armature resistance of which was rather under 2 per cent., the factor $c$ came up to 3·5. With this type an extended series of tests was undertaken, which resulted in proving that the "load-loss" $= [c-1]\,R\,I^2$ was quite the same, with the same E.M.F. per single turn in the armature, whether the armature is wound as a drum or as a Gramme ring, for high or low pressure, as a parallel or as a series-wound drum. It also made no difference whether the armature wires were put in slots in the armature core, or wound in a single layer on a smooth core, the air gap in this latter case being more than double that used with the slotted core. The armature of this dynamo was also connected to two collector rings, and the load-loss was sensibly the same when a certain amount of energy was furnished by the dynamo either as direct current or in the form of an alternating current. Having a field-magnet of the ordinary type in massive iron, or a laminated field magnet, proved equally without influence on the amount of the load-loss.

The most remarkable thing about this load-loss is the fact that the strength of the magnetic field has not much influence on the load-loss caused by a given current in the armature, the load-loss being apparently nearly exclusively determined by the number of ampere-turns on the armature. Even with a short-circuited armature, and a field only just able to induce the normal current in the short-circuit, the load-loss was more than one-half of the value found for same when the dynamo gave the same current at the standard E.M.F.



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Up to now the dependence of the load-loss upon the speed has not been exactly determined; anyhow, the load-loss increases more rapidly than the speed, but less than the square of it.

An experimental alternator of 30 H.P., the design of which was outside the limits of commercial machinery, and which had a constant reluctance of the magnetic circuit for all relative positions of armature and field, gave the extravagant value of 7 for $c$; the load-loss amounted to 14 per cent. of the total "capacity" of this machine.

Only one of the types of electrical machines I experimented upon was free from this load-loss; it amounted to less than $\frac{1}{2}$ per cent. of the rated "capacity" of the dynamo. This was the A type of alternator, built by Messrs. Ganz and Co., nearly without any alteration for the last 10 years. The field-magnet consists of a spoked wheel, without rims, built up of sheet iron, while the stationary armature cores have the form of T's, the coils being slipped on the inwardly-radially projecting shafts of the T.

As to the question in what part of the dynamo the energy of the load-loss is dissipated in heat, it could only be ascertained that most of the heat is evolved in the armature iron, while in the armature coils and the field-magnet iron only a small portion, if any, of the load-loss could be located.

## CABLE SPECIFICATIONS AND TESTS.*

BY JOS. A. JECKELL (SOUTH SHIELDS).

The persons who issue specifications for cables may be divided into three classes: 1. Those who know what they want, and are desirous of obtaining it on the most favourable terms. 2. Those who have not made up their minds what they will have, and are anxious to receive suggestions. 3. Those who do not care what they have, so long as it is cheap. It is only proposed to consider specifications issued by the first class, since by this time it is not too much to assume that all borough electrical engineers are capable of deciding what, in their opinion at any rate, is the most suitable kind of cable for their purpose; and having done so, it is only right that they should clearly set forth in the specification what cable is required.

It is not at all fair to contractors for an engineer to issue an open specification, when he has a very clear idea what cable he intends to have, and it is only a question who will offer it on the best terms. Contractors are put to an enormous amount of unnecessary trouble and expense by wide, indefinite specifications, and of course, for this they make some one pay; therefore, in the end, this unnecessary expense is borne by the Corporations, and increases the price of the cable. The same difficulty, of course, must always beset an engineer who has to draw up a specification for almost all electrical plant, and that is, the specification cannot be as favourable to one maker as to another if he does not define clearly what he wants; but if he does this, there is an end of the matter. If the specification states that compound cables are required, then all makers of compound cables are very much on the same footing, and makers of rubber cables are out of the hunt, and *vice versâ*. This manner of clearly specifying what is wanted seems to be best for all parties. But the writer has heard of a case where, one class of cable having been very clearly specified, a maker of another class sent some one round to interview the members of the Electric Lighting Committee, to try and get the specification altered. The firm dared not go to the engineer, because they knew very well that he had had a considerable amount of their cable before, and it had been very unsatisfactory. In this case the members of the Electric Lighting Committee were far too shrewd to listen to the fairy tales of the contractor, who wanted to push his goods as against the impartial advice of their engineer, and the contractor got the treatment he deserved—treatment which ought to be meted out to any others who may be inclined to adopt the same method of business. Another reason for clearly stating what manner of cable is required, is that there will be much less difficulty in stating what tests the cable will be required to stand, for those which are suitable for a rubber cable are unsuitable for a compound cable and *vice versâ*, perhaps. If an engineer, for instance, is determined to have rubber-covered cables, how much better it would be if he said so clearly, and not exclude all others by putting in some test which he knew none but rubber-covered cables could stand. Let it be assumed, therefore, that the engineer has made up his mind what kind of cable he wants, and that he clearly sets this forth in his specification.

Tinned copper wire for cable manufacture can now be obtained having 100 per cent. conductivity according to Dr. Matthiesen's standard. Some cable manufacturers say that they can obtain copper wire having 100 per cent. conductivity, but not tinned copper wire and gauged over the tin. But the best makers of copper wire are prepared to guarantee 100 per cent. when gauged over the tin; in fact, they cannot find any perceptible difference in the gauge after it has been tinned, such a very small coating is put on.

If the price lists of the various makers are examined, it will be found that there is a very considerable difference between the conductive resistance of cables. This may be accounted for by many causes; for instance, the conductivity of the copper used; the length of lay of the wires; the tightness of the lay; whether the wires are twisted or cabled; and whether each wire in the strand is more or less insulated from the rest. A very simple way to get over all these difficulties, and to obtain just what is wanted, is not to give the number of strands and their size in the specification, but simply specify what resistance per mile the conductor has to be, and the number of strands of which it has to be composed—and, if desired, the conductivity of the copper; but this does not much matter, because it makes no difference to the engineer whether the cable manufacturer uses 98 per cent. copper and puts more in, or 100 per cent. and puts in less; what he does want is that the cable shall have a certain conductivity per mile, as he has based all his calculations on this.

All strands should be cabled, and not twisted—*i.e.*, the machine used for this purpose should be of the sun and planet motion; unless this is done, the wires will themselves be twisted, and therefore hardened; but very few makers are so far behind the times as to use the old twisting machine now.

If the cable required is concentric, care should be taken to specify that the outer conductor must have the same copper resistance as the inner; for if the outer has the same sectional area as the inner, its resistance certainly will be more than that of the inner. It has been known to be as much as $7\frac{1}{2}$ per cent. more, but this is rather an outside figure.

Now, as to the insulation, the specification of this, of course, depends upon whether the engineer has decided to have rubber cables or compound. If the former, it is well to specify that the rubber shall be well vulcanised together, so that the different layers cannot be parted by mechanical means, because there are cables where the various layers can be peeled off from one another. And it is as well to state that the tape or felt next the rubber which is vulcanised should be broad, because a narrow one sometimes presses too deeply into the rubber when it is vulcanised, if it has been put on rather tight. With regard to the insulation resistance, this must, of course, depend upon the kind of cable required. There is no use in having a very high insulation resistance *per se*; what is required is an insulation that will not deteriorate. If, however, rubber cables are specified for, it is absolutely necessary to fix a high insulation resistance per mile, because when a sufficient thickness of rubber has been put on for mechanical purposes, the insulation resistance is sure to be high if the rubber and workmanship are good. It is hard to obtain a very high insulation resistance on a rubber-covered cable unless the rubber and workmanship are of the best, and therefore, generally speaking, for a given thickness of rubber insulation the insulation resistance is a very fair test of the quality of the material and workmanship. If a high insulation resistance is obtained, even when poor rubber is used—and it is possible to do so—the rubber will generally on examination appear to be of inferior quality. About 5,000 megohms per mile is a very fair insulation to require for a first-class rubber cable, and of course this test should be made with a battery having at least 500 volts.

But if compound cables are specified for, it is very undesirable to insist on a high insulation resistance; not that it is impossible of attainment, but if it is obtained, it is pretty certain that the cable will be quite spoilt. Almost all compound cables are made very much in the same way. The conductor is covered with some hygroscopic substance, out of which all damp is extracted, and then it is impregnated with some insulating compound. If a high resistance is required, the cable will have to be over-baked and the hygroscopic substance reduced to tinder, and that of course spoils the cable. Great care should be taken in accepting a compound cable having a high insulation resistance; for this reason a pressure test is of much more value, in order to see if a compound cable is good or not. The weak point of a compound cable is that it is liable to be damaged if it is bent, therefore it is as well to put into the specification a bending test. Some engineers have specified that the cable should stand being bent six times backwards and forwards over a drum 2ft. in diameter. This is a very good method, but the object to be arrived at is to be sure that the insulation is not damaged with any bending that does not damage the lead, because if the lead seems sound and the insulation is damaged, a cable may be injured and nothing known about it. Therefore any bending tests that will prove this will be satisfactory. Some compound cables when placed in a vice, and the end bent first one way and then the other once, snap off like a carrot.

It is very much safer and more satisfactory that the makers of the cables should do the laying, because otherwise they could not

* Paper read before the Municipal Electrical Association.

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guarantee them, as even the best cable can be irretrievably damaged by being badly laid, and it is really surprising how very few men know how to lay a cable properly. It is not more economical to the purchaser to lay the cable himself, because he very frequently expends twice as much on wages in drawing in or laying as the manufacturer of the cable would do. The writer is not, however, an advocate of letting the trench work to the cable manufacturer. This work they would sublet generally, and it is much more convenient that it should be done by the Corporation workmen who are always engaged in repairing the streets, &c.

Whatever tests are specified as having to be conducted at the makers' works should undoubtedly be repeated as far as practicable after the cables have been laid and jointed up. For a rubber cable for high-tension working a pressure test of double the working pressure, and afterwards a test of the insulation in megohms, which should be about 5,000 per mile, would be satisfactory. The copper resistance should also be taken, to make certain all the joints are well made. It is rather hard to specify what the insulation resistance of compound cable should be, because the resistance varies very much with the different substances used for insulation, but of course the insulation should be uniform. If a certain cable, well made, has, say, an insulation resistance of 1,000 megohms per mile, a length should not be accepted which had only 500 megohms per mile; and yet a different cable having 120 megohms, if that was the insulation when it was well made, would be quite satisfactory. In one instance the writer joined a cable having 1,200 megohms per mile to a different cable having only 120 megohms; both cables worked equally well at a pressure exceeding 2,000 volts.

The insulation tests will be made after one minute's electrification, because that is the generally accepted method; but why one minute should be the time limit is not very evident. It would be all very well to have one minute as the time limit if all substances electrified equally, but it is quite conceivable that we might have one cable which after one minute's electrification showed a lower resistance than another, and yet when it was completely electrified it might show a higher insulation resistance than the other. Therefore there is an additional reason for specifying a pressure test. This pressure test would probably vary under different circumstances, some makers not objecting to test their cables to 20 times the working pressure.

The question of a long guarantee is rather an awkward one, as many makers will not guarantee their cable unless their own men make all the joints on it after it has been put to work. This, of course, is rather awkward to arrange. It very much depends, however, upon the system on which the cables are laid; but considering that there are various kinds of insulations being introduced, and that a lasting quality is so very essential, it seems very desirable that the life of the cable should be guaranteed. In one instance a firm who were tendering for some cables, on being asked how soon they would undertake to send men to repair a fault if it occurred, guaranteed that the men should start the repairing work within two weeks of receiving notice. Rather more expedition than that would be required in most electrical stations.

DISCUSSION

Mr. C. H. WORDINGHAM (Manchester) said the mains were the most important thing in a system. He thought the author was a little hard in his opening paragraph as to people who did not know what they wanted. For his part he believed in having alternative specifications, one for rubber and one for another class of cable. As to high insulation resistance not being necessary, *per se*, he entirely agreed with that. He entirely disagreed with the author as to its being more satisfactory to let one man put in the pipes and another to join the cables. He believed a lot of mistakes had been caused through this. Personally, he thought the Corporation should do the whole of the work.

Mr. A. B. MOUNTAIN (Huddersfield) said they had had some difficulty with their mains at Huddersfield, and the remarks that the author made about laying the pipes were interesting. He thought that should be taken in hand by the Corporation themselves or the whole of the work left to the contractor. They had had far more difficulty with cables laid in pipes than they had with those laid in the ground. He did not think the mechanical damage to cables was sufficiently acknowledged.

Mr. J. HARDIE McLEAN (Oxford) said there would be no chance of the cables being damaged if the system of pipes was right. If the contractor was paid for laying them, the station engineer was supposed to see that they were put in properly; and if they were damaged, it ought to be found out at the time the damage was done, and not later on.

Mr. H. TALBOT (Nottingham) said he believed in the guarantee system. The cables they had at Nottingham were guaranteed for three years.

Mr. ALEXANDER SIEMENS said he should wish to talk as much as possible from the consumers' point of view. The principles laid down in the Paper were very good, but he did not think Mr. Jeckell had gone far enough. The question of cables first cropped up when central stations began to be built, and the firm with which he (Mr. Siemens) was connected at once took the matter in hand, and they had come to the conclusion long ago that rubber cables, unless they are covered with lead, were no use whatever. They were absolutely certain to lose their insulation gradually, especially when in places where they get alternately wet and dry. This did not apply to rubber cables in houses, because there they were prevented from becoming alternately wet and dry, and the insulation would then last sufficiently long for practical purposes. But even in houses damage had been done simply on account of the crazy desire for high insulation. He thought the real secret, which Mr. Jeckell had mentioned in his Paper, was that the quality of the insulation should be uniform throughout. He thought Mr. Jeckell was wrong in repeating that 5,000 megohms should be the insulation, because he did not state for what size cable. He thought it was really unscientific to say that the insulation of a cable, no matter what the diameter was, should be a certain fixed figure. They had found jute cables lasted very well. In one instance a cable, which was lying in front of Charing Cross station, was tested under 3,000 volts. It was the first his firm had made for the London Electric Supply Company, and it was tested to 3,000 volts, although the regular voltage was not to exceed 2,400. It took 2,400 very well, but directly they put 3,000 volts on it, it sparked through. They made a proposition to the Company not to pay them for that cable for three years, and to see what it would do, and to use it for their regular work. The Company had used it down to the present time, and it had never given the slightest trouble.

Mr. STUART A. RUSSELL (India Rubber Company) thought the high-pressure test should be made before the bending test was applied. Mr. Jeckell seemed to think that high insulation was proof of a good cable, and low insulation was necessarily proof of a very inferior article; but he (the speaker) was not at all convinced on that point. He thought experience rather tended to show the opposite.

Mr. W. ARNOT (Glasgow) thought the cable specification should state the copper resistance wanted, and that would keep the lay in the strand right.

Mr. G. H. NISBITT (Insulated Wire Company) said he thought Mr. Jeckell had made a very good Paper in a very short space. Mr. Jeckell had divided the class of engineers who issued specifications into three. He should like to add a fourth class, and a most important class—those who did not care what they had so long as it answered their purpose. As to the question of durability on this point, as far as appearances went at present, the lead-covered cables were the better.

Mr. CALLENDER had strong objections to a specification definite in every detail, calling upon them to give a certain class of cable only to find that something else was really wanted. It was often a matter of serious expenditure, for in many cases samples were called for. All he asked for was that a specification should be left perfectly open, or that only general particulars should be given. He knew of some cases where cables were specified first as to the number of strands, and then as to the section of square inch, and the two differed by 8 or 9 per cent. With reference to compound cables and the high insulation test, he had made some very good cables and had got 15,000 megohms.

Mr. CROMPTON said he generally found that cables were affected by the climate. A cable that would last a lifetime in England would break down in a very few years in India, and that was a very serious thing, and it only showed that they must devise some means of producing or specifying a cable which would last under difficult conditions, which, although they did not exist in this country, did exist abroad. He believed the time would come when it would be found that rubber was no longer useful as an insulating material. With regard to lead-covered cables, he thought there was no doubt that they had led to most disastrous results in places.

Mr. J. S. RAWORTH said all the previous speakers had trenched a little bit upon his ground, without getting exactly to the point he wanted to bring before the meeting. There was length and breadth and thickness to an insulator. They persistently stuck to one dimension, and that was the mile. What they wanted to get at was, what was the resistance of an acre of a certain insulator 1in. thick, and could they ascertain by measurement or by coaxing the manufacturer, what was the very best insulation per acre that was to be got out of the very best specimen of that class. They could then specify that a cable should not be insulated up to more than class D, and that the insulation should not be less than 75 per cent. of its calculated value. They would immediately know then whether they were getting value for their money or not. They did not know how to describe their insulation, and the manufacturer made it just what he liked. They only wanted to know that the manufacturers had given them what they had asked for and paid for.

---

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## THE THREE-WIRE PATENT.

A question which for the past twelve months has been exercising the minds of engineers and electric lighting committees connected with low-pressure supply systems was effectually set at rest by the Judicial Committee of the Privy Council on Wednesday morning last in a little more than an hour and a-half. The Chancery Bar mustered in its strength; Sir RICHARD WEBSTER was there, and so were Mr. FLETCHER MOULTON, Mr. BOUSFIELD, Mr. WALLACE, and Mr. WALTER. The great army of expert witnesses was also well represented by Lord KELVIN, Sir FREDERICK BRAMWELL and Mr. VERNON BOYS. The representatives of municipaldom, in the persons of well-known central-station engineers, town clerks, and chairmen of committees, also helped to fill the not unlimited accommodation of the Privy Council chamber. But this marshalling of forces was to little purpose. By one o'clock the petitioners for the prolongation of the three-wire patent No. 3,576 of 1882 were non-suited—and non-plussed.

At the commencement of the proceedings the Attorney-General, on behalf of the Crown, raised a technical objection, the purport of which both the Court and Mr. FLETCHER MOULTON, who appeared on behalf of the Westinghouse Company, apparently misunderstood, since the intricate point of law, which was thereupon argued at great length, was, whether a favour intended for patentees proper could be granted to a joint-stock company to which a patentee had sold his entire rights. Seeing that the Patents, Designs, and Trade Marks Act of 1883 expressly defines, in Section 46, a patentee as "the person for the time being entitled to the benefit of a patent," and seeing that extensions have from time to time been granted to public companies, as assignees, the inadmissibility of the plea seemed self-evident to the lay mind; and when, after an instructive legal discussion between the Judicial Committee and Mr. FLETCHER MOULTON extending over nearly an hour, Sir RICHARD WEBSTER rose to say that he had been completely misunderstood, no one appeared in the least surprised. The position taken up by the Law Officer of the Crown was in reality that the Westinghouse Company, in clause 29 of their pleadings, asked for an extension of the HOPKINSON patent upon grounds which were not recognised by the Act of 1883. Below we

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give this fateful plea of the petitioners, and have italicised the fatal argument. Lord DAVEY, from whose lips the ominous phrases "a mere commercial speculation," "a bad speculative bargain," came often and with emphasis, was probably easily brought to see the impropriety of this particular plea, and after a quarter of an hour's deliberation the Committee became of one mind, and the petition for extension was straightway dismissed.

> "Your petitioners submit that, in the face of the great opposition to the claims of your petitioner, Dr. John Hopkinson, to any patent rights in the three-wire system, and the certainty that, when the electric lighting companies commenced to lay their cables on the three-wire system, such rights could only be enforced after long and protracted litigation, it was essential for the proper development of the three-wire system that the interest in the patent should be vested in a company having the means to carry on the litigation, and the means to develop the invention; and *the petitioning Company submit that, at the present day, it is a meritorious action on the part of public companies to take up and assist inventors in developing inventions of great public utility; and that it is reasonable that if, through circumstances over which they have no control, they have not been able to obtain a sufficient remuneration for the moneys expended by them in developing the invention, their merit in undertaking the development of the patent should be recognised by an extension of the term of the patent, sufficient to enable them to obtain such reasonable remuneration.*"

The electric supply industry will, therefore, on and after Monday, July 27th, be freed from the shackles (such as they are) of this master patent. In February last (see *The Electrician*, February 28th, p. 586) we discussed at some length this very question of the prolongation of patents beyond their natural term of 14 years, and expressed views adverse to the present system of here and there extending the life of a patent. If it be found that patentees are not as a rule adequately remunerated in 14 years, let the life of *all* patents be sufficiently extended to attain that laudable aim; but do not let us increase the speculative character of the already highly speculative enterprise of patenting by every year arbitrarily varying the duration of a few patents. The proceedings in connection with Dr. HOPKINSON'S invention have not tended to make us alter that opinion. It may be said that the life of patents is not arbitrarily, but judicially, varied. The term "arbitrarily" may be "unparliamentary," but it is apposite. Can anything be more arbitrary, in the ordinary acceptation of the word, than that the fundamental questions of the meritoriousness of an invention, and the adequacy of the inventor's remuneration, should be made entirely subsidiary to the degree of legal craft displayed in drawing up a petition? It certainly will be an ill day for the electrical industry of this country when the American custom of forming powerful combinations to run master patents "for all they are worth" is imported into England, and becomes recognised as an entirely legitimate mode of making money. But at the same time it cannot be denied that there is much truth in the plea of the Westinghouse Company that at the present day few inventors can get their rights without the aid of protecting syndicates or companies. That being so it would seem desirable in the interests of inventors to treat companies' petitions with the same tender solicitude that is displayed in the case of the genuine poor inventor when he on rare occasions manages to plead his cause before the Judicial Committee of the Privy Council. The evident tendency which exists to place a ban upon the petitions of joint-stock companies is an excellent way of lowering the market value of patents and so far discouraging invention. The three-wire patent was in every sense of the word a good patent, and it would have been more satisfactory in every way for the question of its extension to have been fought out on its merits with the aid of the large corps of barristers and experts engaged on either side. That Dr. HOPKINSON'S patent possessed sufficient merit to warrant a seven-year extension there can be no doubt. The interesting and instructive point would have been the assessment by the Judicial Committee of the remuneration which properly rewards an invaluable idea. The non-suiting of the petitioners in this case should prove a useful object-lesson for those desirous of impressing upon the Legislature the necessity of prohibiting the game of chance known as petitioning the Privy Council to prolong a patent.

## FUNERAL OF SIR JOHN PENDER.

On Friday last, in the "God's acre" of the quaint little parish church of Foot's Cray, Kent, within a short distance of the house where so many pleasant memories cluster, were laid to rest the mortal remains of Sir John Pender, Knight, "born September 10, 1816; died July 7, 1896." The vault wherein the body, in its plain oaken coffin, was deposited had not been opened since the burial of Lady Pender in 1890. Here also lies interred the body of Sir John's second son, Henry Denison Pender, who died at Foot's Cray on January 13, 1881, aged 28, after an illness contracted in Rome

Foot's Cray Place being close to the church, the mourners were able to traverse the journey through the park surrounding the house on foot. The mourners included—Mr. James Pender (M.P. for Mid-Northamptonshire, eldest son of the deceased), Mr. J. Denison Pender (youngest son), Masters John Cuthbert Denison and Henry Denison Pender (grandsons), Sir G. W. des Vœux (son-in-law), and Mr. des Vœux (grandson). Sir John was followed to his last resting place by a large number of those associated with him in the great enterprises with which his name will always be so closely connected. The little church was packed with a congregation of about 200, who listened intently to the beautiful "Service for the Dead," which was impressively rendered by the Vicar of Foot's Cray, the Rev. Charles Birch, assisted by the Very Rev. Dean Bradley, Dean of Westminster, who conducted the closing scenes of his old friend's earthly career with great sympathy, and deep emotion. A large and reverent crowd of villagers was attracted to the prettily-situated churchyard, where the family vault of the Penders was literally covered with the floral offerings of friends absent and present. Owing to the absence from England of a great number of Sir John's fellow-workers in his great submarine cable enterprise, many who would otherwise have been present were prevented from paying the last tribute of affection to their old comrade and chief; but some consolation to those who, from circumstances beyond control, were compelled to remain at Buda Pesth to watch over the important interests of the great cable companies, is given in the fact that all the leaders of the industry who could possibly pay this last token of respect to the man who has done so much for submarine cable work were present, and mingled their grief with that of Sir John's family at the death of one whose memory will long be held in reverence as the leading spirit for half a century of that noble and necessary work of "bridging the distance" between the nations, of cementing peace and goodwill among men, and of enabling the colossal commercial transactions associated with the close of the nineteenth century to be conducted with that speed and absolute accuracy so essential to a successful issue.

In addition to the members of the family, those present at the funeral included:—The Marquis of Tweeddale, Lord Sackville A. Cecil, Admiral Lord John Hay, Lord Kelvin, F.R.S., Lord Portsmouth, The Hon. W. St. John Brodrick, M.P., The Hon. A. G. Brodrick, The Very Rev. Dean Bradley (Dean of Westminster), Messrs. C. F. Vennidt and H. Schiotz (representing the Great Northern Telegraph Company), Mr. Fred. Ward (representing the Commercial Cable Company), Messrs. J. T. Crowe and J. A. Chisholm (Deputation from the London Caithness Association), Admiral Sir Leopold Geo. Heath, K.C.B., Sir Henry Mance, C.I.E., Sir Eyre M.

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Shaw, Mr. E. Cunliffe Owen, C.M.G., Mr. E. M. Underdown, Q.C., Mr. Allen, Mr. Kenneth L. M. Anderson, Mr. W. T. Ansell, Mr. F. Bailey, Mr. S. Barber, Mr. E. R. Barker, Mr. S. Barlow, Mr. W. Barnett, Mr. F. A. Bevan, Mr. W. Boeck, Mr. W. G. Bond, Mr. A. Brown, Mr. T. A. Bullock, Mr. W. H. Burman, Mr. Charles Burt, Mr. John Cambrook, Mr. T. Cole, Mr. Richard Collett, Mr. Sidney Collett, Mr. E. W. Cox, Capt. W. H. Davies, Mr. F. Dawes, Mr. C. W. Earle, Mr. R. Enfield, Mr. W. Faulkner, Mr. T. Finnis, Mr. A. C. Forshaw, Mr. W. G. Foster (of Cadiz), Mr. D. Gair, Mr. E. Gardner, Mr. S. Goodman, Mr. M. Kaye Gray, Capt. Greey, Mr. J. G. Griffiths, Mr. A. R. Hardie, Mr. J. F. Harrap, Mr. P. L. Isaac, Mr. G. C. Jack, Señor J. W. P. Jauralde, Mr. A. R. Johnson, Mr. T. Johnson, Mr. F. R. Lucas, Mr. W. R. Lyne, Mr. A. R. H. Mackay, Mr. H. R. Macdonald, Mr. MacLennan, Mr. J. McMillan, Mr. W. H. Owen, Mr. E. W. Parsons, Mr. E. D. Payne, Mr. J. E. Payton, Mr. W. Payton, Mr. H. W. Pinnell, Mr. H. A. E. Plank, Mr. F. T. Preddle, Mr. J. Porter, J.P. (of Colwyn Bay), Mr. J. Lloyd Price, Mr. P. R. Ranger, Mr. A. W. Rixon, Mr. F. L. Robinson, Mr. H. A. C. Saunders, Capt. Scott Smith, Mr. R. R. Simpson (Edinburgh), Mr. W. Smithson, Mr. G. B. Stacey, Mr. C. E. Stewart, Mr. C. W. Strong, C.B., Mr. Herbert Taylor, Mr. Geo. Tucker, Mr. John Tucker, Mr. A. Urquhart, Mr. J. L. Verne, Mr. F. Walters, Mr. L. S. Wells, Mr. T. H. Wells, Dr. T. Wholey, Mr. W. Williams, Mr. A. P. Windridge, and Mr. G. H. Wood (Isle of Man Railway).

Many beautiful wreaths were received at Foot's Cray Place, in addition to those from the family and from gentlemen present at the funeral. These included floral offerings from the Marchioness of Tweeddale; Mary, Countess of Derby; Theresa, Countess of Shrewsbury; Lady Mance, Lord and Lady Esher, Lord James of Hereford, Sir James and Lady Sivewright and Miss Page (Capetown), Lady Gwendoline and Major Little, Sir George Elliot, Mrs. Kenneth Anderson, Mrs. George L. Reid (Manchester), Mrs. C. J. Hetherington, Mr. Louis Floersheim, Mr. R. M. Renwick, Mr. and Mrs. Bonitto, Mr. F. Dawes, Mr. P. B. Walker (Sydney, N.S.W.); from the Directors and Head Office and Foreign Staffs of the Eastern, Eastern Extension, Eastern and South African, Black Sea, Brazilian Submarine, Direct United States, Anglo-American, Great Northern, Direct Spanish, West African, African Direct, Pacific and European, Europe and Azores, West Coast of America, and Globe Telegraph Companies; from the officers and crews of the cable ships "John Pender," "Mirror," "Electra," "Chiltern," "Amber," "Great Northern," and "Duplex"; from the Telegraph Construction Company, the staffs of *The Electrician*, the London and Caithness Association, the Ibero-American Benevolent Society, the servants of Sir John's household, and from the tradesmen of Foot's Cray.

Letters and telegrams of condolence were received by the family from Viscount Hampden and Lord Brassey (Melbourne); Lord Glasgow (New Zealand); the Hon. R. J. Seddon, Premier of New Zealand; Sir Charles Todd (Adelaide); Sir Walter Francis Hely Hutchinson, Governor of Natal; Sir John Robinson, Premier of Natal; Sir James Sivewright (Capetown); the Director-General of Telegraphs, Simla; S. R. French, Postmaster-General, Cape of Good Hope; the Director-General of Telegraphs, Cochin China; Senor Clavet and the Director-General of Telegraphs, Manilla; the President of the Municipal Council, Alexandria; the Governor, Chamber of Commerce, and Community of Hong Kong; the Marques de Lema, representative of Spain at the Buda Pesth Conference; the Governor of Malta; P. W. Walker and J. Lambton (Sydney); Mr. Mollison (Yokohama); the Delegates of the Government Administrations represented at the International Telegraph Conference at Buda Pesth; the representatives of all the Telegraph and Cable Companies at Buda Pesth; Señor Carlos Santos (Lisbon); the Cable Companies' managers and staffs in China, the Brazils, Egypt, the Mauritius, Suez, Marseilles, Malta, Mombassa, Grand Bassam, and the Azores; the Home and Foreign stations' staffs; the staffs of the London and Provincial stations of the Cable Companies, and from many friends and colleagues of the late Chairman, both at home and abroad.

## THE CAPILLARY ELECTROMETER IN THEORY AND PRACTICE.*

BY GEORGE J. BURCH, M.A.

The capillary electrometer was invented by Lippmann, and described by him in a thesis published in 1875. Being specially adapted for the study of electromotive changes of short duration, it attracted the attention of physiologists. In 1877 Marey employed it in investigating the functions of the electrical organ of the torpedo, and succeeded in obtaining photographic records of its indications. In England Prof. Burdon Sanderson used it first in a research by which he proved that the closure of the leaf of the Venus' Fly Trap is preceded by electrical changes resembling those which accompany the contraction of animal muscles. In a lecture delivered before the Royal Institution in 1882 he exhibited photographs of the excursions of the capillary electrometer produced in this way.

My own connection with the subject dates from the winter of 1886, when I was shown the originals of these photographs and the apparatus which had been in use up to that time. As none of the capillary electrometers were in working order, and there was a difficulty in obtaining fresh ones in England, I offered to make some, and succeeded, after a few trials, on the last day of the year. Finding the whole subject to be of great interest, I undertook also the installation of new photographic apparatus, and since that time have devoted a good deal of my leisure to perfecting the method and collaborating with Prof. Burdon Sanderson in its physiological applications.

It is strange that an instrument so easily constructed and so sensitive should have remained for nearly 20 years practically unknown, save to physiologists. But although the principle of the electrometer had been studied up to a certain point, the practical details essential from the standpoint of the instrument-maker had not been worked out. My object was to find out these details by a systematic investigation of the mechanical and electrical constants involved and to publish them.

After two or three months' work I began to see much greater possibilities. There was a feeling among physiologists that the indications of the capillary electrometer did not represent quantitatively the value of rapid changes of E.M.F., because the meniscus, although it moves very rapidly, requires an appreciable time for its excursion. Accordingly such photographic records as had been obtained were relied on solely to determine the direction of a current and the period, but not the amount, of any change in its intensity. It occurred to me that if the laws of the movement could be determined it might be possible from the photographed curve of an excursion to draw another curve representing the variations of E.M.F. which caused it. I had already nearly sufficient data, and after a few more experiments was able, without using any hypotheses, to show that the velocity of the meniscus at any moment is directly proportional to the distance through which it would have to move before coming to rest under the influence of a constant current equal in intensity to the P.D. between the terminals at that instant. Furthermore, I invented a simple method of measuring the velocity of the meniscus at any point on the photograph of an excursion.

This discovery places the capillary electrometer in a unique position. It becomes available for a class of work that no other instrument can perform. A cycle of electromotive changes can be plotted down within 1 per cent. of the truth, at intervals of $\frac{1}{2000}$th of a second, with the present apparatus, and there is every indication that it might be driven five times as fast. It seems probable that the capillary electrometer may do for the dynamo what the indicator diagram does for the steam engine. In the summer of 1894 I obtained by its means photographs of the excursions produced by telephone currents, in which the characteristic vibrations of the various consonant sounds could be distinguished.

I propose in these articles to describe minutely the method of making an electrometer, and to discuss the relation of its

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MSS. received October 17, 1895.

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physical constants to the dimensions and form of the capillary. I shall then give full details of the apparatus for producing the photographic records and measuring them, together with a brief account of the applications of the method during the seven years that it has been in use, including among the illustrations the hitherto unpublished photographs of telephone currents which I exhibited at the meeting of the British Association in Oxford. These will be followed by the current-curves of several dynamos recently photographed by myself. I shall conclude with the methods of using the instrument for direct observation without photography.

The principle of the capillary electrometer may be best illustrated by the following experiment. Take a piece of soft glass tubing of about 5mm. or 6mm. diameter, and draw it out in the middle so as to form a capillary of about 0·5mm. bore. Cut it in two, and bend each half into a U-shape, the limb formed by the capillary being shorter than the wide limb. Fill each with pure mercury and support them side by side in a beaker of dilute sulphuric acid of 25 per cent., so that the orifices of both capillaries may be immersed. Expel the air from the capillaries by blowing down the wide limbs of the U-tubes.

The mercury will stand higher in the wide portions of the two tubes than in either of the capillaries, and the difference of level will be greatest in that U-tube which has the narrowest capillary. Now pass a clean platinum wire into each of the wide limbs, and connect these wires for a moment with the derived circuit of a rheocord, or any convenient source of P.D. not exceeding 0 5 volt. The mercury column in the capillary by which the current enters will rise, and that by which it leaves the circuit will be depressed. This altered condition will persist after the circuit is broken, but on joining the two platinum wires together the mercury will instantly return in both tubes to its former level. Lippmann explains this phenomenon by saying that the surface-tension between the mercury and the sulphuric acid is altered by the action of the current, and that this alteration is directly proportional between certain limits to the P.D. between the terminals. In practice it is unnecessary, and would be inconvenient to observe the movement in both tubes, and accordingly one of them is made larger in both limbs than the other, and serves to contain the acid into which the capillary point of the second tube dips. For some purposes, however, the arrangement above described answers better than any other.

*How to make a Capillary Electrometer.*

In determining the form of the instrument the following considerations must be borne in mind. The pressure of the mercury against the glass must be sufficient to keep the acid from creeping past it to the platinum wires, and the columns should therefore occupy at least 5cm. of the vertical part of the tubes. Provision must be made for washing out the acid and replacing it with fresh, from time to time.

The maximum sensitiveness, and the greatest rapidity of action, are only obtained together when the tube is cut off at a certain part of its length. This is best done after the electrometer has been put together. For these reasons I much prefer those forms in which the capillary is not permanently fixed to the U-tube.

Soft soda-glass answers best. The tubes should be examined with a lens for capillary passages in the walls. These, if large, are not always obliterated in the subsequent manipulation, and they impair the definition under the microscope. The selected pieces must be washed out three times with aqua regia, and then rinsed very thoroughly with *pure* distilled water. If on heating a tube so prepared over a Bunsen burner and sucking air through it, the least taste can be perceived, the cleansing is not sufficient. Finally, the tubes are dried by aspirating air through them. The operation of making the electrometer should be proceeded with at once.

The normal form for ordinary use is shown in Fig. 1. The electrometer tube A is from 4mm. to 6mm. in diameter and 10cm. or 12cm. long from the top to the first bend. The walls should be about 1mm. thick. To make it, cut off about 25cm. of the cleansed tube, and heat it in the middle before the gas blow-pipe till it thickens, and the bore is reduced to one-third of its original diameter. Remove it from the flame, and very gently draw it out, till the centre portion is 1mm. or 1·5mm. in diameter. Fuse the middle of the narrow part in the point of the flame till it separates, sealing up both ends in the act. You have now a pair of tubes tapering at one end to a strong, thick walled capillary, the bore of which is several times larger than that of the finished instrument. The next step is to make the crook. Holding the tube in both hands, heat it just above the tapering part for a distance of 1cm. When it is soft a slight lateral displacement of the hands, the two ends of the tube being kept parallel, forms both bends of the crook in one operation. A little care is necessary to prevent the tube from becoming flattened. Lastly, the upper end of the tube is rounded in the flame, which must not be allowed to blow into it.

The U-tube B has next to be made; this may be of thinner glass than the other. After forming a slight lip on one end and rounding the walls of the other, it is heated in the flame until it thickens and begins to close up. It is then very slightly stretched out and at the same time bent into the shape shown in the figure. The object of making the tube narrow in the bend is to prevent the mercury from flowing too freely from side to side when the instrument is carried about. The clip C is of thin sheet brass. It is about 25mm. wide, and is lined with a strip of morocco leather of the same width. The tubes A and B are gripped firmly by it, but not

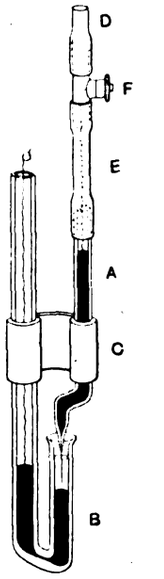


Fig. 1.—Normal Form of Capillary Electrometer.

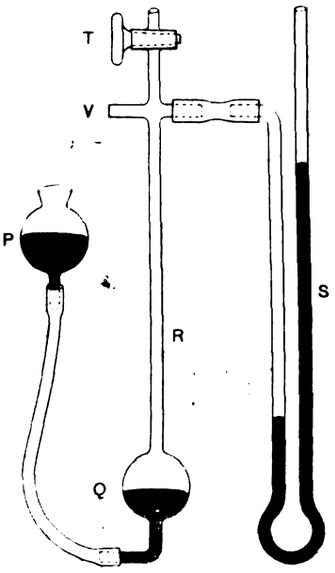


Fig. 2.—The Pressure Apparatus.

so tightly as to require undue force to adjust them. It remains to draw the capillary point of the tube A. For this purpose I employ the flame of an ordinary bat's wing burner turned so low as almost to go out. Holding the tube in the left hand and the drawn out end between the finger and thumb of the right hand, I bring the middle of the narrow part into the flame, the heat of which is just sufficient to soften, but not to melt it. Removing it, I suddenly and firmly draw it out, taking care to keep it parallel with the large end of the tube. I then cut it across the middle. For this purpose I use a small three-cornered file with the teeth ground off, hardened by dipping it while red-hot into cold mercury. Nothing but practice will ensure the drawing of a good capillary, but if on examination with the lens it does not appear satisfactory a piece of glass may be fused on and a new point drawn. I have even made a new point to an old electrometer tube without emptying out the mercury. The instrument is now ready for putting together. The tubes are slipped into the clip and twisted round until the end of A comes directly over the mouth of B. Exact parallelism of the capillary part of A with the walls of the U-tube B is secured by slightly bending the brass clip C. Mercury is then poured into A from a capillary pipette freshly made from a piece of perfectly clean glass tubing. The tube B is also filled

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with mercury to a depth of about 5cm. The mercury must have been recently distilled in vacuo.

It remains to attach the pressure apparatus. This consists of a pair of glass bulbs, P and Q, connected by a thick-walled rubber tube. P is suspended by a cord passing over a small pulley and attached to a bobbin, by turning which it can be raised or lowered. The bulb Q has attached to it the four-way tube R, leading to the pressure gauge S, the stop-cock T, and the tube V, with which the electrometer is connected. The stop-cock is necessary in order that the bulb Q may be easily refilled with air in case of leakage. A piece of pressure tubing, D, about 40cm. long, part of which is shown in Fig. 1, is slipped over the tube V (Fig. 2) and secured with wire.

The mode of completing the circuit is seen in Fig. 1. F is a terminal attached to a piece of brass tube, inside which a platinum wire is soldered. This wire passes down the short piece of rubber tube E nearly to the bottom of the straight part of the tube A, and a similar wire is inserted in the open limb of the tube B. The platinum should be made red-hot before putting it into position, to burn off impurities. All the joints should be made with burnt rubber, save that which connects E with A, for which vaseline may be used, so that it can be easily taken on and off.

A screw clamp fixed to the adjustible stage of a microscope, with its tube horizontal, grasps the tube A firmly just above the clip C, and an insulated support must be provided to take the weight of the rubber tube D so as to prevent any undue strain on the capillary.

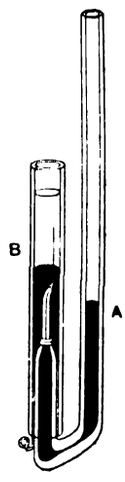


FIG. 3.—Electrometer with Upward Pointing Capillary.

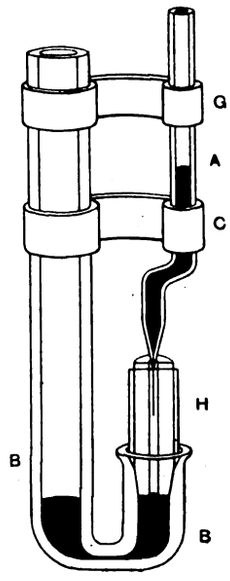


FIG. 4.—Projection Electrometer.

When everything is ready the bulb P, Fig. 2, is raised, and mercury flows into Q, expelling some of the air from it, and thus forcing the mercury in the electrometer tube through the capillary. When this is the case a few drops of dilute sulphuric acid of 25 per cent. are poured into the short limb of the tube B, and the pressure-bulb immediately lowered till the flow ceases. The circuit is next completed by connecting the platinum wire in B with the terminal F, after which the pressure may be cautiously increased until the mercury column nearly reaches the tip of the capillary, when the electrometer is ready for testing. The circuit must always be closed before increasing the pressure, otherwise the instrument acquires a charge which prevents the mercury from rising to its proper position in the capillary.

Another form of electrometer, illustrated in Fig. 3, is useful for some kinds of work. It differs mainly in having the point of the capillary directed upwards instead of downwards. The tube B is reduced to a mere collar slipped over the wide part of the U-shaped electrometer tube. A platinum wire twisted round the neck of the capillary passes downwards between it and the tube B, which may be fused on, or secured by cement. Mercury is then poured into A and B, and a few drops of acid are put into B. These electrometers work well for a time, but do not last long if cement is used.

Owing to the curvature of the surface through which the capillary has to be observed, the top and sides of the mercury column are not in focus simultaneously under the microscope. The definition is greatly improved by placing a thin cover-glass against the tube B, to which a drop of acid causes it to adhere. The acid has the advantage of not drying up, and any other liquid would be likely to creep round into the electrometer and spoil it.

For the production of photographic records by projection more perfect definition is needed, and I accordingly employ the modification shown in Fig. 4, in which nothing but a thin cover-glass comes between the capillary and the objective. The tube A is somewhat longer than the corresponding part of Fig. 1, in order to allow room for two clips, G and C, instead of one. The tube B is considerably larger, and much more strongly lipped. In the shorter limb it carries a piece of very thick-walled burette tubing, H, ground in like a stopper, and projecting about 25mm. The front of this tube is ground away, so that the bore of it is laid open from end to end, thus forming a trough just wide enough to contain the capillary without undue risk of breakage. A piece of thin cover-glass closes the trough in front, and the surface tension of the acid keeps it full of liquid. The clips C and G are clamped firmly by means of screws not shown in the diagram, and they are so arranged that the small adjustments necessary to bring the capillary exactly parallel with the front of the trough can easily be made. This instrument is somewhat fragile, but the definition of the projected image is greatly superior. I am at present engaged upon an improved form, which will need less careful handling.

*(To be continued.)*

## PRINGLE AND KENT'S SURFACE RAIL TRACTION SYSTEM.

The rapid advance of electric traction is naturally directing the attention of engineers to perfecting the means of distributing electric energy to moving vehicles. Existing systems, such as the American-born trolley, are being overhauled, improved and adapted to English requirements; and quite new systems are being brought forward and developed. One of these latter is the surface rail system of electric traction which has been invented by Mr. P. J. Pringle, of Sidcup, who, in conjunction with Mr. Money-Kent, of Messrs. Sharp and Kent, has been busy for some time in perfecting its details.

This system is a closed conduit or surface sectional rail system, having all the supply equipment underground, and with no open slots as in the slot conduit system. It can be erected at a cost not much higher, it is said, than good overhead construction. Several forms of this class of system have already been proposed, the main principle being to have a switching device for every surface rail actuated either mechanically by the movement of the car, or electrically by electro-magnets carried by the car, or contained in underground switch boxes. As the spacing of the rails is dependent on the length of the car, the number of these switching devices required per mile of track is some 300 or 400. It will be contended that any advantage which may accrue from these systems is obtained at the expense of greatly increasing the complexity of the same, and the liability to break down. These switch-boxes must be as simple and reliable as possible, and the number required greatly reduced, to ensure satisfactory working and a reasonable first cost and maintenance. In the present system about 13 automatic switching devices or distributors are used per mile of track; these being placed about 135 yards apart, preferably under the footpath, for convenience of inspection. The distributor is shown in plan and section in Figs. 1 and 2, and consists of two electro-magnets, $M^1$ and $M^2$, the movable armatures of which are coupled to each end of the rocking bar B. Suppose $M^1$ is magnetised, its armature is sucked in, drawing down the bar B against the action of the spring S, and allowing the pawl P, which is thrown over by the

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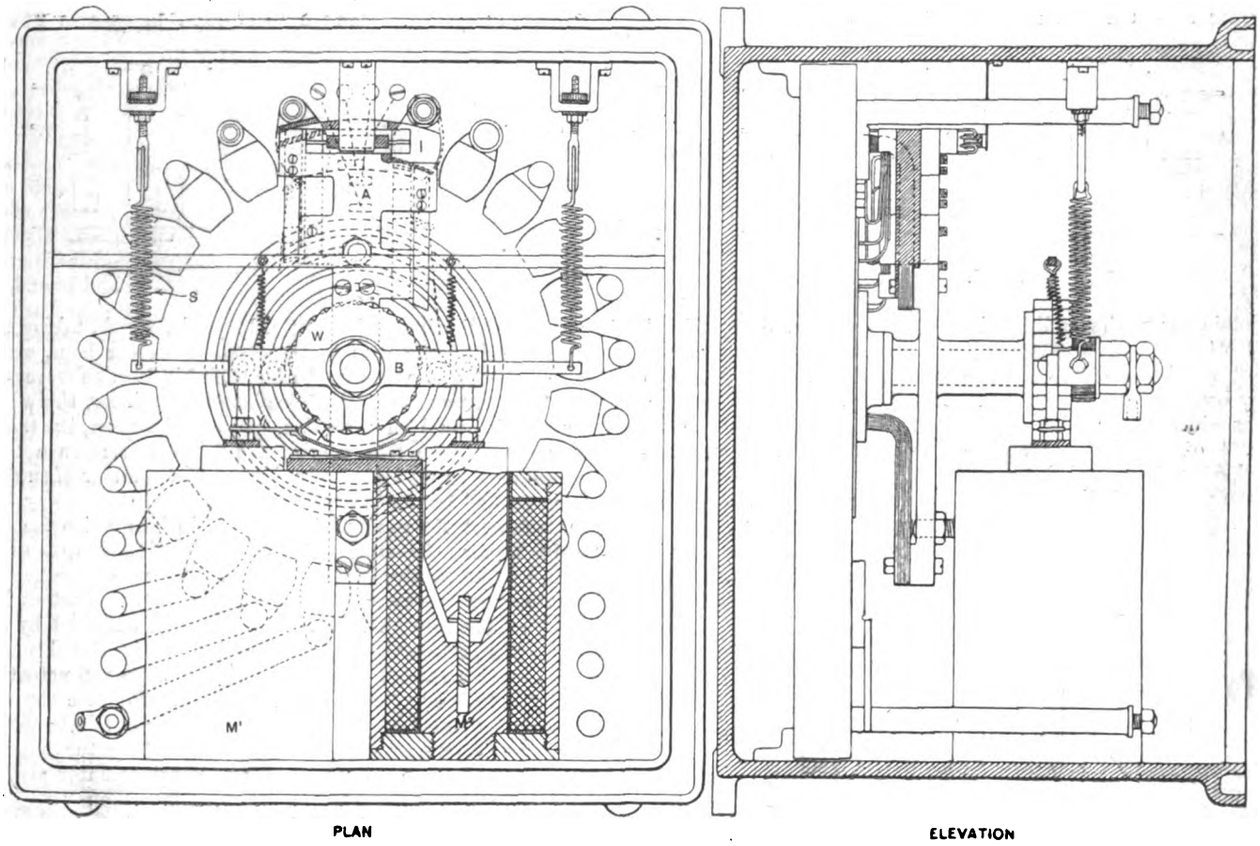
small spring S, to engage in a tooth of the ratchet-wheel W, adjoining the one it was previously opposite; at the same time the left-hand catch X is disengaged from its ratchet-wheel by the plate Y. On $M^1$ becoming demagnetised the spring S draws back the movable bar, which, by the aid of the pawl and ratchet-wheel, moves the main supply switch-arm A, together with the shunt contact arms on each side of it, from the position shown to contact 1, and the left-handed catch X returns and




FIGS. 1 and 2.

locks it. The magnet $M^2$ acts similarly in the reverse direction. Should, however, the line be double track, and cars only required to move in one direction, only one magnet, ratchet wheel, &c., and one shunt arm is required. The parts are mounted on a slate base, and contained in an iron box filled with a light oil, which has the advantage of reducing wear and tear to a minimum and keeping out dirt and moisture. The contact pieces have rods continued from them, so that the cables can be connected to the same at a level above the oil. The cables pass out of the box through glands, so that the box can be kept watertight. All contacts of the distributor are readily adjustable, and may be moved and replaced if necessary; and as the main arm never breaks current, and the shunt arms have, during the major part of the time they are in action, only a fraction of an ampere passing through them (this being the exciting current required for the magnets) the wear and tear is exceedingly small. Of course, during the short-circuiting of the magnets a larger current flows, but there is very little sparking.

Fig. 3 shows diagrammatically the connections for two distributors arranged for working cars in either direction. Each distributor has 24 contacts, feeder cables running from these right and left to 24 of the surface rails. All the distributors are in parallel between the main supply cable C and the rails E, which act as the return to the source of supply D. The action of the distributor is as follows:—Supposing the tramcar to be receiving current from surface

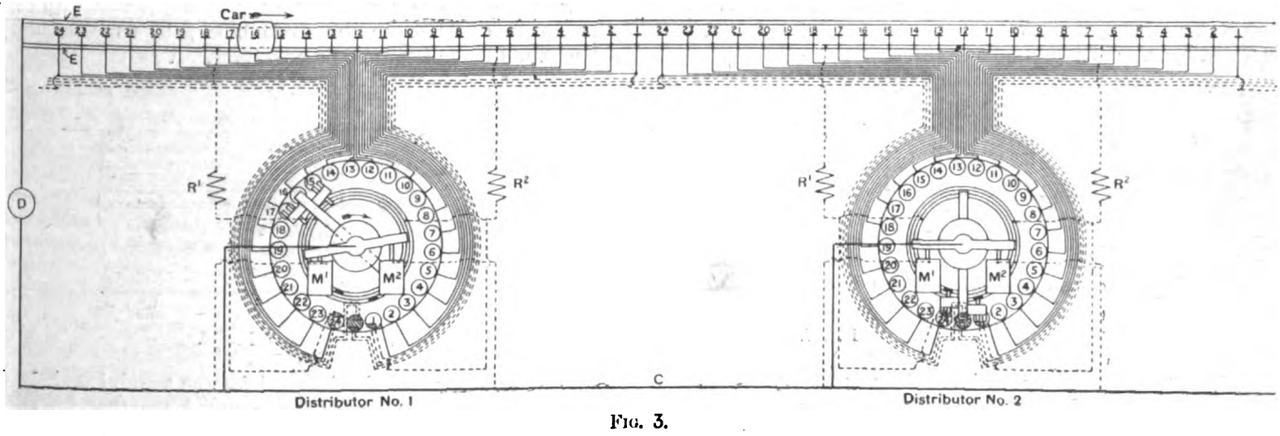



FIG. 3.

rail No. 16 of distributor No. 1, and travelling in the direction of the arrow, the main switch arm of distributor is on contact No. 16, and two of the shunt arms on contact No. 15. By following the connections magnet $M^1$ will be magnetised by a shunt current flowing from main conductor C through $M^1$ of the shunt arms on contact No. 15, then through the resistance



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$R^1$ to the tram rails on return. These connections are more easily seen in Fig. 4, at A. On the car advancing so that the collectors under the car can bridge across the surface rails No. 16 and No. 15, as in Fig. 4 at B, it will be seen that $M^1$ is short-circuited by the cable supplying current to contact 16. This causes the main arm of distributor to be switched on to contact No. 15, as in Fig. 4 at C, when immediately the magnet $M^1$ becomes magnetised again ready for a similar action to occur. When the car is passing from the block controlled by one distributor to an adjoining one, the additional contacts (*see* Fig. 3) by No. 1 and 24 contacts, and the shunt connections shown dotted together with the two outer contact arms, are then and then only brought into requisition. Fig. 5 at A shows the connections which occur when the car has reached the surface rail No. 1 of distributor 1 and is about to enter the block controlled by distributor 2. Magnets $M^1$ of both distributors then become magnetised through their resistances $R^1$, and on the car advancing so as to connect No. 1 and No. 24 surface rails, both magnets become short-circuited, the main arm of distributor 1 being switched off on to its insulated contact No. 25 and the main arm of distributor 2 switched on to contact No. 1, when the same actions occur as in Fig. 4, *a*, *b*, *c*. When a distributor is switched out of gear, as distributor 2 in Fig. 3, not only the main arm is insulated from the supply, but the shunt arms are also, so that it is impossible for any person maliciously inclined to interfere with the distributors by tampering with the surface rails; also when the distributors are in action and supplying current to the cars it is equally impossible to affect their action. As regards safety to the traffic, only those surface rails actually supplying current to the cars are alive—that is, connected with the electric supply; and as this is automatically carried out by means of the distributors in exact relationship with the advance of the tram cars, these surface rails so connected are always covered by the base of the tram cars, so that it is impossible for traffic to be endangered. With regard to the surface rail in advance of the one supplying current to the car the potential at this point can, by suitably adjusting the resistances $R^1$ and $R^2$ with reference to the resistance of the magnets, be brought down to perfectly safe limits. As each distributor controls a certain number of surface rails constituting a block, and only one at a time can be supplied from the same, the cars are enforced to keep a certain distance apart, as in our railway block systems, which has the advantage of regulating the traffic. About 24 surface rails to each distributor is the most economical number; beyond this it will be found that the extra outlay in feeder cables is not sufficiently warranted by the reduction in the number of distributors required. The length of each block with 24 surface rails per distributor is about 135 yards, which, taking the average speed of the cars to be seven miles per hour, would require two-thirds of a minute for each block to be traversed. Allowing, say, two blocks distance between each car, this would easily permit of a 1½min. service. Should, however, the traffic at any part of the line require a quicker service than this, this can be arranged for by reducing the number of surface rails controlled by the distributors.

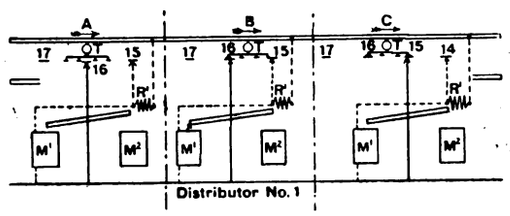


FIG. 4.

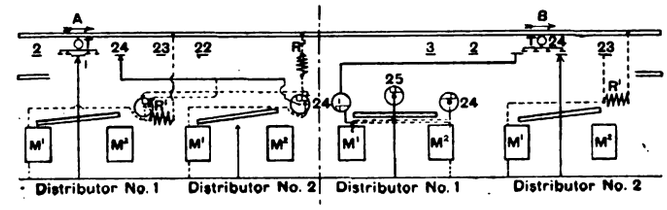


FIG. 5.

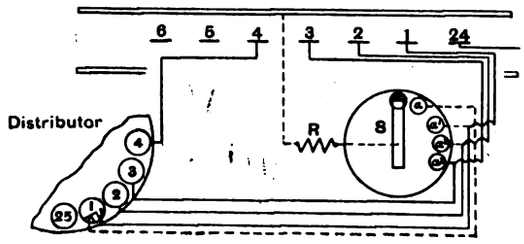


FIG. 6.

In the event of a car running into a block in which there is already a car, the supply is switched off, and cannot be reconnected until the block is clear. This reconnection is carried out by means of a supplementary switch fixed underground at the junction of two blocks, and actuated by the driver. The connections of this are shown in Fig. 6, which permits in this case of the supplementary switch S actuating the distributor over contacts 1, 2, and 3. Suppose the car, having had its current switched off at surface rail 24, is carried by its own momentum on to surface rail 2, on turning the switch arm of S on to "*a*" contact, the distributor magnet would become magnetised, and on switching it off "*a*" then demagnetised, moving its main switch arm into contact 1. Then, on further moving the switch arm of S so that it connected contacts 1*a* and 2*a* (which would make similar connections to those made by the car in passing over surface rails 1 and 2), the magnet would become short-circuited, and the main switch arm moved on to contact 2, ready for supplying current to the car. The switch S is so designed that while in action contacts 1*a*, 2*a*, and 3*a* are disconnected from the surface rails 1, 2, and 3, so that none of the latter while exposed can become alive. If the cars followed one another at such intervals that with care no two cars could enter the same block, the supplementary switch would not, of course, be necessary. A switch somewhat similar in action would also be used for the termini and depôt yards where the cars would be grouped together for short distances of the line. The surface rails are about 3½ft. long, and placed at intervals of every 16ft.; this spacing of the surface rails required five collectors under the cars. The advantage in using several collectors is a reduction in the number of surface rails required per mile of track, and at the same time they can be shorter, correspondingly reducing the surface leakage in damp weather. As there are never more than two surface rails per car connected with the main supply

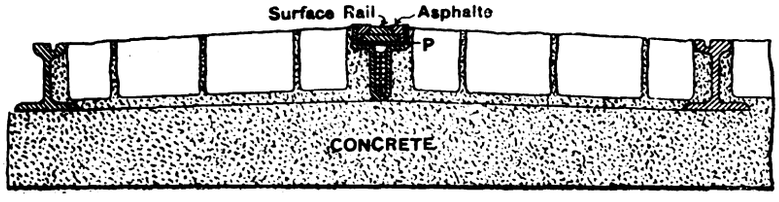


FIG. 7.

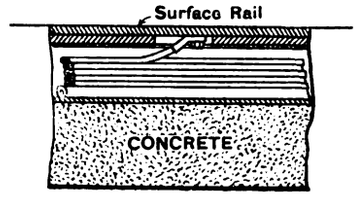


FIG. 8.

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(the greater part of the time there being only one), the surface leakage from these would, even in wet weather, be of small account, and would compare favourably with the overhead and slot-conduit systems in this respect.

Figs. 7 and 8 show the form of conduit used in this system, which consists of a rolled iron trough, the upper part carrying the surface rails bolted to creosoted wood, and the whole embedded in asphalte, similar in composition to that which is used in paving roads, and the lower parts taking the main conductor and feeder cables. The plate P is laid in after the cables, and retains the asphalte. The top sides of the conduit and the surface rail being undercut cause the asphalte to firmly embed the surface rails, the whole forming a compact and thoroughly durable form of conduit. It also has this advantage, that should it be necessary to open the same at any time, this can be done without disturbing the road surface. The number of feeder cables laid in the conduit varies from one to twelve, and the depth of the lower part can therefore be varied to suit the number. The ironwork of the conduit would break joint at short intervals, so that no section would be very well earthed, in case a connection were made between it and a surface rail by some metallic substance lying on the track during the passage of a car. It is evident that the tyres of vehicles would have no effect, as no surface rails exposed beyond the base of the cars are alive. As this conduit is only 5in. wide by 6in. deep, it can be laid in an existing track without a very expensive disturbance of the road.

The total cost of this system of electric traction, assuming it to be adapted to an existing tramline, has been estimated by Messrs. Pringle and Kent to be £2,300 per mile of single track, or £4,130 per mile of double track. These estimates place the Pringle system in a favourable comparison with the slotted conduit systems, and it will be seen that it is not very much more costly than the overhead trolley system. Apart from the question of prime cost, however, the Pringle system of traction possesses several important advantages. The absence of overground construction and of open slots or conduits, the exposure of the surface conductor to working pressure only when covered by the car, with the consequent increased safety and decreased leakage, and the interlock system involved in the use of the distributors, are among these advantages. The system undoubtedly deserves to be given a fair trial on a length of real, full-size tramway; and, so far as it is possible at present to judge, it ought to prove a success.

## HOT-PRESSES WITH ELECTRICALLY-HEATED GLOSS-BOARDS.

Prof. E. Müller, of Hanover, in an article in the *Leipziger Monatsschrift für Textilindustrie* describes a system of glossing textile goods with electrically-heated pressing-boards, the invention of Herr Julius Sarfert. These heating gloss-boards consist of two thin sheets of fibrous non-conducting material, glossed on one side only. Between these are placed, in zigzag, strips of nickel 0·1mm. thick, which are cut out of plates of this metal, the spaces between being, of course, filled with non-conducting material. The two cardboard plates are then glued together with a special glue which stands heat and moisture well. The total thickness of such a heating plate is only 1·3mm., and weighs 1·59lb., for a size of 28⅝in. by 22½in., an ordinary gloss-board of the same size and 0·65mm. thickness weighing 0·53lb. The workman in putting the ordinary glossing-boards into the stuff leaves one out now and then and places a heating gloss-board instead. The exact distance between these latter depends upon the thickness of the stuff to be pressed, and it will be smaller for thicker cloth and greater for thinner. The whole set is then placed in position in the press, and all the heating plates are connected up. There are two terminals on each plate, one at each end of the heating metal conductor. The current is supplied at different pressures up to 50 volts, and about 292 watts are required for plates of the above-mentioned size.

To obtain reliable figures, tests were made at the laboratory at Hanover under the direction of Prof. E. Muller. A piece of cloth 15 metres long was built up in the ordinary way with 22 gloss-boards. The heating-press plates were distributed in the following way. First came five ordinary boards, then one heating plate, then 10 ordinary boards, then one heating plate and then another five ordinary boards. The whole was closed top and bottom by wooden boards. Observations of the different temperatures between the layers were taken. Thermometer No. 1 was only two layers from one of the heating plates, while No. 2 was placed exactly mid-way between the two heating plates. The current was then switched on at 35 volts pressure, and after 15 minutes was raised to 40 volts. After another 15 minutes the current was switched off, and the total heating lasted therefore half an hour. The external temperature at the beginning was 15·2°C.

The different readings are shown in the following table :—

| Time in minutes after commencement of test. | | Degrees in centigrade. | |
|---|---|---|---|
| | | No. 1. | No. 2. |
| 0 | | 29·0 | 28·7 |
| 5 | | 46·0 | 42·0 |
| 10 | 35 volts. | 64·5 | 63·0 |
| 14 | | 73·0 | 72·0 |
| 15 | | 75·0 | 74·0 |
| 20 | | 89·5 | 87·5 |
| 25 | 40 volts. | 98·0 | 97·0 |
| 29 | | 109·0 | 108·5 |
| 30 | | 111·1 | 110·5 |
| 31 | Current | 111·0 | 111·0 |
| 53 | switched | 81·3 | 85·0 |
| 180 | off for | 32·5 | 34·0 |
| 240 | cooling. | 26·0 | 27·0 |

In another test, with a gradual rise in pressure up to 45 volts in three-quarters of an hour, a temperature of 121°C. was reached. The mean power consumption for each plate was 311·5 watts.

With regard to working expenses, Prof. Müller thinks that an ordinary hot-press, with 70 heating plates, would cost per half-hour, on a moderate tariff, about 6d. That the system has found favour in the textile industries is shown by the fact that a large German firm of textile manufacturers has laid down a plant of 12 large electrically-heated hydraulic presses.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July 3, 1896.*

**The New York Telephone Company.**—In connection with the incorporation of the New York Telephone Company, which was noted in my last letter, and the object of which gave rise to considerable speculation in electrical circles, it is announced this week that it has taken over the property and business of the Metropolitan Telephone and Telegraph Company of New York. The successor Company assumes all contracts and other obligations of the Metropolitan Company. The absorption also includes the Westchester Telephone Company, which carried on operations in Westchester and Rockland counties and a portion of Connecticut, all of which territory lies to the north of Manhattan Island. The object of the consolidation is to provide additional capital for the extension and improvement of the new absorbed systems. Concurrently with this notice was one sent out by the American Telephone and Telegraph Company (long distance telephone) to the effect that on and after July 1st, the charge for overtime beyond the initial period of five minutes will be made by the minute at the rate of one-fifth of a single message for each additional minute. The Company has discontinued the practice of notifying the subscriber at the end of each five minutes, how much time has elapsed.

**Convention of the Street Railway Association.**—Active preparations have already begun for the next Convention of the American Street Railway Association, which will be held in St. Louis, Mo., Tuesday, October 20 next, and continue for four days. As is usual at conventions of this Association, a large exhibition of electric railway apparatus and appliances will be held, and for this purpose a large space in the Convention Hall has been set apart. The convention and exhibition will be held in the same building in which the recent National Republican Convention held its meeting. The current for the operation of apparatus at the exhibition will be supplied at 550 volts.

**A New Railway Signal.**—A test was made a few days ago on the Delaware, Lackawanna and Western Railroad, near this



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city, of an interesting railway signal. The principal feature of the signal is a revolving semaphore arm. On a bracket attached to the signal post is a box containing an electric motor which revolves the semaphore. When the block ahead is clear the semaphore revolves, indicating to the engineer of the train by its motion that he also may continue in motion. When the block is not clear, the semaphore remains stationary, in a horizontal position, the same as the ordinary block signal when in "danger" position. The inventor of this signal, Mr. Henry Bezer, of New Rochelle, New York, claims many advantages for this rotary signal, the most important of which is that the engineer cannot fail to interpret its language. At night a signal lamp revolves on a vertical spindle, flashing alternately red and white lights. When the signal is at "danger" only the red light shows. The apparatus is quite simple, and has many commendable features.

## CORRESPONDENCE.

### NEGATIVE RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: When the actual dynamics of a phenomenon is unknown, convenience and clearness are what should decide our definitions. The case of an electric arc is essentially of this kind. We know very little indeed about what is going on in the arc, and practically nothing about the dynamics of what is happening. Prof. Silvanus Thompson seems to think that some *a priori* conceptions should control our definitions. The whole question is essentially one of convenience of definition. This is particularly evident from the very far-fetched nature of the quantity which Messrs. Frith and Rodgers have called the negative resistance of the arc. If one were to try and describe it accurately it would require an even more elaborate description than that of an alternating voltage, and it seems almost impossible to avoid a great complication because the phenomenon of the arc is itself very complicated. Prof. Silvanus Thompson, for instance, has not proposed any other convenient way of describing the phenomena observed, unless he intends that "distributed adjuvant electromotive force" should be used instead of "negative resistance." The actual complication of the phenomenon described as "negative resistance" makes it very difficult to get a really satisfactory term to use for it; and there seems some reason in the objection to use the term "resistance" at all, for what certainly involves the change of resistance with current in some form or other, though not in the simple way that Prof. Silvanus Thompson suggests.

The theoretical *à priori* objections to negative resistance do not seem of much importance. We know a great deal too little about resistance to justify *à priori* reasoning of the kind. Prof. Silvanus Thompson's paradoxes have been entirely answered by your leader's remark that nobody suggested that a negative resistance could exist alone in a circuit any more than a back E.M.F. His own $R=\frac{a}{C}+R_0$ actually involves this back E.M.F., for $a$ is a back E.M F. in this equation, as is evident by the form $E=RC=a+R_0C$. But the best answer to these *à priori* objections is that given by Prof. Silvanus Thompson's own ingenious examples. He himself concludes that a distributed adjuvant E.M.F. is indistinguishable from a negative resistance, and suggests two ways in which such a distributed adjuvant E.M.F. can exist. The first case he cites is that of a dynamo which helps to drive the current, and the second is that of the Thomson effect in an unequally heated conductor. He says that one could distinguish between the effects of resistance and E.M.F. in these cases by reversing the current; but this would not be so if in the first case the dynamo were a series dynamo, or were driven by another dynamo which was driven by the current, so that both reversed along with the current. In the second case, the adjuvant E.M.F. would similarly reverse with the current if the heating and cooling of the junctions were that produced by the current itself. An interesting example of this very difficulty of distinguishing between E.M.F. and resistance is the recent suggestion of Lord Rayleigh (see *The Electrician*, June 26, p. 277), that the cause of the extra resistance of alloys is a thermo-electric E.M.F. These two cases have many points in common. There is really very little essential difference between a dynamo turning electromagnetic energy into heat by friction on a large scale and the innumerable molecular machines by which the ordinary resistance of a wire transforms electromagnetic energy into heat on a small scale. Just as we can have the dynamo at one place driving another so as to produce adjuvant E.M.F., so we can have heat production at one place producing adjuvant Thomson effects elsewhere. In fact, there seems a great deal of reason for expecting that, wherever there are Peltier effects and differences of temperatures at different junctions with variations of temperature between, in some of these latter regions there should be adjuvant Thomson effects—*i.e.*, negative resistances. Hence, from Prof. Silvanus Thompson's own examples it seems almost impossible but that the very negative resistance he so objects to should exist in some part of the arc.

As it does not require any differences of temperature to transform directed energy into heat, but does require differences of temperature to transform heat into directed energy, such as that of an electric current, there is some ground for not using the term "resistance" for any reversed thermal phenomenon, and consequently preferring such a term as "adjuvant Thomson effect" for any distributed thermal action which helps the current. If this use of the term "resistance" were recognised, the term "negative resistance" would generally imply a failure of the second law of thermo-dynamics; and as neither Messrs. Frith and Rodgers nor Prof. Ayrton suggest that they have obtained this very interesting but extremely improbable result, it would, perhaps, be better to give some other name than "negative resistance" to the phenomenon they have observed.—Yours, &c.,

Trinity College, Dublin,
July 13, 1896.

GEO. F. FITZGERALD.

## LEGAL INTELLIGENCE.

### The Three-Wire Patent.

On Wednesday last, before the Judicial Committee of the Privy Council (present, Lords Hobhouse, Morris and Davey, and Sir Richard Couch), the petition came on for hearing of the Westinghouse Electric Company, of Victoria-street, and of Dr. John Hopkinson, for a prolongation of the Hopkinson three-wire patent, No. 3,576, of July 27, 1882. Mr. Fletcher Moulton, Q.C., Mr. R. Wallace, Q.C., and Mr. R. Walker appeared on behalf of the petitioners. The opponents of the petition were represented as follows: The Attorney-General (Sir Richard Webster, Q.C., M.P.) and Mr. Sutton, for the Crown; Mr. C. A. Cripps, Q.C., M.P., and Mr. J. C. Graham, for Edinburgh, Belfast and Aberdeen; Mr. W. R. Bousfield, Q C., M.P., and Mr. Jenkin, for the Corporations of Glasgow, Dundee, Hull and Bradford, and for the General Electric Supply Company of Preston; Mr. T. Terrell, Q.C., for Liverpool; Mr. Ashton, for the Callander Bitumen Company; and Mr. W. Neill, for the Whitehaven Corporation.

The ATTORNEY-GENERAL in opening took a preliminary objection. Upon the face of the petition, which was that of the Westinghouse Company, it appeared that Dr. Hopkinson had received at least £19,400, the patent having been sold outright by the inventor to that Company. It was not suggested, nor could it be sustained, that the petition was for the benefit of the inventor, Dr. Hopkinson, and therefore he held that it could not be heard. He called their Lordships' attention to the decision given in 1885, in the case of Bowerdorf, in which it was laid down that an assignee of a patent would not be granted an extension unless the inventor himself was entitled to, and would himself receive, benefit from such extension. He also cited other decisions in which it was laid down that the Court would grant no extension without the patentee, either directly or indirectly, receiving some benefit. From the beginning to the end of the petition there was no suggestion that it was on behalf of Dr. Hopkinson. It was his duty therefore to submit that, inasmuch as the patent was commercially sold in 1889, and had been the sole property of the Westinghouse Company since—Dr. Hopkinson being only a nominal petitioner, the petition being on behalf of the assignees—that there was no ground on which their Lordships could allow the assignees an extension.

Mr. BOUSFIELD intimated, on behalf of his clients, that he submitted the same objection to the hearing of the petition.

Mr. FLETCHER MOULTON said he hoped he should be able to show that such a principle as that indicated by the Attorney-General had never

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yet been laid down, and, further, that if laid down, it would have the worst possible effect. It was almost impossible, with all the more important inventions, for an inventor to push his own invention, so that he was obliged to go to some one for assistance. Therefore the system of passing the property of a patent to some other person or company, who would relieve the patentee of all expense, was one that was essential. He submitted that, in a case like the present, where the assignees had treated the patentee liberally and put themselves in his position, although their Lordships might say the prolongation should not be solely for their benefit, yet that they should say it was one where the assignees should have an opportunity to further push the invention, and recoup some of the loss they had sustained hitherto. There never could be a stronger case than the present for considering the position of an assignee, for during six years of the patent's existence it was prevented by restrictive Acts of Parliament from having any commercial value for the purpose for which it was chiefly valuable—the economical distribution of electricity for lighting purposes. The consequence was that the patent had only had in reality eight years of commercial existence. The question was of special importance at the present day, because the system of working almost all commercial undertakings by joint-stock companies, in which people could put capital without incurring liability beyond a certain point, had become nearly universal, the result being that nearly every important patent was worked by some company formed for that special purpose. In the event of an extension being granted the Committee had power to say what portion of the benefit should go to the inventor. The direct saving already of this patent in large installations had been something like half-a-million. The granting of the prolongation was a matter of favour, not of right, and their Lordships had power in giving a decision to consider all the circumstances of the case.

Lord HOBHOUSE drew Mr. Moulton's attention to a finding in which it was stated that there was no case in which the Board had granted an extension of a patent to an assignee which did not, directly or indirectly, tend to the benefit of the inventor.

Mr. FLETCHER MOULTON replied by turning to a case in Moore's Reports, in which he contended a prolongation was granted to an assignee. In another case a patentee sold an invention to a company, in which he was given some shares, and the company succeeded in obtaining an extension. That was a very similar case to the present, because Dr. Hopkinson was given some shares in the Westinghouse Company. If he were able to go into the facts of the case he should be able to show that before getting a penny Dr. Hopkinson had had to fight an action costing £5,000.

The ATTORNEY-GENERAL contended that, without considering the question whether the assignee might or might not apply for a prolongation, the petitioners must be non-suited by the allegations contained in their own petition.

After further argument the room was cleared while their Lordships consulted together. On the readmission of the public,

Lord HOBHOUSE said: Their Lordships are of opinion that the objection raised by the Attorney-General, arising on the face of the petition, must prevail, and therefore their Lordships cannot report to Her Majesty in the way which is necessary for the prolongation of the patent. They will not now deliver their reasons, being desirous to look further into the cases, but will deliver them at some future date. Regarding the question of costs, his Lordship said the strict course was to dismiss the petition with costs; but in the present case they would allow one set of costs among the opponents.

The proceedings then terminated.

### Lee and Hancock v. Piper.

On Monday, at Westminster County Court, London, the case of Lee and Hancock v. Piper was heard. It was a claim by a firm of electricians, of Chelsea, for £23. 17s. 11d. for lamps, brackets, &c., supplied for the New Wheel Club, Kensington. Mr. Lee deposed to doing the work, and said defendant contracted for repairs and alterations at the Club. He took the orders from the Club secretary, understanding from defendant that he was to take orders for anything wanted, above his £9 estimate, from the secretary. Mr. Oliver, the secretary, said defendant had a contract for £771 from Mr. de Pinna, the Club proprietor. He arranged with defendant that he might order additional lights and fittings for the conservatory, &c., from plaintiff, and the amounts should be put on his account to the proprietor. Defendant had been paid the amounts.

Mr. A. PIPER, the defendant, denied giving the secretary authority to order anything from plaintiff, who was paid the £9 according to his estimate. That was the total amount he charged the Club proprietor for electrical work. In answer to his Honour, he said he did include the amounts on his bill to oblige Mr. Oliver.

His HONOUR found for the plaintiffs, with costs.

## BOOKS RECEIVED.

"Induction Coils." By H. S. Norrie. (London: E. and F. N. Spon. Price 50 cents.)

"Jordan's Tabulated Weights of Iron and Steel." By C. H. Jordan. (London: E. and F. N. Spon.)

Calendar for 1896-7 of the Glasgow and West of England Technical College. (Glasgow: Robert Anderson. Price 1s.)

"Practical Radiography." By H. Snowden Ward. (London: Dawbarn and Ward. Price 1s. 6d.)

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. THE NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied. price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

TENDERS INVITED.—The Hull Corporation invite tenders for an engine and dynamo. Tenders to the Borough Engineer, Town Hall, Hull, by the 23rd inst.

——— The Municipal Authorities of Turis (Valencia) invite proposals for the concession for the electric lighting of the town for 10 years. Tenders to El Secretario del Ayuntamiento de Turis (Valencia), Spain.

——— The Municipal Authorities of Vich require tenders for the concession for the electric lighting of the streets for 10 years. Tenders to El Secretario del Ayuntamiento de Vich, Spain, by the 17th inst.

——— The Bray Town Commissioners invite tenders for the erection of a brick chimney and for sundry alterations to existing buildings at the electricity works. Tenders to the Town Clerk, Town Hall, Bray, by the 20th inst.

——— The Electricity Committee of the Blackpool Corporation require tenders for the supply of lubricating oil. Tenders by the 27th inst.

TENDERS ACCEPTED.—The Wakefield City Council have accepted a tender for the erection of a refuse destructor at the joint electricity and refuse destructor works for £3,596.

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TENDERS ACCEPTED.—The Ealing District Council have accepted the tender of Messrs. W. Foord and Son for extensions at the electricity station for £1,952.

——— The Plymouth Town Council have accepted a tender for the supply of electric light cables for Old Town, Ebrington and Ham-streets for £723; and the tender of Messrs. Doulton and Co., Lambeth, London, for the supply of stoneware conduits, &c., for £227.

——— The tender of the Private Wire and Telephone Installation Company has been accepted by the Wakefield municipal authorities for providing and fitting telephones throughout the new municipal buildings.

——— The Windsor and Eton Electrical Installation Company have accepted the tender of Messrs. Siemens Bros. and Co., for the supply of the plant and machinery for their electricity supply station. The contract for the mains has been given to the Callender Company.

APPOINTMENTS.—Mr. H. M. Sayers, Managing Engineer of the Bournemouth and District Electric Supply Company, has been appointed Chief Engineer at Madrid of the Electricity Supply Company for Spain.

——— Mr. C. S. Vesey Brown has decided to accept the appointment offered him by the Lincoln Corporation as electrical engineer for the borough. The Sunderland Corporation, in whose service Mr. Brown has been for some years, offered him a considerable increase of salary, and it has, we understand, been arranged that he will superintend the electrical extensions about to be carried out in Sunderland.

APPOINTMENTS VACANT.—The Governing Body of the Northampton Institute invite applications for the following positions:—Chief Assistant in the Department of Applied Physics (including electrical engineering), at a salary of £180 per annum; Head of the Department of Mechanical Engineering and Metal Trades, at £250 per annum; and Head of the Artistic Crafts Department, at a salary of £250 per annum. Applications must be sent in to Dr. R. Mullineux Walmsley, at the Institute, St. John Street-road, Clerkenwell, E.C., by Tuesday, the 28th inst. Some additional particulars are given in our advertisement columns.

——— The Plymouth Corporation invites applications for the post of draughtsman and assistant to the Borough Electrical Engineer. Salary £150 per annum, increasing by yearly increments of £10 to £200. Applications must be delivered at the office of the Town Clerk (Mr. J. H. Ellis), Municipal Buildings, Plymouth, by Thursday, the 30th inst. Additional particulars are given in our advertisement columns.

——— The Cape Town and Suburban Electric Lighting Company (Limited) invite applications for the office of Electrical Engineer to manage the electric lighting works of the Company, and to carry out any new constructive works which may be required. Commencing salary, £300. Some further particulars will be found in our advertisement columns, and applications must be sent in to Messrs. Davis and Soper, London agents, 54, St. Mary Axe, E.C., by 31st inst.

DISSOLUTIONS OF PARTNERSHIP.—Messrs. William Fox and Thos. Edward Rowe, electrical engineers, 64, Fountain-street, Manchester, have dissolved partnership. Debts by Mr. Fox, who continues.

——— Mr. W. H. Druce informs us that the partnership between himself and Mr. F. F. Bennett having been dissolved, he has taken offices at Temple Chambers, 33, Brazennose-street, where he intends to practise as a consulting engineer.

——— We announced in our issue of June 26th the registration of Messrs. Taylor, Tunnicliff and Co. (Limited), and legal notice is now given that the partnership lately existing between Messrs. Thomas Taylor and William Tunnicliff has been dissolved by mutual consent. All debts due or owing to the late firm of Taylor, Tunnicliff and Co. will be received and paid by the newly-registered corporation.

PERSONAL.—Mr. W. Lowry desires us to state that he has severed his connection with Messrs. Mellier and Co., with whom he has served as electrical engineer for five years, to take charge of the electrical department of Messrs. Turner, Lord and Co.

——— Mr. A. H. Vesey informs us that he has relinquished his private practice as a consulting engineer, and joined Messrs. Vaughan and Brown in a similar capacity.

——— Mr. A. E. Hunt, who has for some years been associated with the sales department of the Edison Swan Company, was last week presented with a marble clock, as a token of respect from the sales department staff, on the occasion of his marriage. Mr. C. M. Downie, in making the presentation, complimented Mr. Hunt upon his past services, and voiced the hope of all who know him for his future success in life.

LIQUIDATIONS.—It was resolved on May 6, 1896, to wind up Swinburne and Co. (Limited) voluntarily. This resolution was confirmed on June 4th, when Mr. H. Sherwin Holt was appointed liquidator, and was authorised to carry out the agreement dated January 1, 1896, with the Nalder and Harrison Construction Syndicate (Limited), for the sale of the goodwill, patents, &c. Claims must reach Mr. Holt, 66, Victoria-street, London, S.W., by August 31st. Our readers will remember that the Nalder and Harrison Syndicate (Limited) decided to go into liquidation on May 11th, when Messrs. N. F. Nalder, J. A. McMullen, J. G. M. Hilton and K. J. McMullen were appointed liquidators, a new firm (Messrs. Nalder and Hilton) being formed for the purpose of carrying on the business of both companies.

LIQUIDATIONS.—At a sparsely-attended meeting of the creditors of the Gülcher (New) Electric Light and Power Company (Limited), held at the Receiver's office, 73, Lombard-street, on Wednesday, to receive a statement as to the winding-up, and to formally pass the accounts presented by Mr. Fitch Kemp, it was stated that there were no assets for distribution, the amount realised by the sale of the estate having been swallowed up in legal expenses. The accounts as presented were passed. It was stated by the Chairman that Mr. D. de Castro, after a series of misfortunes in electrical undertakings, had resumed his practice at the bar.

——— Creditors of the Acme and Immisch Electric Works (Limited) must send in particulars of their claims to Mr. Edwin Wilding (one of the liquidators of the Company), 2, Clement's-inn, Strand, London, W.C., by the 25th inst.

——— It has been decided to wind up the Improved Electric Glow Lamp Syndicate (Limited) voluntarily. Particulars of claims must reach the liquidator, Mr. S. A. Bartlett, 1, Arundel-street, Strand, London, W.C., by August 24th.

BELLISS ENGINES.—Reference was made in a previous issue to the record passage made by the torpedo-boat destroyer "Swordfish," engined by Messrs. G. E. Belliss and Co., of Birmingham. With equal success the boat passed her official trial at Chatham, the average power developed by the machinery showing 10 per cent. above the contract. The total weight of engines and boilers of the "Swordfish" amounted to 56lb. per I.H.P., against 400lb. in the fastest Atlantic liners.

ALUMINIUM.—At a meeting of the British Aluminium Company yesterday at the Westminster Palace Hotel (reported elsewhere), a number of interesting exhibits were on show, including small propeller and other castings, and a large number of culinary and other domestic utensils, made at Milton from the products of the Company's factory at Foyers. The Chairman of the Company explained that they were the only makers of aluminium in this country, and that the progress made had been astonishingly rapid. The Company claim to have a practical monopoly of the water power of the Kingdom, and that the Foyers installation has worked smoothly from the first. The initial difficulties, so far as the water power was concerned, were promptly overcome. Orders already in hand exceed the capacity of the works at the present time. The Directors look forward to a large business in the manufacture of ships' fittings, portions of torpedo boats, and especially from any development of the motor car industry.

"IREX" CARBONS.—We have received from the Carbon Syndicate, Limited, of 3, Whitehall-place, London, S.W., particulars of the special carbons manufactured by them in various forms, including crucibles of all sizes, plates and rods, linings for electric furnaces, electrodes for electrolysis, pencils for arc lamps, &c. It is claimed for this special make of carbon that chemical action is resisted and temperatures which result in the disintegration of ordinary carbon is withstood, that it can be subjected to extremes of heat and cooling without breaking, that it is remarkably hard and is only with great difficulty broken, that it can be moulded to any required shape, and that its electrical conductivity is very high. The price list includes those for crucibles, and plates for batteries and electrolysis. The Carbon Syndicate are the sole manufacturers of "Irex" Carbons, and agencies have been opened at Birmingham, Cardiff, Ince, Newcastle-upon-Tyne, Swansea, and Gasgow.

THE "ENGINEERING MAGAZINE."—The text and illustrations in the July issue of this excellent magazine maintain their usual high standard. The contents of the current number include: "The Cause and Remedy for Business Depression," by Edward Atkinson; "The Turning Point in Railway Reforms," by Melville E. Ingalls; "The Filtration of Municipal Water Supplies," by Rudolph Hering; "The Utilisation of Anthracite Culm," by Edward H. Williams, Jr.; "The Direct Production of Electrical Energy from Carbon," by George H. Stockbridge; "Recent Improvements in Gold Milling," by Henry M. Chance; "Modern Machine Shop Economics," by H. L. Arnold; "The Architecture of Home-Making," by Charles E. Benton; "Japan's Invasion of the Commercial World," by A. R. Foote; and "A Practical Exposition of Electric Lighting," by Prof. W. A. Anthony. The usual exhaustive review of the World's Press is also given. This number, as well as all the back numbers, may be obtained at the offices of the European edition, 1, 2, and 3, Salisbury-court, Fleet-street, London, E.C.

"HINTS TO SMALL INVESTORS."—In its issue for the 11th inst., the *Statist* calls attention to the value as an investment of Anglo-

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American Telegraph Ordinary and Preferred stock. A digest of the dividend payments from 1890 to 1895 on both stocks is given.

CATALOGUE.—We have received from the Universal Electrical Fittings Company (Limited), of Suffolk-road, Sheffield, a copy of the second edition of a useful catalogue of main and branch switches, distributing boards, lamp holders, artistic fittings, safety devices and other electric lighting accessories. The book occupies over 40 quarto pages, is admirably arranged and well printed, the illustrations affording every assistance to those ordering electrical apparatus of this character. The catalogue may be taken as evidence that the Company is in a position to supply a large variety of electrical goods. A special feature of the catalogue is the space devoted to service switches, main cut-outs, junction-boxes and other apparatus connected with underground main work. The display of electroliers, standards, brackets and ship lighting fittings shows an artistic and serviceable variety.

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ABERDEEN.—It has been decided to light the harbour and quays electrically. The Harbour Commissioners have agreed to provide the arc lamp standards and to superintend the lamps, while the Town Council will lay the mains from the electricity station to the harbour and supply current. The harbour and borough electrical engineers are to supervise the carrying out of the work. The Council anticipate a material increase of income by supplying electric current to enable vessels being discharged at night.

ASSURANCE OFFICE LIGHTING.—The offices of the British Workman's and General Assurance Company, Birmingham, are being fitted up for the electric light.

AYR.—The Town Council have decided to make some extensions of the electric light mains at a cost of £574.

BALLYMENA (IRELAND).—The Town Commissioners intend to apply for a Provisional Order.

BERMONDSEY (LONDON).—The Vestry have decided to oppose the application of the County of London and Brush Provincial Company for a Provisional Order.

BOLTON.—The receipts from the sale of electric current from April 1st to June 30th amounted to £1,352, against £538 for the corresponding period of last year.

BURRELTON (PERTHSHIRE).—The villages of Burrelton and Woodside have recently been formed into a special lighting district, and are considering the question of introducing the electric light. There is some water power available in the locality, and investigations are being made as to whether this can be utilised.

BURY ST. EDMUND'S.—The Town Council have decided to establish electricity supply works at an estimated cost of £20,000. It was pointed out in the course of the debate that the late Town Clerk had decided that members of the Council financially interested in the gas undertaking could not vote upon the electric lighting question, but that the present Town Clerk had expressed a contrary opinion.

CANARY ISLANDS.—News was received yesterday that the "Dacia" had succeeded in securing the broken ends of the Canary Islands cable belonging to the Spanish Government.

CARDIFF.—The following letter from Mr. Sydney F. Walker on the Cardiff electricity works appears in the *Western Mail* of the 11th instant :—

"In view of the failure of the electric light in Cardiff on the night of the Prince of Wales's visit may I again urge upon the Corporation the wisdom of abandoning the rectifiers, particularly as this can now be done without very great expenditure? I was in St. Mary-street at the time the lights first began to fail, and was in the streets until after the whole of the lights were extinguished. What I noted was as follows:—Half the arc lamps began to flicker and then went out. A little later the same lamps were seen trying to relight, but without success, and a very few minutes after all the arc lights and all the incandescent lamps went out together. I read the cause thus:—One of the rectifiers supplying alternate arc lamps failed. An attempt was made either to get the rectifier to work again or to switch in the spare one. This would appear to have failed, so the whole station was shut down, while a fresh start was made. I need hardly dwell upon the seriousness of a failure of this kind at such a time, not only to the traffic in the streets, but also to shopkeepers and the proprietors of houses of entertainment; but what I wish to point out most strongly is that it is just on these occasions when it is of the utmost importance the light should not fail that it may fail, under present conditions. We have been free from failures of the kind for many months now; but our freedom has been bought by ceaseless care on the part of those in charge, and it is just at times such as the one referred to that care is apt to relax. No matter how careful a man may be, he has only one head and one pair of eyes, and if these are overstrained his capacity for taking care is reduced. As the Corporation are increasing their plant I would suggest their adopting the plan that has worked so well at Newport: place a small transformer at the base of each lamp-post, and work each lamp independently. Only a break in the mains could then extinguish the arc lamps, and if these are fed by separate pairs of mains, alternate lamps being on different cables, the chances of complete failure would be very remote. It would probably be necessary to use larger currents in the arc lamps than are now employed, and to provide reflectors of some kind above the arcs; but the cost of this would be small compared to the freedom from failure that would be ensured, and there would, of course, be the saving of the £200 per annum now expended on the 'rectifier' station. I need hardly say that I still adhere to my view that a removal of the generating station to the centre of the town, and the adoption of the low-tension system, would be the best plan and the cheapest in the end; but, as the Corporation are hardly likely to do this, I have suggested the above in the hope that we may at least have immunity from such total failure as we had on the night in question."

At the last meeting of the Council a question was asked as to the cause of the failure of the electric light for twenty minutes on the 27th ult., and the borough engineer stated that it was caused by a hot bearing upon an engine, the load being thereby thrown on to a second engine. Then the bearing of that engine also became hot, and the electric light went out. The matter was being fully reported upon by the electrical engineer.

CHELTENHAM.—The Borough Electrical Engineer (Mr. Hamilton Kilgour) has been authorised to order some additional arc lamps and transformers from the Brush Company, at a cost of £835, to obtain a 100-kilowatt steam alternator, at a cost not exceeding £1,900, and to issue specifications for the supply of a suitable engine for the alternator to Messrs. Willans and Robinson, G. E. Belliss and Co., and the Brush Company. There is now an equivalent of 6,500 8 c.p. lamps connected, while 1,000 more are ready for connecting up. The Town Council have decided not to renew the insurance on their electric lighting station, but will devise a scheme for themselves insuring the whole of their property after November next.

CHINA AND THE POSTAL UNION.—It is stated that China is about to enter the Postal Union, application having already been made through the Inspector-General.

DARFIELD (YORKS.).—The Urban District Council have asked Mr. Johnson, of Messrs. Tasker, Sons and Co., Sheffield, to prepare and submit an estimate of the cost of lighting the streets electrically.

DORKING.—The District Council are making inquiries into the advisability of lighting the streets electrically.

EDINBURGH.—The Electric Lighting Committee again recommend the Town Council to establish a special depreciation fund in connection with the electricity works, so as to be in a position to renew portions of the plant if occasion should demand it. The Chairman of the Committee (Mr. Mackenzie) explained the proposal, and said that, in addition to the annual sum required for paying off the capital outlay in 30 years, it was proposed to set aside a certain sum out of the surplus as a reserve fund on account of those portions of the plant which were known to have a much shorter life than 30 years. Up to the present the authorised works of the Council had cost £200,000, and it had been calculated that a portion of their plant (meters, batteries, transformers, arc lamps, &c.) would not last more than 10 years, while another portion of the machinery at the station would only last 20 years. The Committee therefore proposed that, on the 20 years' item, an additional 2 per cent. should be set aside, and on the 10 years' item 7 per cent., so that the totals would be paid up in 20 and 10 years respectively. In 31 years the £15,000 spent on the more perishable articles under the 10 years' heading would amount to £30,000; and in 21 years the £48,000 spent on boilers, engines, &c., would be increased to £64,000. The effect of this system of financing the undertaking would be seen at once to lead to disaster. He was certain that within the next five years the plant under the 10 years and 20 years' headings would be doubled, while the value of the land and buildings would not increase. The station was large enough to contain 8,000 H.P., while the present additions would only bring it up to 4,000. This, therefore, was an additional reason for establishing a depreciation or renewal fund. He was not quite sure if they were wise in not providing additional depreciation for the mains, and they must also bear in mind that discoveries and inventions might make portions of their plant obsolete long before it was worn out. The members did not appear to take a great interest in the subject, as the chamber was counted out before any decision was come to.

EGYPT.—Notice is given that telegrams are now received for places in Egypt south of Waddy Halfa (third region).

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from July 8th to July 14th, with the ports of destination :—

*Argentina*—Buenos Ayres, £830. *Australasia*—Adelaide, £25; Melbourne, £602 (including £242 telegraph material); Sydney, £343; Wellington, £489. *Ceylon*—Colombo, £200. *Egypt*—Alexandria, £22; Suez, £10. *France*—Boulogne, £18. *Holland*—Amsterdam, £150. *Hong Kong*, £86. *India*—Calcutta, £82 (including £69 telegraph wire); Rangoon, £84. *Mexico*—Vera Cruz, £110. *Panama*—Santos, £77. *Peru*—Callao, £22 (telegraph apparatus). *Russia*—Novorossiisk, £1,200; Odessa, £200; St. Petersburg, £40. *South Africa*—Cape Town, £420; East London, £367; Port Elizabeth, £922 (including £775 telegraph

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material). *Spain*—Bilbao, £56; Cadiz, £7,300 (submarine cable); Gijon, £8. *Straits Settlements*—Singapore, £2,610 (telegraph material). *Sweden*—Stockholm, £655 (telegraph material). *United States*—Baltimore, £18.

*Foreign made Electrical Apparatus and Material.*—Foreign manufactured electrical goods have been exported as follows:—

*Spain*—Pasages, £170. *West Indies*—Trinidad, £95 (telephone apparatus).

FULHAM (LONDON).—A further debate on the combined electric lighting and refuse destructor scheme has taken place, but the Electric Lighting Committee's report recommending the appointment of a deputation to visit various towns where dust destructors are in operation, has been referred back.

GALLERY LIGHTING.—The order for the electric lighting of the National Gallery of British Art, now being built on the site of the Millbank Prison by Mr. Tate, has been placed in the hands of Messrs. Drake and Gorham, who are employing Russell's patent system of wiring throughout the building. Mr. C. N. Russell, whose agreement with the London and Lancashire Electric Company has terminated, has joined Messrs. Drake and Gorham's staff, and is personally supervising the work at this important installation.

GERMAN TRADE WITH THE FAR EAST.—The Germans are making strenuous exertions to push their wares in the Far East. The first number of a paper printed in Japanese, entitled the *German Industrial Advertiser*, has recently been published at Berlin, and is to be devoted to the description of a variety of German manufactures. The first number deals with articles supplied by engineers, tool makers, metal founders, &c., and the next number is to give details of chemicals, optical instruments, glass, &c. The dates of succeeding issues will be regulated by the German Consuls in Japan, and will give particulars of such articles and manufactures as may for the time being be most in request in that country. Copies of this periodical are distributed broadcast amongst Japanese merchants, engineers and manufacturers, Government officials, Chambers of Commerce, Clubs, &c., while the reading-rooms of hotels and railway stations are also being liberally supplied. The efforts of German manufacturers are being ably supported by their consular officials, as well as by agents and experts resident in Japan, and it is anticipated that by this combined effort most of the Japanese trade will be captured. It is intended to adopt similar tactics in China and in the East generally, the issue of similar trade periodicals in Chinese and other Oriental languages being contemplated. The time has come when British manufacturers should be on the alert and take steps to enter the lists with the vigilant and plodding German. Perhaps the British consuls in the Far East could be instructed to perform their share of this important work.

GREAT YARMOUTH.—The receipts from the sale of electric current for the six months to June 30th amounted to £1,082, and the expenditure to £817. There are at present 177 customers, representing an equivalent of 8,365 8-c.p. lamps connected.

HAMMERSMITH (LONDON).—The Vestry have decided upon the recommendation of their engineer to adopt the Electric Lighting Committee's report, advising the fitting of superheaters to the boilers being supplied by Messrs. S. Z. de Ferranti, at an addition to the contract of £270.

HAMPSTEAD (LONDON).—The Vestry have decided to lay additional high-tension feeders from the supply station to certain of the sub-stations, at an estimated cost of £787. 14s. 2d, and to provide a supplemental water supply to the station, at an estimated cost of £155.

ILFRACOMBE.—The District Council have refused sanction to the Postmaster-General for the erection of telegraph poles on the Capstone, in connection with the coast communication system, on the ground that this would disfigure one of the principal features of the place, and recommended that the wires should be placed underground.

IPSWICH.—The question of applying for a Provisional Order has been referred to the General Purposes Committee for consideration and report.

ISLINGTON (LONDON).—The Electricity Committee have decided to ask the Vestry to sanction an additional expenditure of £20,000 for electric lighting purposes.

KIRCALDY.—In a report just published by Prof. A. B. W. Kennedy the Town Council are recommended to establish electricity supply works at an estimated cost of £20,000.

LIGHTING THE BLACKWALL TUNNEL.—At the weekly meeting of the London County Council on Tuesday the Bridges Committee reported that they had considered the question of lighting the Blackwall Tunnel, and had decided that electricity was the best and cheapest form to adopt. The light would be required both night and day, and this would greatly decrease the cost per unit. The expenditure entailed would be about £25,000, which included buildings, subway, plant, mains, and lamps for the light at 10ft. centres, and would be paid out of the £50,000 provision money which had been set apart for work of that description. They had given directions for the generating station to be erected on Northumberland Wharf, Poplar, the most convenient site for the purpose. Messrs. Pearson and Son would erect the station. With regard to the plant and machinery, the specification was well in hand, and the necessary drawings were being prepared; and the Committee anticipated that the cost of working, exclusive of depreciation, repairs, and capital charges, but including lamp renewals, would be about £5,000 a year. The Committee proposed to obtain tenders for plant from a few selected firms, as it was necessary that the plant to be supplied should be of the highest excellence. As the Council was about adjourn for the summer vacation, and as the work must be proceeded with without delay, the Committee recommended that the Bridges Committee be authorised to invite and accept tenders for the plant required. This was agreed to. The same Committee stated they had received from the Westminster Electric Supply Corporation an offer to sell to the Council, for £1,300, two Davey-Paxman engines, each direct-coupled to a Crompton dynamo of the size required for the larger units for the lighting of the tunnel. The Corporation, finding those machines too small for their requirements, were anxious to replace them by larger ones, and were, therefore, willing to part with them at a comparatively low price, the original cost of the two sets being £2,294. As the machines were nearly new, and in good order, the Committee recommended that the Council accept the offer, which was agreed to.

LIMEHOUSE (LONDON).—The County of London and Brush Provincial Company intend to apply for a Provisional Order for this district.

MILE END (LONDON).—The Vestry have rejected the report of the Special Electric Lighting Committee recommending the erection of electricity supply works.

MOTHERWELL.—The local gas company have reduced the price of gas from 3s. 6d. to 2s. 11d. per 1,000, with a special discount of 2½ per cent. The Town Commissioners possess a Provisional Electric Lighting Order, and since the granting of the Order reductions in the price of gas, amounting to 10d. per 1,000, have been made, and in addition gas meter rents have been abolished.

NEWCASTLE-ON-TYNE.—The Lighting Committee have decided to ask for a reduction in the price charged by the Newcastle Electric Light Companies for current to the street lamps. In portions of the town the electric and gas lighting is still duplicated. Although the gas company have been requested to discontinue the gas lighting they refuse to comply with the request, and maintain that they are entitled to charge for same.

NEWINGTON (LONDON).—A notice from the County of London and Brush Provincial Company of their intention to apply for a Provisional Order for this district has been referred to the special Electric Lighting Committee. The Vestry have decided to engage Messrs. Kincaid, Waller and Manville, at a fee of 50 guineas, to prepare a report on the system of electrical distribution best suited to the district.

PAISLEY.—The Town Council in Committee have adopted the following seven names as a short leet from whom they propose to to select a resident electrical engineer:—Messrs. Gilbert Bell (assistant engineer, Manchester), John Christie (borough engineer, Londonderry), A. T. Cooper (assistant engineer, Blackpool), J. Pilling (electrician, Bolton), F. Teague (engineer at Coatbridge), and two local gentlemen, Mr. Pender and Mr. Anderson. The salary of the appointment is £200 per annum.

PROVISIONAL ORDERS.—The District Councils of Levenshulme, Ogwen and Withington are each in the happy position of being wooed by two electric light companies. In the case of Levenshulme the matter is being considered by a committee, at Ogwen the District Council displayed their impartiality by granting both applications, while the Withington Council have formed a Special Committee to report upon the question of electric lighting generally.

REDDITCH.—The District Council intend to oppose the application of the Manchester Edison-Swan Company for a Provisional Order, having decided to themselves apply for an Order.

RUBBER CULTIVATION IN CEYLON.—Experiments are being made in the cultivation of Para rubber in Ceylon. About twelve months ago a firm purchased some 50,000 plants, and planted them on the Halwatura estate in the Kalutara district. According to present reports the trees show a wonderful growth, and promise well. The Ceylon Government are also making experiments in the same direction.

STAFFORD.—The salary of the Borough Electrical Engineer (Mr. J. S. Highfield) has been increased from £120 to £140 per annum, and the salary of the Assistant Engineer (Mr. T. D. Clother) from £80 to £100. The Finance Committee of the County Council have decided to accept the Town Council's offer to light the County Buildings electrically, at a charge of £175 per annum.

SWANSEA.—The Electric Lighting Committee have made a fresh agreement with the local Tramway Company, and, consequently, recommend the Council to proceed with their Bill for the purchase of the tramways.—The Directors of the Swansea and Mumbles

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Railway Company are making inquiries as to the advisability of introducing electric traction on their railway, a line of about six miles.

TARIFF CHANGES.—Under the new Customs Tariff of Victoria, the following articles are admitted free of duty : arc lamps without globes, storage batteries, bells (6in. and under) and bell fittings, carbons, and lightning conductors.——A duty of 13 lire per quintal is payable on wooden electric bell mountings imported into Italy.

TELEPHONE TRUNK WIRES.—On the 25th inst., at 4 p.m., the Post Office takes over from the National Company the working of the trunk wires at the following towns :—Aberdare, Abergavenny, Balbriggan, Barry Dock, Belfast, Briton Ferry, Cardiff, Cheltenham, Chepstow, Drogheda, Dublin, Dundalk, Evesham, Gloucester, Llanelly, Lydney, Merthyr Tydvil, Neath, Newport (Mon.), Pontypool, Pontypridd, Sharpness, Swansea, Tredegar, and Worcester.

THE COST OF ELECTRIC CURRENT IN THE CITY.—Mr. Brooke Hitching again referred to this question at the meeting of the Commission of Sewers on the 10th inst., and asked the Chairman (Mr. Turner), whether he had placed before the members the question of approaching the City of London Company with a view to obtaining a reduction of the present rates. Mr. Turner replied in the negative. As regards the public lighting, he thought the Commission had made an excellent bargain.

TORQUAY.—Col. A. G. Durnford, R.E., held a Local Government Board inquiry at Torquay, on Friday last, into the application of the Town Council for sanction to borrow £23,000 for electric lighting purposes. Mr. Percy T. Pearce, who appeared in support of the application, gave particulars of the rateable value and financial position of the town. A Provisional Order was obtained in 1891 ; and the Town Council, who were anxious to maintain the position of the town as the queen of watering-places, recognised that they could not compete with other watering-places unless they improved their lighting and were in a position to supply electric current. Mr. Percy then gave an able *resumé* of the progress made with the electric light undertakings of Local Authorities and private companies, and contended that everything pointed to the scheme at Torquay proving a success. The Town Clerk said that notice had already been received from the Guildford Electricity Company of intention to apply for a provisional order ; and, from a canvass of shopkeepers and residents, there was every reason to think that there would be a good demand for current. Mr. W. H. Trentham, the consulting engineer, gave technical details of the scheme. He thought the high-tension system the most suitable, partly on account of the extreme length of the compulsory area and also on account of the character of Lincombe and Warberry districts, where the houses were some distance apart. Mr. Beavis, who was pulled up two or three times by the Inspector for irrelevancy, objected to the scheme, because Mr. Trentham had not previously acted as electric adviser to a local authority! Mr. E. Manville gave evidence, and endorsed Mr. Trentham's figures, except as to probable revenue, which he thought had been estimated at too low a figure. Alderman Dr. Richardson favoured the introduction of electric light from a health point of view ; and here Dr. Bunting distinguished himself by admitting that for health electricity was the light, but not for Torquay. He favoured the introduction of the electric light, but not by the Council. The inquiry lasted seven hours.

WALSALL.—A memorial from a number of the leading ratepayers of High-street and Digbeth for the extension of the electric light mains has been referred to the Streets Committee.

WATFORD.—The District Council have decided to engage Mr. W. C. C. Hawtayne to advise them as to the advisability of applying to the Board of Trade for a Provisional Order, and as to the best system to be adopted, area to be lighted, &c.

WOLVERHAMPTON.—The report of the Electric Lighting Committee, to March 31, 1895, states that as a result of the year's operations there was an adverse balance of £1,162. 4s. 9d. ; but this is accounted for by the fact that the accounts for this period were debited with interest on capital, and also with a sum of £868. 3s. 6d. for one year's instalment to the sinking fund, while the receipts for electric current supplied only extended over a period of two months. The revenue account shows a credit balance of £1,570. 2s. 8d., which represents a profit of 4·85 per cent. on the borrowed capital ; interest on capital and contributions to the sinking fund amounted to £1,811. 7s. 2d., leaving a deficiency of £241. 4s. 6d. In conclusion, the Committee state that they view the year's results with satisfaction, and anticipate that before long the undertaking will become a source of profit to the Corporation. It is proposed to carry forward the balance, and to meet the same out of future profits, there being no necessity to ask for a rate in aid. The report and accounts were passed at Monday's meeting of the Council after a brief debate, all references to the position of the electricity department being of a congratulatory character. Mr. S. Craddock, who is one of the most influential members, stated that he had adopted the electric light at his works, and had found it cheaper than gas.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

June 17, 1896.

13,339. H. S. JACQUES. Cheltenham. An improved controlling and feeding mechanism for electric arc lamps.

13,405. W. M. MORDEY. London. Improvements in dynamo electric machines.

13,407. C. KELLNER. London. Improvements in electrolytic apparatus.

June 18, 1896.

13,449. C. MACKINTOSH. London. Improved blasting apparatus for mining and other purposes fired by pressure, heat, or electricity.

13,485. J. ANDERSON, R. W. HUTCHISON and C. E. VAN CURVEN. London. Improvements in telephone-switchboards.*

13,488. P. BAMBERG. London. Improvement in electric incandescent lamps.

13,496. E. J. SANDER and A. CLIFFORD. London. Improvements in incandescent electric lamps.

13,520. C. POLLAK. London. Improvements in plates for accumulators or secondary batteries.*

13,521. P. JENSEN. London. Improvements in the manufacture of carbon anodes for electrolytical processes. (H. Cappelen and D. Cappelen, Norway).*

13,522. A. F. BERRY. London. Means or apparatus for use in measuring power in alternating current circuits.

June 19, 1896.

13,542. M. MCGOWAN. Dublin. The electric type-writer.

13,553. G. DUBBERT. Glasgow. A hygienic earpiece for telephone receivers and such like.*

June 20, 1896.

13,644. F. W. GREENGRASS and S. R. DOCKING. London. Improvements in electrical accumulators.

13,645. J. D. F. ANDREWS. London. Improvements in electric wiring and in apparatus for making connection therewith.

13,646. W. H. SMITH and W. WILLIS. London. Improvements relating to electric accumulators or storage batteries and to the manufacture of plates or electrodes therefor.

13,688. A. E. BONNA, A. LE ROYER and P. VAN BERCHEM. London. Improved electrical apparatus for the treatment of air, gases and vapours.

13,689. A. E. BONNA, A. LE ROYER and P. VAN BERCHEM. London. Improved electrical apparatus for the treatment of air, gases and vapours.

13,690. A. LE ROYER, A. E. BONNA and P. VAN BERCHEM. London. Improvements in electrolytic apparatus.

June 22, 1896.

13,723. G. GERMER and F. A. HÜLLER. London. Improvements in and in connection with incandescence electric lamps.

13,729. L. CEREBOTANI and M. BERNSTEIN, proprietor of the firm of J. F. Wallmann and Co. London. Improved process for telegraphing with Morse-apparatus.*

13,730. M. BAUMER. London. Improved solenoid for electric arc lamps.*

13,767. E. CANTONO. London. Improvements in dynamo electric generators, motors and transformers. [Date applied for under Patents, &c., Act, 1883, sec. 103, 11th February, 1896, being date of application in Italy.]*

13,775. H. PIEPER, fils. London. Improvements in polyphase electric motors.

June 23, 1896.

13,814. J. ENRIGHT. London. Improvements in electric tramways.

13,824. W. HIBBERT and T. SEWELL. London. A standard of electromotive force or potential difference.

13,847. J. T. ARMSTRONG and A. ORLING. London. Improvements in and relating to electro-mechanically operated gas-lighters and the like.

13,889. L. K. OPPENHEIMER. London. Improvements in and relating to electrical distributors.*

13,891. C. ALEWIJNSE and ROOTHAAN ALEWIJNSE AND CO. London. Improvements relating to incandescent electric lamps.

June 24, 1896.

14,005. C. C. VAN DER VALK. London. Apparatus for automatically closing and operating by electrical agency the barriers of railway level crossings.*

14,014. G. C. DYMOND, of the firm of W. P. Thompson and Co. Liverpool. An improved electric cooking and frying or roasting apparatus. (The Chemisch-Elektrische Fabrik "Prometheus" Gesellschaft mit beschranker Haftung, Germany)*.

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14,015. G. C. DYMOND, of the firm of W. P. Thompson and Co. Liverpool. Improved electric heating devices. (The Chemisch-Elektrische Fabrik "Prometheus" Gesellschaft mit beschranker Haftung, Germany.)*

14,020. C. P. F. CLERC and A. G. PINGAULT. London. Improvements in electrically propelled velocipedes.

June 25, 1896.

14,064. D. SINCLAIR and W. AITKEN. Glasgow. Central battery telephone exchange system.

14,092. C. P. F. CLERC and A. G. PINGAULT. London. Improvements in electric motors especially applicable to the propulsion of velocipedes and motor cars.

June 26, 1896.

14,157. J. S. HIGHFIELD. Stafford. An improved form of washer for use in connecting secondary battery lugs and other electrical conductors.

14,187. E. HOLMES and SIEMENS BROS. AND CO. (LIMITED). London. A portable electric drill.

14,197. C. ALEWIJNSE and ROOTHAAN, ALEWIJNSE AND CO. London. Improvements in or relating to incandescent electric lamps.

14,220. W. B. SAYERS. London. Improvements in electrically-heated radiators.

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

10,951. FREUND. Secondary batteries.
11,976. HEADLAND. Electric safety lamps.
12,030. DAVY. Electric arc lamps.
12,374. HACKING and BRAND. Electric lamps, &c.
12,871. MCEVOY. Electrical circuit closers.
13,618. BEEVOR. Electrically actuated mechanism.
14,342. KOLB and LAMBERT. Electrolysing appar atus.
14,476. LIBBEY. Telephones.
23,404. ZAPATA. Electric motor.

1896.

719. WILLCOX. (Société L'Accumulateur Fulmen). Electric accumulators.
1,238. NEWTON (Willms). Electric batteries.
4,632. ROYCE and CLAREMONT. Dynamo electric generators and motors.
5,298. BOULT (Bruns). Electric flash light apparatus for photography.
5,703. BOULT (Jolles an another). Arc lamps.
7,013. DEVONSHIRE (Steinmetz). Electric meters.
7,038. BAURLIN. Arc lamp regulators.
7,161. CHAPMAN. Electric light fittings.
7,556. REAGAN. Electric railways.
8,210. FISHER. Electric arc lamps.
9,528. LAKE (Burke). Telegraphic relays.

# COMPANIES' MEETINGS AND REPORTS.

## United River Plate Telephone Company (Limited).

The tenth ordinary general meeting of this Company was held on Tuesday at Winchester House, Old Broad-street, under the presidency of Mr. J. Irving Courtenay.

The SECRETARY (Mr. Robert Herring) having read the notice convening the meeting,

The CHAIRMAN said: It is again my pleasant duty to congratulate you upon the improved condition of your property. The results of the twelve months under review are better, the prospects for the future look brighter, and the Directors therefore recommend a dividend of 4 per cent. on the paid-up share capital, being an increase of 1 per cent. on last year's dividend. You are all aware how rapidly matters change in the Argentine Republic. Our past experience of comparatively recent date is not forgotten—how periods full of promise have been suddenly succeeded by gloom and by anxious times; and it is therefore all the more gratifying to observe the increasing steadiness and stability of affairs generally in the River Plate, by which this Company has profited to an extent that has quite equalled our expectations. The system of accounts has been altered since April, 1895, the receipts and expenses having been taken at the actual sterling value each month, instead of at the par of exchange as heretofore. The accounts are thus presented in a somewhat different form this year; but it is the method employed by most British companies, and in any comparison you may make the change should be remembered. The gross receipts are £48,744, against £36,673 in the previous year, and the working expenses in the River Plate £24,957 against £17,555. The small proportional increase in working expenses is owing to the increase in the wages of the employés. To give a first-class service such as this Company now gives, it is necessary not only to have the plant in good working order, but that it should be handled by intelligent and skilful operators, and these naturally command good wages. The Directors consider the extra amount spent in wages, as recommended by our representatives in the River Plate, to be both necessary and beneficial. The percentage of working expenses against receipts was 47·90 for 1895 and 51·02 for 1896. The number of subscribers continues to augment, there being a total on March 31st of 6,231, an increase of 433 for the year. Exchange has also been more favourable to us this year, the average being 235 against 260, which is a most important factor in our increased profit. The last quotation given me is 184—a slight rise over a day or two ago. Our plant generally is in very good order, but a large continuous outlay is necessary owing to the opening of new streets and the erection of new buildings. Mr. Chappell, our general manager in the River Plate, reports that most of the important alterations and repairs to our outside lines and wayleaves, commenced over a year ago, are either finished or rapidly approaching completion. The Provincial Telephone Company, in which we are largely interested, is progressing, having secured an increase of subscribers of something over 10 per cent. The manager reports that all the staff have worked well. The result of the year's working shows a decided improvement over 1895, and all the indications point to the current year being still more satisfactory. Everything is being done to give an efficient service, and the increase in the number of our subscribers shows that our efforts are appreciated by the public. With these remarks I beg to move—

"*That the report and accounts submitted to this meeting be and they are hereby received and adopted, and that the Company declare the dividend recommended in such report.*"

The MANAGING DIRECTOR (Mr. Frank W. Jones): I have very much pleasure in seconding the resolution. I think our report and accounts will be regarded by the shareholders as very satisfactory.

The motion was carried unanimously.

Mr. F. W. JONES proposed and Mr. COLE seconded the re-election of Mr. John Irving Courtenay as a Director, and the motion was carried unanimously.

The CHAIRMAN thanked Mr. Cole and the shareholders for his re-election, and afterwards proposed the re-election as a Director of Mr. Frederick Green.

Mr. UNWIN seconded the motion, which was carried unanimously.

Messrs. Welton, Jones and Co. were elected auditors for the current year, at a remuneration of 25 guineas.

Mr. JONES proposed that the thanks of the meeting should be given to the General Manager in the River Plate, Mr. Chappell, the Buenos Ayres manager, Mr. Parker, and their general staff: also to the local consulting Directors, Messrs. Fels and Krabbé, for the ability and zeal with which the business of the Company in the River Plate had been conducted during the past year. He moved a resolution in almost similar language last year, and they all considered that these gentlemen had in the interval devoted themselves with very great zeal and with the most excellent results to the Company's business.

Mr. UNWIN seconded the motion, and remarked that he had reason for knowing that it was well deserved.

The resolution was carried unanimously.

On the motion of Mr. CUTHBERT, a cordial vote of thanks was passed to the Chairman.

The CHAIRMAN, in acknowledging the vote, said the Board had always been well supported by their shareholders in times of trial; and now, when matters were changed, they much appreciated the presence of the shareholders; and the proceedings then terminated.

## Electrical Power Storage Company (Limited).

The seventh ordinary general meeting of this Company was held yesterday (Thursday), at 4, Great Winchester-street, under the presidency of Mr. J. Irving Courtenay.

The SECRETARY (Mr. J. W. Barnard) read the notice convening the meeting.

The CHAIRMAN said: Gentlemen, I have pleasure in stating that the Directors recommend the same dividend as last year—viz., 5 per cent. Full provision has been made for the maintenance of buildings and plant by the sum of £2.272. 16s. 8d. It is satisfactory to know that the quantity of the Company's manufactures sold during the year shows an increase, in spite of keen competition. As you will have seen from the Directors' report and the advertisements in the technical papers, a most valuable acquisition has been made by the Company. It has given us much pleasure to have M. Camille A. Faure (to whose brilliant invention in 1881, as you well know, secondary batteries owe their commercial existence) associated with our Mr. Frank King, with the result that, after long and exhaustive experiments in the Company's laboratory, extending over 1½ years, a reduction in weight in the battery of over 40 per cent. and a reduction in space of 45 per cent. have been achieved, and this without any sacrifice of stability. For full details of the new battery I may refer you to the circular now being issued by the Company. The importance of these improvements in connection specially with autocars, tramcars, and self-propelled vehicles generally, cannot be over-stated, and they have just come when most wanted by engineers and the public. I may here add that I have read with some surprise the statement in a report of a committee of the Glasgow Corporation, that the combined system of the overhead trolley and accumulators which had been installed at Hanover in Germany, was, in their opinion, objectionable. In consequence of this statement I have taken some pains to get official information in regard thereto, and I find that the results of the installation were so favourable that the Directors of the Hanover street tramways have resolved to very considerably increase the size of the installation, which appears to have given every satisfaction, and to have fulfilled all the claims made upon it; and further it is important to notice that the finan-

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cial results as regards the maintenance of accumulators have been exceedingly satisfactory. More than this, the Local Authority, which, in this case, is the Police Authority, confirms the great superiority of the arrangement of accumulator traction in the town of Hanover over any other system of electric traction. We are at this time constructing a battery to be used on a similar system in this country, and we look forward to a considerable degree of success in the practical working of the battery, besides greater economy for the tramway company. He concluded by moving the adoption of the report and the payment of the dividend therein recommended.

Sir DANIEL COOPER, in seconding the motion, said it was unnecessary for him to detain them with any remarks. They were all pretty well acquainted with the merits of the important accumulator in the hands of the Company, and they were in hopes that it would enable them to do more and better work than had hitherto been done by accumulators.

Mr. JAMES W. BARCLAY said he desired, on behalf of the shareholders, to state that the results submitted to them in the annual report were regarded as very satisfactory, especially in view of the keen competition which had been going on during the past twelve months. Moreover, they considered that their prospects were even more satisfactory. The great improvement in their secondary battery, to which reference had been made, would, no doubt, bring its use within the scope of a great many objects where its excessive weight had been prejudicial up to the present; and he thought that their confidence in their prospects was greatly strengthened by the knowledge that the original inventor of the accumulator (M. C. A. Faure) had been co-operating with their engineer (Mr. Frank King) in bringing about this great improvement, and by the knowledge of the great care and trouble which had been taken to test the new cell before it was offered to the public. He thought that a Company so carefully and cautiously managed ought to command the confidence of the public; and certainly, so far as he had been able to learn, the accumulator cells they had been putting on the market would command that confidence, and still further develop the business of the Company. He trusted that for the coming year they would be able to submit a report which would, to some extent, correspond with their greatly improved prospects.

The CHAIRMAN then put the motion, and it was carried unanimously. He afterwards proposed the re-election as a Director of Sir Daniel Cooper, Bart., G.C.M.G.

Mr. JAMES PENDER, M.P., seconded the resolution, which was carried unanimously.

The auditors, Messrs. Jas. Meston and Co., were afterwards re-elected.

The CHAIRMAN then proposed a vote of thanks to the Manager (Mr. Frank King), and his staff, for their services in the past year. He observed that the introduction of a new accumulator demanded unremitting attention on the part of the staff and their chief, and he could assure the shareholders on the part of the Directors that the vote of thanks to these gentlemen was thoroughly well deserved.

Mr. FREDERICK GREEN seconded the resolution, which was carried unanimously.

The MANAGER (Mr. Frank King, M.I.E.E.), in acknowledging the compliment, stated that the staff had certainly had to work very hard at the new cell, but they had felt that they had something good to deal with. They had altered it in various ways until at last they had got what he believed was the very best secondary cell at present in existence.

On the motion of Mr. JAMES W. BARCLAY a cordial vote of thanks was passed to the Chairman; and the proceedings then terminated.

## British Aluminium Company.

The first ordinary general meeting of this Company was held yesterday at the Westminster Palace Hotel; Mr. R. W. Wallace, Q.C., presiding.

The SECRETARY (Mr. Charles F. Jones) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, it is my pleasure to preside at the first ordinary meeting of this Company, and I should like to call your attention to the title of the Company, because it has been confused with another company, called the Aluminium Company. The Aluminium Company is a prosperous concern, but it does not make aluminium. It was started originally for the purpose of making aluminium by another process, which was not found to be so successful as the process we adopted, and they have now turned their attention to the making of other articles, in which they have been successful. Now, we are the only Company in Great Britain which manufactures aluminium. Aluminium is made in three other countries, viz., at Neuhausen in Switzerland, at Froges and La Praz in France, at the Niagara Falls in America. With the first two of these Companies we are in friendly relations, and they have agreed that they will not import aluminium into this country. With the last we are not at present in friendly relations; in fact, we say that they have no right to send aluminium into this country, and an action is proceeding with reference to the matter, to which I will afterwards refer. Now, the development of aluminium in recent years has been very striking and remarkable. In 1885 the price of aluminium was 60s. per pound. This has been reduced to 1s. 4d. per pound. This reduction has been brought about by the introduction of electrical processes and especially that of Neuhausen, which is the process that we adopt in our manufacture. In starting this Company we determined that we would bring about a strong combination, that we would first of all secure what we could in the nature of monopoly by securing the patent rights in existence in order that we should control as far as possible all the different portions of the process and manufacture, beginning with the raw material, the aluminia, which is afterwards treated into aluminium. We also determined that we would own suitable water power for this purpose, which is a very difficult thing to get in this country. And then, with regard to the working of the metal afterwards, the Cowles Company was working at Milton, near Stoke; and we determined, instead of having any conflict with the Cowles Company, that it would be better to put all we had into one Company, rather than squander our money in law and fighting. We were successful in getting together this strong combination. We also determined to own the mines where the raw material was obtained, and were also successful in this. In order to get the bauxite (our raw material) in the most efficient way, we found that it was necessary to purchase the patent of Dr. Dayer, a gentleman of very great knowledge in this matter, who had worked out a successful process for making aluminia, which has been adopted in France. At Larne, on the coast of Antrim, we have established a large factory, which is capable of doing double the work we are at present doing, because we thought it necessary to erect buildings sufficiently large for extension purposes. All the plant has been designed, ordered and directed in these works within the space of the year, which I think you will consider is very remarkable progress at the commencement of an industry like this. Those works have been started without any hitch, but of course there were little details which had to be attended to; but we have commenced to make aluminia in an extremely satisfactory manner without any drawbacks at all. Now, from Larne, which is on the sea coast, we take our aluminia (which has been reduced to two tons from five tons of bauxite), and that is taken across to Lake Ness. Both our factories are very accessible to shipping, and do not require any special carriage of any kind except water carriage. Now, at Foyers these two tons of aluminia are turned into one ton of aluminium. Electrical energy furnishes the heat for this purpose. In the original prospectus it was proposed that we should utilise water power in Wales; but during the floating of this Company it was found that the estate of Foyers was in the market, and the Directors thought it better to relinquish the project we had in hand of utilising the Welsh water power, and to endeavour to get Foyers. I am pleased to say that we succeeded in securing Foyers and the right to the water power. In obtaining this water power we had to purchase a very large estate of about 8,000 acres in extent, and we have water rights in addition to that of over 100 square miles, so that we have there ample water power for all present purposes and also for further extension. Here the turbines are set to work, and electricity is conducted to those furnaces. The mud comes out when tapped, leaving no residue whatever; the carbonic acid which is driven off is the only waste product that we have. The Larne factory building, I may say, is about 200ft. long by 140ft., and in addition we have the Foyers building, which has been enlarged. The raw material, prepared as I have described, is then sent to Milton, where the old Cowles works are. These are large freehold works, which have been very greatly extended by putting down fresh rolling mills and other appliances for the manufacture of aluminium into sheets, castings, and other articles. With regard to the patents, I mentioned just now that the Americans had imported aluminium into this country. Now, of course, patents are all very well in their way, but the great thing is to see that you have a good industry; and we are in this position that, if we had no monopoly, and had to fight the Americans on the basis of a mere commercial industry, we should be able to beat them, because we own our water power, which has cost us practically nothing, and because we have our own estates and our own raw material. I am thankful, however, to say that our patents do cover a very great deal of ground, and the Directors believe we shall hold the field, and prevent the Americans selling aluminium in this country. The Government have already recognised that by the payment of the royalties. It has been found that our patents control the manufacture of carbide of calcium used for making acetylene. With regard to the demand for aluminium, in my opinion 700,000 tons is a small quantity to be consumed for a metal such as this, and it will be fully taken up in a year or so. Therefore, it will be necessary to go in for a further extension. The money that is necessary for this extension of water power is already subscribed. It is not necessary to say anything about the profit and loss account, because it is only since we made aluminium that a profit has been made, and that you will hear more about at the next general meeting. I think the rest of the accounts are very clear, but if anyone would like to ask me any questions about them I shall be glad to answer them. With regard to our prospects, the only comparison I can make is with the Neuhausen Company, which has not the same advantages that we have and who propose to buy their raw material from us. This Company has made a profit of £43,000, which has been steadily increasing in succeeding years, and their shares now stand at 100 per cent. premium. I think, therefore, that we have a very profitable business, and it ought to be one of the greatest industries in the country. I should like to refer to the help accorded us by Lord Kelvin, who has given us a great deal of time and a great deal of advice. Our Managing Director (Mr. Ristori) has been unfailing in his attention to his work. You see from the number of cases which are in process of operation that there is a great deal to be done, and Mr. Ristori has worked night and day. Mr. Birch and his assistant, Mr. Graham, have also done very excellent work. Mr. Weiss at Foyers, Mr. Sunderland at Larne, and Mr. Jones our secretary, and Mr. Varley, who has been attending to the sale of the metal, have all done extremely well for the Company, and the success which we have achieved could not have been brought about if I had not had the assistance of an excellent Board of Directors. I should like to say, in conclusion, that this industry, which has such a promising future, is not confined to any section of the British Isles—it will benefit Ireland, Scotland and England. I, for one, am very thankful that the Duke of Westminster has not succeeded in preventing this industry being adopted in this country. I think he for one would be the first to see that he had made a mistake, and I think that the future of this Company will show that those who started it have conferred a great benefit on the country. I now propose the adoption of the report and accounts.

Lord KELVIN, in seconding the resolution, said: I think the shareholders will agree with me that we have listened to a most satisfactory

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report. It is not often that a report presented at the first ordinary meeting of shareholders of a great Company shows such magnificent progress as has been shown in the statements of fact put before us on this occasion. We can conceive, I think, without having seen, what a great work has been done. I myself saw the place and the work in progress last September, and I must say that I scarcely hoped that by this month of July aluminium would be placed before us, actually extracted in Scotland from the ore obtained in Ireland, as has been explained by Mr. Wallace. It is most satisfactory in Scotland to find that the people of the place—who know what is good for them, who know their own scenery and value it—have been thoroughly with us from the beginning, and are now, I believe, enthusiastic in their sympathy with the work that has been done by the British Aluminium Company. You might go a great deal further, I think, looking forward to the benefits, for Scotland begun with this work. There is water power all over Scotland in great abundance, very little of which has been used, and the time is coming when the value of that water power will be more and more appreciated and put to uses such as this Company is now doing. And many other applications of it not yet in immediate prospect will be made, and there can be no doubt that there is a future for the Highlands of Scotland which a few years ago was scarcely imagined. We shall probably see factories for the production of aluminium, working under licence from this Company, established in large numbers, as well as factories of other kinds. Water power, with the electrical means of applying it, is now for the first time beginning to be of real importance in practical engineering; and I think that the first steps in this direction, taken by the British Aluminium Company, redounds very greatly to the credit of the Company. The building arrangements, the getting of the dynamos from the Swiss factory where they were made, and setting them up in such a way that they have run perfectly from the first hour, was certainly an achievement that those who have performed it have some reason to be proud of. I feel sure the shareholders will appreciate the work which has been done for them by the Directors, and by others for the Directors, in connection with this great undertaking.

The resolution was agreed to unanimously.

Mr. HARVEY DU CROS proposed, and Mr. R. HEATH, J.P., seconded, the re-election of Messrs. A. S. Bolton and A. A. Common as Directors, which was carried unanimously.

A vote of thanks to the Chairman, proposed by Mr. STOCKWELL JONES, seconded by Mr. CREWDSON, brought the proceedings to a close.

## Eastern Telegraph Company (Limited).

The following report of the Directors of this Company for the half-year ended March 31st last will be presented to the general meeting to be held at Winchester House, Old Broad street, London, on the 23rd inst., at one o'clock:—

The revenue for the period amounted to £466,093. 6s. 3d., from which are deducted £99,151. 17s. 9d. for the ordinary expenses and £33,955. 19s. 10d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £4,413. 0s. 10d. for depreciation of spare cable, £388. 15s. 4d. due to re-valuation of currency assets, £5,806. 13s. 11d. for income tax, and transferring £20,000 to the fire insurance fund, there remains a balance of £302,376. 18s. 7d., to which is added £49,352. 17s. 9d. brought from the preceding half-year, making a total available balance of £351,729. 16s. 4d. From this balance there have been paid—

| | | | |
|---|---|---|---|
| Interest on Debentures and Debenture Stock..... | £29,281 | 14 | 6 |
| Dividend on Preference shares ..... | 20,296 | 4 | 1 |
| An interim dividend of 2s. 6d. per share on the Ordinary shares ..... ..... | 50,000 | 0 | 0 |
| | £99,577 | 18 | 7 |

Leaving a balance of £252,151. 17s. 9d., out of which the Directors have placed £10,000 to the reserve fund for maintenance ships, and £125,000 to the general reserve fund.

The Directors now recommend the declaration of a final dividend for the year ended March 31, 1896, of 2s. 6d. per share and a bonus of 3s. per share, amounting together to £110,000, both payable on the 23rd inst., free of income tax, and making, with the three previous payments on account, a total distribution of 13s. per share, or 6½ per cent., for the year on the Ordinary shares. The balance of £7,151. 17s. 9d. shown at the foot of the revenue account is proposed to be carried forward to the next half-year.

The revenue includes £32,914. 10s. dividends and bonus for the half-year upon the Company's investments in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

The International Telegraph Conference is being held at Budapesth, at which the Acting Chairman, Managing Director, and other representatives of the Company have been in attendance, but the labours of the Conference are not yet completed.

The Directors deeply regret to report the death on the 7th inst. of their esteemed colleague Sir John Pender, Chairman of the Company since its formation. The high position which this Company has attained is in a great measure due to his untiring energy and devotion to its interests, and to the cause of submarine telegraphy throughout the world.

The Directors have appointed, as Chairman of the Company, the Most Hon. the Marquis of Tweeddale, who has been Vice-Chairman since 1874. They have also appointed the Managing Director, Mr. J. Denison Pender, Vice-Chairman of the Company, and Mr. C. W. Earle a Director of the Company.

## Anglo-American Telegraph Company (Limited).

The report of the Directors of this Company for the half-year to 30th June last, is to be submitted to the meeting of the proprietors, to be held at Winchester House, Old Broad-street, E.C., on Friday next, at 2 p.m.

The report states that the total receipts from the 1st January, 1896, including the balance of £794. 0s. 11d. brought forward, amounted to £154,832. 4s. 8d. The traffic receipts show an increase of £11,917, compared with the corresponding period of last year. The total expenses of the half-year, including the repair of cables, &c., amounted to £57,028. 19s. 5d., an increase of £1,644. 17s. 1d. The Directors, under the powers conferred upon them by the Articles of Association, have, before declaring the net profits, set apart the sum of £12,000 to the renewal fund, leaving a balance of £85,803. 5s. 3d.

One quarterly interim dividend of 12s. per cent. on the Ordinary Stock, and of £1. 4s. per cent. on the Preferred Stock, was paid on 1st May, absorbing £42,000, and a second quarterly dividend of 12s. per cent. on the Ordinary Stock, and £1. 4s. per cent. on the Preferred Stock, amounting to £42,000, will be paid on the 1st August, leaving a balance of £1,803. 5s. 3d. to be carried forward.

The Company's repairing s.s. "Minia" has been employed during the past half-year in the repair of several of the cables connecting Newfoundland with Cape Breton. She has also been employed by the Direct United States Cable Company for the repair of a cable belonging to that Company, the payment for which appears in the revenue account.

## NEW COMPANIES, STATUTORY RETURNS, &c.

*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1896, pages *318-340, &c., &c.*

**RIVER PLATE ELECTRIC LIGHT AND TRACTION COMPANY (LIMITED).**—This Company was registered on July 7th, with a capital of £300,000, in £5 shares, to enter into an agreement with the River Plate Electricity Company (Limited), for the acquisition of certain property and rights, to carry on the business of supplying electric energy for light and motive power purposes in the Argentine Republic, Uruguay, Paraguay, Chili, Bolivia and Brazil in South America and elsewhere, and to construct and equip tramways and railways with electric or other mechanical system of traction. The first subscribers, with one share each, are:—W. Y. Yeoman, W. B. Butler, D. J. Prosser, J. A. Fuller, J. H. Chapman, J. W. Honess, and G. A. J. Smallman.

**VERITY'S (LIMITED).**—This Company was registered on July 9th with a capital of £2,000, in £1 shares, to carry on the business of electricians, electrical engineers, &c., in the neighbourhood of Dulwich.

**CHINA AND JAPAN TELEPHONE COMPANY (LIMITED).**—The annual return, to May 19th, has just been filed. The capital is £20,000, in £1 shares, and 14,761 of these have been taken up, and all have been issued as fully paid.

**CRYSTAL PALACE DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return, to May 21st, has just been filed. The capital is £100,000, in £1 shares, and 28,586 of these have been taken up, 14,166 have been issued as fully paid, and the full amount has been called on the remainder, resulting in the payment of £14,420. 3,264 shares have been forfeited.

**ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).**—The annual return, to July 2nd, has been filed. The capital is £200,000, divided into 39,900 Ordinary and 100 Founders' shares, of £5 each, 20,000 of the former, and all the latter, have been taken up. The full amount has been called on the Founders' shares, while a call of £1 per share has been made on the others.

**ELECTRIC TRACTION COMPANY (LIMITED).**—The annual return, to June 19th, has been filed. The nominal capital is £300,000, in 29,880 Ordinary shares of £10 each, and 1,200 Deferred shares of £1 each. All of these have been subscribed for, £2 per share has been called on the former, and the full amount has been called on the Deferred.

**ELECTRICAL APPLIANCES SYNDICATE (LIMITED).**—The annual return, to May 8th, has been filed. 1,054 shares have been taken up out of a capital of £2,000, in £1 shares, and 450 have been issued as fully paid. The full amount has been called and paid on the remaining 604 shares.

**ELECTRICAL PURIFICATION ASSOCIATION (LIMITED).**—The annual return, to December 31st, has only just been filed, no meeting having been held for 1895. The nominal capital is £25,000, in £1 shares, of which 18,326 have been taken up. 5,000 of these have been issued as fully paid. 13,326 shares have had the full amount called, and £13,226 has been paid.

**ELIESON ELECTRICAL SWITCH (LIMITED).**—The annual return, to January 2nd, has just been filed. The nominal capital is £5,000, in £1 shares. 3,806 shares have been taken up, and 2,500 have been issued as fully paid. The full amount has been called on the remainder, and £1,301 has been paid.

**ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY (LIMITED).**—The annual return, to May 11th, has been filed. The nominal capital is £250,000, divided into 75,000 Ordinary and 50,000 Preference shares of £2 each; 62,981 of the former and 15,121 of the latter have been taken up, and 25,000 Ordinary have been issued as fully paid. The full amount has been called on 37,981 Ordinary and the 15,121 Preference, resulting in the payment of £106,204. £1,457. 12s. 10d. has been paid in

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respect of 1,682 Ordinary and 48 Preference shares forfeited; 10,327 Ordinary shares have been cancelled.

**RICHMOND (SURREY) ELECTRIC LIGHT COMPANY (LIMITED).**—The annual return, to April 30th, has been filed. 6,266 shares have been taken up out of a capital of £50,000, in £5 shares. The full amount has been called, and £31,320 has been paid.

**WEST AFRICAN TELEGRAPH COMPANY (LIMITED).**—The annual return, to June 25th, has been filed. The capital is £400,000, in £10 shares. 23,109 shares have been taken up, and the full amount has been called and paid.

**WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).**—The annual return, to June 12th, has been filed. The whole nominal capital of £300,000, in £10 shares, has been taken up, and the full amount called and paid.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The annual return, to June 3rd, has been filed. The capital is £2,445,630, in 200,000 Ordinary, 34,563 First Preference, and 10,000 Second Preference shares, of £10 each. 88,321 Ordinary, all the First Preference, and 4,669 Second Preference shares have been taken up, the full amount has been called, and £1,275,530 has been paid.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31d$\frac{27}{32}$. per oz. (July 16th). Consols (2$\frac{3}{4}$ per cent.) 113$\frac{3}{8}$—113$\frac{1}{2}$ for money, 113$\frac{7}{16}$—113$\frac{9}{16}$ for account; 2$\frac{1}{2}$ per cent. 107$\frac{7}{8}$—108$\frac{1}{8}$ (July 16th). Stock Exchange Settling Days: Consols, Aug. 4th; Stocks and Shares Continuation Day, July 28th; Ticket Day, July 29th; Pay Day, July 30th; Mining Share Carry-over Day, July 27th.

**ALUMINIUM COMPANY (LIMITED).**—The report of the Directors of this Company for the twelve months ended June 30th states that the general business at Oldbury, and the various undertakings in which the Company are interested, are progressing satisfactorily. The accounts show a profit of £50,681, which, after payment of fixed charges, allow of a dividend of 15 per cent. on the "A" shares, £10,000 to be written off the works, and £10,000 off the petents, leaving £11,079. 14s. 3d. to be carried forward. Of the net profits for the year, £33,523 arises from the cash profit made on the sale of patents, &c., which were included among the assets at a nominal figure. The contract with the Castner-Kellner Alkali Company has been completed, and the shares in that Company held by this Company have been placed to reserve. The provisional contract of sale with the Mathieson Alkali Company has been confirmed, and all instalments due to the present time have been paid, while the shares received in part payment have been treated in a similar manner to those held in the Castner-Kellner Company. Large works are about being erected by the Mathieson Company at Niagara Falls, and after January 1st the profits of this Company will be further increased by a minimum annual royalty of £4,000. The American Company mentioned in the last report has been duly incorporated under the title of the Niagara Electro-Chemical Company, and are also erecting works at Niagara Falls, which are nearing completion. Negotiations for the sale of the British and Continental rights under similar patents to those sold to the Niagara Company are proceeding. No mention is made in the report of any "aluminium" work being done by this Company, and it would therefore appear that the title of the concern is misleading and should be altered. The Company is inviting subscriptions for £90,000 Four and a Quarter per Cent. First Mortgage Debenture stock at £103, redeemable in 1906 at £110. It is intended to pay off existing debentures by this issue.

**ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).**—On Friday last the Directors of this Company resolved, after placing the sum of £6,000 to the Renewal Fund, to declare an interim dividend for the quarter ended 30th June of 12s. per cent. on the Ordinary stock and 24s. per cent. on the Preferred stock, less income tax, payable on 1st August.

**BIRMINGHAM CENTRAL TRAMWAYS COMPANY (LIMITED).**—The Directors of this Company have issued a circular to the shareholders setting out the terms of the agreement for the sale of the Company's undertaking to the Canadian Syndicate. Full particulars of these terms were given in our issue of May 22nd; and as the Corporation have now ratified the arrangement, an extraordinary general meeting of the shareholders will be held at the Queen's Hotel, Birmingham, on the 20th inst., for the purpose of formally approving the agreement, and for passing the usual winding-up resolution.

**CHARING CROSS AND STRAND ELECTRICITY SUPPLY CORPORATION (LIMITED).**—The Directors of this Corporation have declared an interim dividend for the half-year ended June 30, 1896, at the rate of £5 per cent. per annum on the Ordinary share capital, and have decided to carry forward £6,100, after payment of all interest on debentures.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The accounts of this Company for the half-year ended June 30th show a balance, after providing for debenture interest and the full dividend on the Five per Cent. Preference Shares, sufficient to allow of the payment of a dividend on the Ordinary stock of 1$\frac{3}{8}$ per cent. per annum, a balance of £1,072 being carried forward. The dividend for the first half of 1895 was at the rate of 1$\frac{1}{8}$ per cent. per annum, while the balance forward amounted to £965. The traffic returns of this Company for the week ended July 12th were £937, against £848 in the corresponding week of 1895, an increase of £89. The total receipts for the half-year amount to £1,818, against £1,763 for the corresponding period of 1895, an increase of £55

**COUNTY OF LONDON AND BRUSH PROVINCIAL ELECTRIC LIGHTING COMPANY (LIMITED).**—The Directors of this Company have declared an interim dividend for the half-year to June 30th on the first and second issues of Preference shares at the rate of 6 per cent. per annum, payable on 21st inst. The transfer books will be closed till the 21st inst., for the purpose of preparing the dividend warrants.

**CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).**—The warrants for the payment of the interim dividend of 6 per cent. per annum for the half-year ended June 30, 1896, on this Company's Preference shares have been posted.

**DIRECT UNITED STATES CABLE COMPANY (LIMITED).**—The Directors of this Company have resolved to recommend a final dividend of 2s. 6d. per share, free of income tax, making, with the interim dividends already paid, 2$\frac{1}{2}$ per cent. for the year ended 30th June; to place £7,500 to the Reserve Fund account, and to carry forward a balance of £4,235. 11s. 11d. The above dividend is payable on and after the 30th inst. The transfer books of the Company are closed from the 14th to the 28th inst. inclusive.

**DUBLIN UNITED TRAMWAYS COMPANY (LIMITED).**—The report of this Company for the half-year ended June 30th states that arrangements have been made for acquiring the system of the Dublin Southern District Tramways Company.

**EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).**—The share transfer books will be closed from the 18th to the 31st inst. inclusive.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 12th inst. amounted to £1,252. The amount for the corresponding week last year was £1,186; increase, £66.

**NATIONAL TELEPHONE COMPANY (LIMITED).**—The transfer books will be closed from 17th to 30th inst. inclusive. Dividend warrants will, it is stated, be posted on the 30th inst.

**NOTTING HILL ELECTRIC LIGHTING COMPANY (LIMITED).**—The Directors have declared an interim dividend for the six months ended June 30th on the Ordinary and Preference shares at the rate of 6 per cent. per annum.

**RIVER PLATE ELECTRIC LIGHT AND TRACTION COMPANY (LIMITED).**—Letters of allotment for the recent issue of £125,000 Five per Cent. First Debenture Stock of this Company have been posted.

**STOCK EXCHANGE NOTICES.**—Application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to the Provincial certificates for, £100,000 Four and a-Quarter per Cent. First Mortgage Debenture Stock of Willans and Robinson (Limited).

**TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).**—An interim dividend of 12s. per share has been declared by the Board of this Company. The transfer books are closed from the 13th to 21st inst., preparatory to the payment of an ad interim dividend of 12s. per share.

**WATERLOO AND CITY RAILWAY COMPANY.**—The fifth half-yearly general meeting of this Company will be held at Waterloo Station, S.E., on the 6th prox., at 2 p.m. The transfer books will be closed from 23rd inst. to August 6th inclusive.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended 10th July, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,889.

**WESTERN UNION TELEGRAPH COMPANY.**—This Company have issued their report for the quarter ended June 30, 1896:—The following statement, dated June 10th, exhibits the condition of the Company at the close of the quarter ended March 31, 1896:—

| | | |
|---|---|---|
| Surplus January 1, 1896, as per last quarterly report... | | $8,022,533 16 |
| Net revenues, quarter ended March 31, 1896 ..... | | 1,051,715 33 |
| | | $9,074,248 49 |
| From which deducting for— | | |
| Dividend of 1$\frac{1}{4}$ per cent. paid April 15th | $1,191,952 50 | |
| Interest on bonded debt ..... | 223,347 75 | |
| Sinking funds ..... | 19,991 00 | |
| | $1,435,291 25 | |
| Left a surplus April 1, 1896, of ..... | | $7,638,957 24 |
| The net revenues of the quarter ending June 30th, based upon nearly completed returns for April, partial returns for May, and estimating the business for June, will be about..... | | 1,500,000 00 |
| | | $9,138,957 24 |
| From which appropriating for— | | |
| Interest on bonds ..... ..... | $223,350 00 | |
| Sinking funds ..... ... . ..... | 20,000 00 | |
| | | 243,350 00 |
| | | $8,895,607 24 |
| It requires for a dividend of 1$\frac{1}{4}$ per cent. on capital stock issued, about ..... | | 1,191,950 00 |
| Deducting which leaves a surplus, after paying dividend, of ..... | | $7,703,657 24 |

In view of the preceding statements, the Committee recommend that a dividend of 1$\frac{1}{4}$ per cent. on the capital stock of the Company be declared, payable on and after the 15th instant.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, July 8. | | Price Wednesday, July 15. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending July 11. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American ..... xd | 49 | 51 | 50 | 52 | 4 16 2 | Jan., Apr., July, Oct. | 50⅝ | 49 |
| £2,993,560 | Stock | 24/0 | Do. Preferred ..... xd | 93½ | 94½ | 93½ | 94½ | 5 5 10 | " " | 93⅝ | 92⅝ |
| £2,993,560 | Stock | 5/0 | Do. Deferred ..... | 9 | 9½ | 9 | 9⅛ | .. | .. | .. | .. |
| £173,400 | 100 | 4⅞ | *African Direct Teleg. 4% Deb. (Reg. & Bearer) .... | 100 | 104 | 100 | 104 | 3 16 11 | January and July .. | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) ..... | 9 | 10 | 9 | 10 | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine ..... | 15 | 15½ | 15 | 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15⅞ | 15 |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) .... | 111 | 115 | 111 | 115 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock ..... | 160 | 170 | 160 | 170 | 4 2 4 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine ..... | 12½ | 13½ | 12½ | 13½ | 5 18 6 | February and August | 12⅝ | 12⅝ |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. ..... | 19½ | 20½ | 20 | 21 | 4 5 3 | " " | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) ..... | 3½ | 4½ | 3½ | 4½ | 5 0 0 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. ..... | 10 | 10½ | 10 | 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each ..... | 106% | 103% | 106% | 109% | 4 2 7 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 ..... | 9¾ | 10¼ | 9¾ | 10¼ | 4 3 0 | Jan., Apr., July, Oct. | 9⅞ | 9⅞ |
| 400,000 | 10 | 2/6 | Eastern ..... | 17 | 17½ | 17½ | 17⅝ | 3 13 3 | " " | 17⅝ | 17 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference ..... | 18½ | 19 | 18½ | 19 | 3 3 2 | " " | .. | .. |
| £1,297,857 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock .... | 131 | 134 | 131 | 134 | 2 19 10 | May and November | 132½ | 131½ |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 ..... | 106 | 109 | 106 | 109 | 4 13 6 | February & August | .. | .. |
| 250,000 | 10 | 6/6 | Eastern Extension ..... xd | 17 | 17½ | 17½ | 18 | 3 17 9 | Jan., Apr., July, Oct. | 17⅝ | .. |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock ..... | 132 | 135 | 132 | 136 | 2 19 9 | February & August | 133 | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 .. | 101 | 104 | 100 | 104 | 4 16 2 | January and July .. | 103½ | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 .. | 101 | 104 | 100 | 104 | 4 16 2 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) .. | 106 | 109 | 103 | 109 | 3 13 11 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) ..... | 111% | 114% | 111% | 114% | 3 10 8 | May and November | .. | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust ..... | 10½ | 11 | 11 | 11½ | 3 13 11 | Jan., Apr., July, Oct. | 11 | 10⅝ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference ..... | 17½ | 17⅝ | 17½ | 18 | 3 6 8 | " " | 17½ | 17⅝ |
| 150,000 | 10 | 5/0 | Great Northern ..... | 23 | 24 | 23½ | 24⅛ | 4 1 8 | Jan., April, and July | .. | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue ..... | 104 | 107 | 105 | 108 | 4 14 1 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European ..... | 52 | 55 | 53 | 53 | 4 9 3 | May and November | 54½ | 53½ |
| 37,548 | 10 | .. | London Platino-Brazilian ..... | .. | .. | .. | .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures ..... | 111 | 114 | 111 | 114 | 5 7 2 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 .. | 105 | 109 | 106 | 109 | 3 13 5 | .. .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's ..... | 6½ | 7½ | 7 | 8 | 5 0 0 | April and October .. | .. | .. |
| 3,381 | £100 Cert. | £2 | *Submarine Cables Trust 6 per Cent. ..... | 136 | 141 | 135 | 140 | 4 5 9 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph ..... | 7 | 8 | 7 | 8 | .. | January and July .. | .. | .. |
| £233,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) ..... | 103 | 106 | 103 | 106 | 4 15 11 | March & September | 105 | .. |
| 30,000 | 10 | 2/0 | West Coast of America ..... | 1 | 2 | 1 | 2 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 ..... | 98 | 103 | 93 | 103 | 7 15 4 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama ..... | 1⅛ | 1⅜ | 1⅛ | 1⅜ | .. | " " | 1½ | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference ..... | 11½ | 11⅝ | 11½ | 11⅝ | 5 2 2 | May and November | 11⅝ | 11⅜ |
| 4,663 | 10 | 6% | Do. 6 per Cent. 2nd Preference ..... | 9½ | 10½ | 9½ | 10½ | 5 14 3 | " " | .. | .. |
| £30,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) .... | 107 | 110 | 107 | 110 | 4 10 11 | June and December | .. | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian ..... | 8¼ | 9¼ | 8¼ | 9¼ | 4 17 7 | May and November | .. | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred ..... | 6¾ | 7½ | 6½ | 7½ | 5 3 8 | " " | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary ..... | 2¼ | 2¾ | 2½ | 2⅝ | .. | " " | 7⅛ | 6⅝ |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 .... | 105 | 109 | 105 | 109 | 5 12 11 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 ..... | 105 | 109 | 105 | 109 | 5 12 11 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds.... | 110 | 115 | 110 | 115 | 6 2 10 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) ..... | 102 | 105 | 102 | 105 | 5 16 6 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) ..... | 3½ | 3¾ | 3½ | 3¾ | .. | .. | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing xd | ⅞ | ⅞ | ⅞ | ⅞ | .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) .... | ¾ | ¾ | ¾ | ¾ | 5 14 3 | Yearly | .. | .. |
| 434,597 | 5 | 3/0 | National ..... | 7⅜ | 7⅝ | 7⅜ | 7⅝ | 3 9 10 | June and December | 7⅝ | 7⅞ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. ..... | 17 | 19 | 17 | 19 | 3 3 2 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid).... | 15½ | 17½ | 16 | 17 | 3 10 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. ..... | 6¾ | 7 | 6¾ | 7⅛ | 3 10 2 | " " | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) ..... | 105 | 108 | 105 | 108 | .. | January and July . | 106½ | .. |
| 58,000 | 5 | 4/0 | United River Plate ..... x l | 3¾ | 4¼ | 3¾ | 4¼ | 4 14 2 | July .. ..... | 4⅛ | 3⅞ |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) ..... | 101 | 103 | 101 | 103 | 4 14 4 | January and July .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) .... | 14½ | 15½ | 14½ | 15½ | 3 4 6 | February & August | 15½ | 11⅝ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) .... xd | 16½ | 17½ | 16½ | 17½ | 3 9 7 | January and July .. | 17 | .. |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) ..... | 133 | 137 | 133 | 137 | 3 13 0 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain .. ..... | .. | .. | .. | .. | .. | .. | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. .. | 8¼ | 8½ | 8¼ | 8½ | .. | .. | 8½ | 8⅛ |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 ..... | .. | .. | .. | .. | .. | .. | .. | .. |
| 24,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8¾ | 9¼ | 8¾ | 9¼ | .. | .. | .. | .. |
| £10,000 | £10 | 3/0 | Do. Pref. (fully paid) ..... x l | 13¼ | 13⅝ | 13 | 13½ | 4 8 11 | .. | .. | .. |
| 8,322 | £5 | .. | House-to-House Electric ..... | .. | .. | .. | .. | .. | .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid). | .. | .. | .. | .. | .. | .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) ..... | .. | .. | .. | .. | .. | January and July .. | .. | .. |
| 45,000 | £5 | .. | Liverpool Electric Supply (fully paid) ..... | .. | .. | .. | .. | .. | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply ..... | 1 | 1½ | ¾ | 1¼ | .. | .. | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) ..... | 13 | 14 | 11¼ | 13½ | 2 19 3 | .. | 13½ | 13¼ |
| £100,000 | Stock | 4½% | * Do. 4½% Debs. ..... | 119 | 121 | 119 | 121 | 3 14 5 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric ..... | 10 | 10¼ | 10 | 10½ | .. | .. | 10½ | 9½ |
| .. | .. | .. | Rand Electric ..... | 1⅛ | 1⅜ prem | 1⅛ | 1⅜ prem. | .. | .. | .. | .. |
| 19,930 | £5 | 5/3 | St. James and Pall Mall ..... | 11⅜ | 12½ | 11½ | 12½ | .. | .. | 12 | 11⅜ |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference ..... | 9½ | 10½ | 9½ | 10½ | 3 6 8 | .. | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) ..... | 10¼ | 10¾ | 10¼ | 11 | 6 7 3 | .. | 10¾ | 10½ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 90,000 | 8 | 1/8 | Brush Electrical Engineering ..... | 1⅝ | 1⅝ | 1⅝ | 1⅝ | 5 8 8 | .. | 1⅞ | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative ..... | 1⅝ | 1⅞ | 1⅝ | 1⅞ | 6 17 2 | .. | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures ..... | 112 | 115 | 112 | 115 | 3 19 8 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref .. | 2 | 2½ | 2 | 2¼ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/8 | Edison and Swan United ("A" Swan) (£3 paid) .. | 1½ | 2 | 1⅝ | 2⅛ | 6 13 4 | February & August | 2 | 1⅞ |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock ..... | 103 | 106 | 103 | 105 | 4 5 9 | January and July .. | 103 | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 110,000 | 2 | .. | Electric Construction ..... | 1½ | 1⅝ | 1½ | 1⅝ | .. | .. | .. | .. |
| 12,845 | 2 | 2 9⅞ | Do. 7 per Cent. Cumulative Pref. ..... | 2½ | 3 | 2½ | 3 | 4 13 4 | September ..... | 2⅝ | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing ..... | ⅝ | ¾ | ⅝ | ¾ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) ..... | .. | .. | .. | .. | .. | .. | .. | .. |
| 50,000 | 10 | 15/0 | India Rubber, Gutta Percha, &c., Works ..... x l | 21 | 23 | 21 | 23 | 4 6 11 | February & August | 22½ | 22 |
| £200,000 | 100 | .. | * Do. 4 per Cent. Debentures ..... | 105 | 108 | 105 | 108 | 5 14 1 | March & September | 107 | .. |
| 15,995 | £10 | .. | International Okonite Ordinary ..... | .. | .. | .. | .. | .. | .. | .. | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference ..... | .. | .. | .. | .. | .. | December and June | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) .... | ⅝ | ¾ | ⅝ | ¾ | .. | .. | .. | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance ..... | 38 | 41 | 37 | 40 | 4 7 10 | March and July..... | 39½ | 39 |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds ..... xd | 102 | 105 | 102 | 105 | 4 15 3 | January and July . | .. | .. |
| 37,514 | £5 | .. | Woodhouse and Rawson Ordinary (£3 15s. paid).. | .. | .. | .. | .. | .. | .. | .. | .. |
| 41,098 | £5 | .. | Do. Preference (fully paid) ..... | .. | .. | .. | .. | .. | .. | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary ..... | 17 | 18 | 17½ | 18½ | 4 10 1 | March & September | 18 | 17⅝ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference ..... | 17 | 18 | 17 | 18 | 3 17 9 | " " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock ..... | 103 | 114 | 103 | 114 | 4 0 0 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. ..... | 43 | 45 | 44 | 46 | 2 14 4 | January and July .. | 44½ | 43 |
| 7,660 | 10 | 5% | Do. 5% Perpetual Preference ..... | 14½ | 15½ | 14½ | 15½ | 3 6 5 | " " | 15⅝ | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture ..... | 135 | 137 | 135 | 137 | 2 18 5 | May and November | .. | .. |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway ..... | 13¾ | 14 | 13¾ | 14 | 2 2 6 | " " | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference ..... | 17¼ | 17⅝ | 17¼ | 17⅝ | 2 16 10 | .. .. | .. | .. |
| 135,000 | Stock | 4% | Do. 4% Debenture ..... xd | 112½ | 114½ | 112½ | 114½ | 3 9 10 | January and July .. | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest but *not* for redemption.

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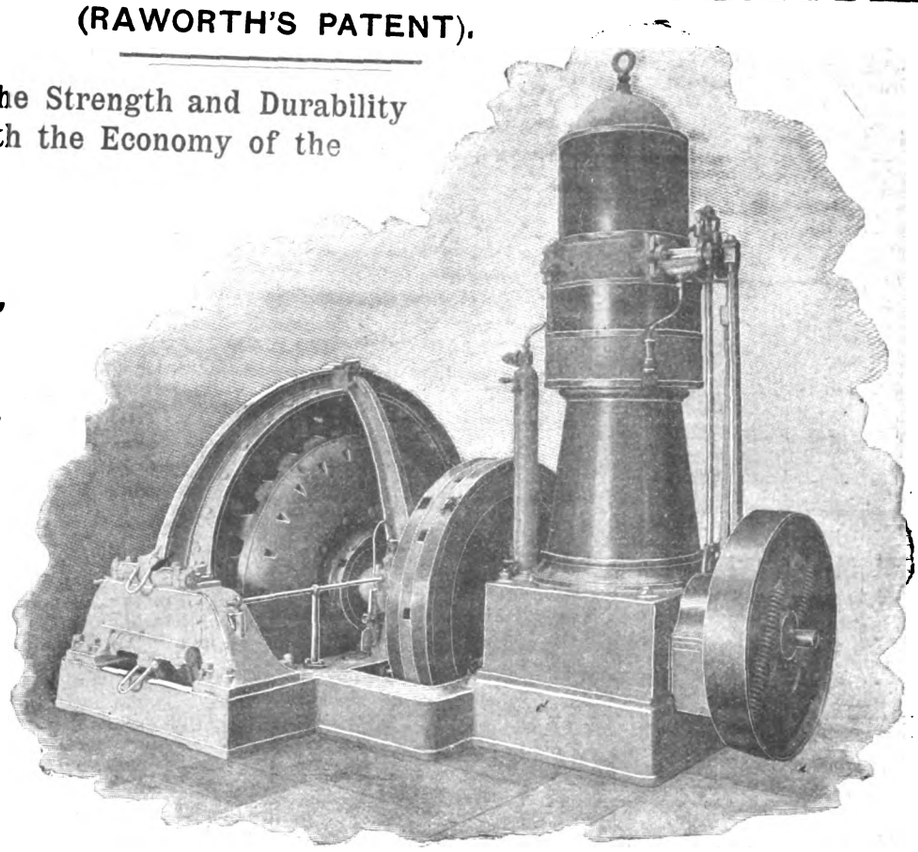

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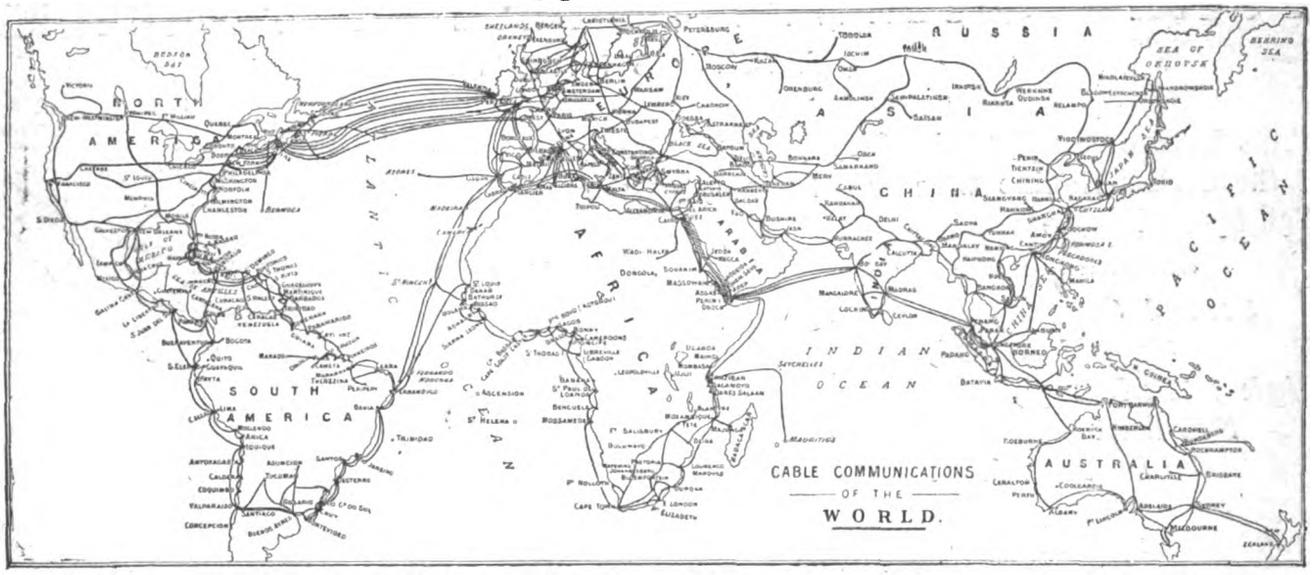


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## TENDERS INVITED.

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TO ELECTRICAL ENGINEERS AND OTHERS.

The GUARDIANS of the POOR of Mile End Old Town are willing to receive TENDERS for the SUPPLY and ERECTION of ELECTRICAL PLANT, LAYING DOWN ELECTRIC MAINS, and WIRING, for lighting their premises in Bancroft-road, London, E., by electricity.

Plans may be seen, specifications and full particulars obtained from Mr. C. F. Burden, Architect to the Guardians, at his Office, on the premises, between the hours of 10 and 4, on production of a receipt from the undersigned of the deposit of a £5 Bank of England note, which will be returned on receipt by the Guardians of a bona fide Tender, accompanied with such specification.

The Guardians do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of accepting such Tender as they may deem fit. The acceptance of a Tender will be subject to the Local Government Board's approval of the scheme, &c.

Tenders to be delivered not later than noon on the 30th day of JULY, 1896.

WILLIAM THACKER, Clerk to the Guardians.

Bancroft-road, London, E., July 9th, 1896.

### CITY AND GUILDS OF LONDON INSTITUTE.

SESSION 1896-97.

THE COURSES OF INSTRUCTION IN ENGINEERING AND CHEMISTRY at the Institute's Colleges commence in October, and cover a period of two to three years. The MATRICULATION EXAMINATION of the Central Technical College will be held on September 21st to 24th and the ENTRANCE EXAMINATION of the Day Department of the Technical College, Finsbury, on September 22nd

**CITY AND GUILDS CENTRAL TECHNICAL COLLEGE**

(Exhibition-road, S.W.), a College for Higher Technical Instruction for Students not under 16 years of age preparing to become Civil, Mechanical or Electrical Engineers, Chemical and other Manufacturers, and Teachers.

THE MATRICULATION EXAMINATION will be held on September 21st to 24th, and the new Session will commence on October 1st.

Professors:—O. Henrici, LL.D., F.R.S. (Mathematics); W. C. Unwin, F.R.S., M.I.C.E. (Civil and Mechanical Engineering); W. E. Ayrton, F.R.S. (Physics and Electrical Engineering); H. E. Armstrong, Ph.D., F.R.S. (Chemistry).

**CITY AND GUILDS TECHNICAL COLLEGE, FINSBURY**

(Leonard-street, City-road, E.C.). The DAY DEPARTMENT provides Courses of Intermediate Instruction for Students not under 14 years of age, preparing to enter Mechanical or Electrical Engineering and Chemical Industries.

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JOHN WATNEY, Hon. Secretary

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There is also a Preparatory Course of Instruction for Agricultural Students. Session Fee, £5. 5s.

An Extract from the Calendar of the College, giving particulars of the Day Classes, and of the various Appliances, Laboratories, and Workshops available for Instruction, may be had on application to the Librarian, at the College, or to the Treasurer of George Heriot's Trust.

DAVID LEWIS, Treasurer.

Treasurer's Chambers, 20, York-place,
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The SESSION commences on Tuesday, OCTOBER 6th.

S. CHAFFERS, Registrar.

## APPOINTMENTS VACANT.

### BOROUGH OF PLYMOUTH.

The PLYMOUTH CORPORATION invites APPLICATIONS for the post of DRAUGHTSMAN and ASSISTANT to the Borough Electrical Engineer.

Applicants must be over 25 years of age, and must have had training in mechanical and electrical engineering, and be competent draughtsmen. Preference will be given to those who have had previous experience in a responsible position in a high-tension electricity works.

The duties will be to assist the Borough Electrical Engineer in the preparation of the designs and plans for the Corporation Electricity Works, to supervise the laying of mains, &c., and to act generally as Chief Assistant during the construction and future working of the station.

The person appointed will be required to devote his whole time to the service of the Corporation.

Salary, £150 per annum, rising by annual increments of £10 to £200.

Applications, accompanied by copies of not more than three recent testimonials, and endorsed "Assistant Electrical Engineer," must be delivered to the undersigned not later than Thursday, the 30th inst.

Canvassing by or on behalf of any candidate will operate as a disqualification.

(Signed) J. H. ELLIS, Town Clerk.

Municipal Buildings, Plymouth, July 13th, 1896.

### CORPORATION OF SUNDERLAND.

The CORPORATION require the services of an ELECTRICAL ENGINEER to act as Resident Engineer at their Electric Lighting Station, and to design and superintend any extensions of their station plant and mains. Any extensions of the station buildings will be designed and carried out after consultation with him by the Borough or other Engineer.

A Schedule of Duties can be obtained on application to the undersigned.

It is essential that candidates should have been properly trained both as mechanical and electrical engineers, have a full knowledge of both the three-wire continuous-current and the high-tension alternating-current system, and have had central station experience.

The candidate selected will be expected to enter upon his duties by the 1st day of September next.

Canvassing is prohibited.

The engagement will be for four years certain from the date of the engineer entering upon his duties, subject to the option of the Corporation to determine it by three months' previous notice in writing expiring at the end of the first year. The salary will be for the first year £300, second year £350, third and fourth years £400 per annum.

Subject as aforesaid the engagement to continue after the fourth year at the salary of £400 per annum, with the right of either party to determine it at the expiration of three months' previous notice in writing.

Applications, stating age, Station experience, and accompanied by original testimonials, to be addressed to the undersigned, endorsed "Application for Electrical Engineer," and to be delivered at the Town Clerk's Department, Town Hall, Sunderland, not later than TUESDAY, the 4th August next.

By order,

FRAS. M. BOWEY, Town Clerk.

Town Hall, Sunderland, 17th July, 1896.

### NORTHAMPTON INSTITUTE, CLERKENWELL,

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All the above appointments will date from 1st October, 1896, but the successful candidates will be required in the meantime to advise the Principal with respect to equipment and organisation.

Applications for any of the appointments are to be sent in to the Principal not later than 10 a.m. on TUESDAY, 28th July, 1896.

The Conditions of Appointment and Forms of Application may be obtained by written application, addressed to the undersigned at the Northampton Institute, St. John-street-road, Clerkenwell, London, E.C.

R. MULLINEUX WALMSLEY, D.Sc., Principal.

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Duties will commence on October 1st next.

Applications and testimonials must be sent on or before August 29th to the undersigned, from whom further particulars may be obtained.

H. F. STOCKDALE, Secretary.

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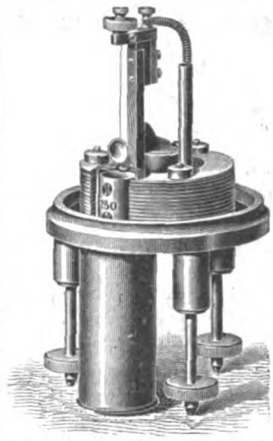

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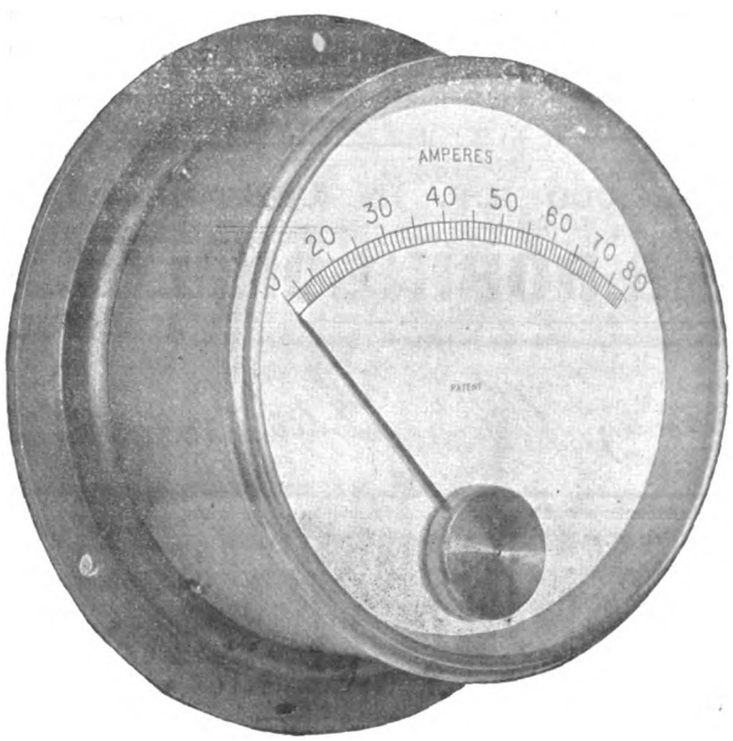


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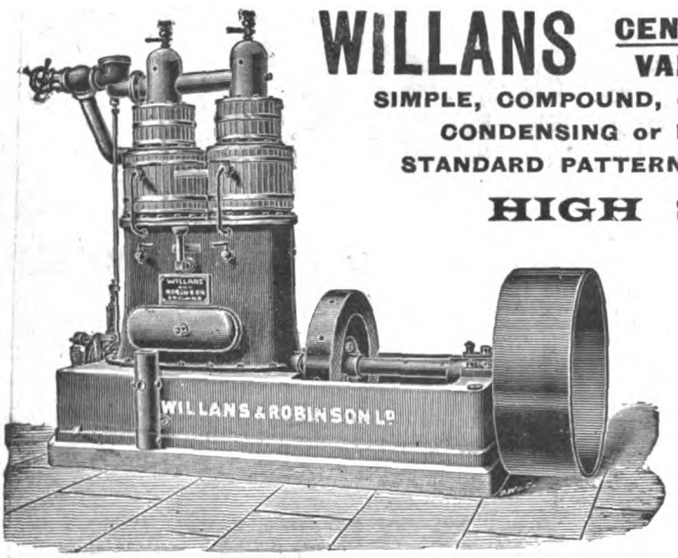


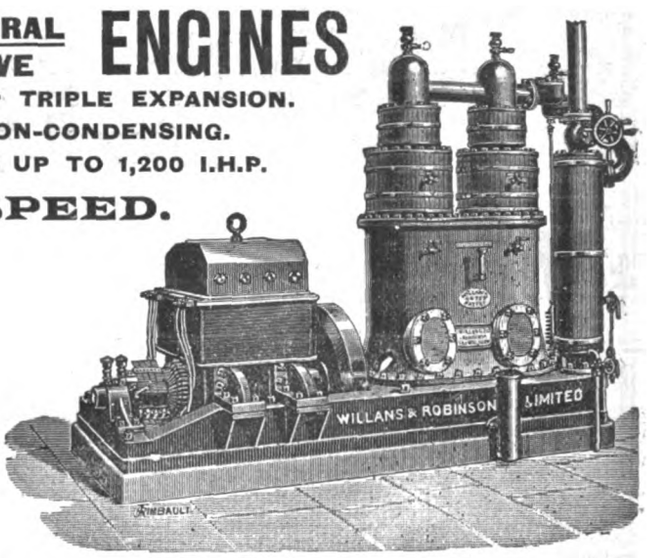


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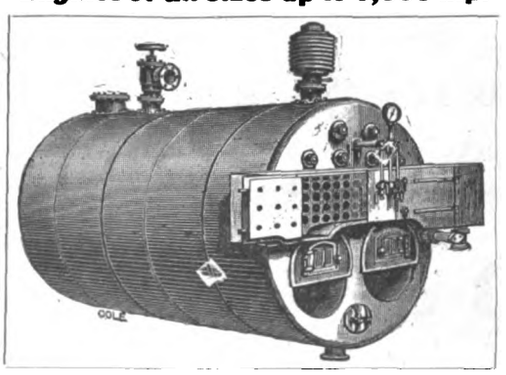

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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## NOTES.

THE minutes of the recent Conference on an International Catalogue of Scientific Literature have now been made public. The contemplated Catalogue will comprise all published original contributions to pure science, and will *not* be limited to Papers published in the *Transactions*, &c., of scientific societies. London is to be the home of the central bureau, and English the language of the Catalogue. The precise limits of the several sciences to be included are left, as are a number of other details, to an International Committee of management to be appointed hereafter. The Catalogue will be arranged both according to subject matter and to authors' names, regard being had, in indexing according to subject matter, not only to the title, but also to the nature of the contents. The conclusions of the Conference, it will be seen, are only on general lines; but a Conference which knows its business always does confine itself to generalities. A great scheme has thus received authoritative international sanction; it now awaits adequate international subsidies.

INFORMAL gatherings are said to possess a charm of their own; no doubt they do, but it is permissible to question whether this subtle charm befits an International Congress as well as it does a picnic. However, be that as it may, the promoters of the so-called International Electrical Congress at Geneva, which has been announced for the beginning of August, are evidently no believers in formality. The technical press has been duly "paragraphed," but no Scientific or Engineering society has been consulted, and no one has been invited to act as a delegate; not even Mr. PREECE, without whose presence an International Electrical Congress would surely be *ipso facto* illegal. We quite agree with Prof. SILVANUS THOMPSON, who, in a letter to be found elsewhere in the present issue, expresses the opinion that the decisions of such a curious Congress "can carry little weight in ernationally." This is, indeed, fortunate, for there is a rumour abroad that only trusty anti-4 $\pi$-ists have been invited, and that it is proposed, after a mock trial, to hang 4 $\pi$ by its neck until it is dead, and, with this impediment to unital perfection removed, to straightway impose the "rational" system upon the consciences—and pocket books—of mankind.

THE assertion that an electric arc cannot have negative resistance is now followed by the doubt, expressed by Mr. ROLLO APPLEYARD in an article this week, whether the arc can be said to possess in any circumstances any true resistance whatever. This piece of scepticism makes great demands upon our mental machinery if we wish to comprehend exactly what it means. That specific resistance should apparently become zero, or even negative, under peculiar conditions, we might credit; but that in an electric arc, with its complicated column of heated vapour, it is necessarily *always* zero, is by no means easy to understand. But, according to Mr. APPLEYARD'S way of regarding the phenomena of the arc, the very attribute of electrical resistance is inapplicable, and what appears to be resistance—whether positive or negative—is really an unknown something else. We cannot think that Mr. APPLEYARD'S view is correct, or even that it tends to elucidate matters; yet may the gods forbid us to say that he is wrong, considering what seems to be conceivable in regard to the electric arc. At any rate, the possibility of so extraordinary a conception leads us to press for a definite answer to the question: What is electrical resistance?

IT was contended, we believe, by paleozoic engineers that a water-tube boiler was not a boiler at all, but "a bundle of pipes." That being granted, there is perhaps more excuse than it would at first sight appear for the absurd dispute now "dragging its slow length along," at the Chiswick works of Messrs. THORNYCROFT and Co. In the middle ages (we speak, of course, from the engineering point of view) boilermaking consisted mostly of bending and riveting plates, and fell to the lot of the members of the redoubtable Society of Boilermakers and Iron Shipbuilders. To-day, especially when we come to deal with such a fantastic collection of twisted tubes as the Thornycroft boiler, boilermaking is mainly a matter of pipework, and hence it becomes an appanage of the fitter, and for some time past Messrs. THORNYCROFT have followed the natural course of giving the work to the members of the Amalgamated Society of Engineers. Some weeks ago, however, the Boilermakers', &c. Society demanded the discharge of the fitters engaged on these jobs. For the sake of peace and quiet the firm agreed to do what was possible in this direction, and transferred certain parts of the work to the boilermakers. But the boilermakers and fitters, taking their cue, no doubt from Westminster, devoted their energies not to the work they were set, but to mutual obstruction, and of course demanded their wages, although next to no work was turned

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out. At last it was arranged that operations should be suspended, whilst Mr. W. ALLAN, M.P., arbitrated; but as the two disputants could not agree even as to the terms of reference, nothing came of the arbitration idea. It is now nearly twelve weeks since work was stopped, and as the fitters will go out on strike if the boilermakers get their way, and the boilermakers will go out if the fitters get their's, and both will strike if anyone else comes in, there would seem to be a strong probability of work not being resumed at all—at least, by "union" labour. Comment on this ridiculous situation is superfluous.

WHAT is the fundamental reason why science teachers should be paid by piece-work? We have never seen this question answered, and we do not propose to attempt to answer it now. But, admitting for argument's sake that the minor teachers of the Science and Art Department should be paid in this way, while the professors and high officials are paid fixed salaries, there yet remains the puzzling question as to how the piece-work is to be estimated. No doubt we shall be told that in many institutions the science teachers are not paid on a sliding scale, and that it is the institutions to which the grants of money are made; but the result is the same in the end, viz., the assessment of award by piece-work. Formerly the money grant depended on the success of the pupils in the May examinations, and even at the present time this system is continued in organised science schools and colleges. Than this, no more pernicious premium on cramming could well be devised. Recently a modification has been introduced, applicable, however, only to schools where science is taught, but which are not organised science schools or colleges. By the new arrangement the grant is made to depend on the number of hours of attendance in class as to its minimum value, and as to its maximum value on the results attained in the May examinations. Though more complex, this is a better system than the former one, as it entails both attendance and attention on the part of the pupil. The dullard who attends, bodily but not mentally, and the cram pupil who reserves both attendance and attention for the last few days of the session, are both heavily handicapped, while the successful plodder reaps the highest reward for his teachers.

A CORRESPONDENT of *Nature* protests against what he stigmatises as "nothing less than a public scandal"—viz., the advertisement by a University College for a demonstrator of chemistry "at a salary of £70 per annum." He points out that a science demonstrator should be "a scholar and a gentleman," and asks how such a man is to support a decent existence on such a pittance. "In these days," he concludes, 'even the miner has his minimum wage. Cannot one be fixed for science demonstrators? It should not be less than £150, . . . certainly anything under £100 is scandalous, even in the present state of public opinion."

THE particular example selected for rebuke is near enough to the average to make the rebuke applicable to the majority of our University Colleges and similar educational institutions. Their defence of the low scale of payment for a demonstrator would probably be, that the salary represents only a small part of the benefit attaching to the post; that, in fact, the demonstrator is largely paid in kind, by the access he receives to valuable and varied apparatus, by the closer contact he makes with his professor and the higher members of the staff, and by the grounding in science he derives from perpetually grinding science into other people. All these are decided advantages, and in the majority of cases they probably weigh more than the question of salary, especially when the demonstrator is qualifying for a professorship and can afford to look upon the time of his demonstratorship as a period of probation.

THIS defence, however, does not justify accepting the services of a demonstrator at less than a living wage, unless a definite limit is placed upon the period during which he is to be engaged. The educational advantages of such a post diminish at a rapid rate after two or three years, and in a short time they are apt to become negative. Unless a demonstrator moves on to a higher post he is likely to deteriorate into a mere teaching machine. Moreover, it is only fair to later batches of students that they also should have an opportunity to compete for this valuable post. Therefore, it logically follows that when a college assesses the value of a demonstratorship on this principle, and not on an ordinary commercial basis, the post should be allotted for a limited period, after the manner of a scholarship, and at the end of that time the holder should be compelled to quit. The only alternative is to pay an honest wage.

**Personal.**—Mr. F. E. Hesse has been appointed to the post of manager in addition to that of secretary of the Eastern Extension, Australasia and China Telegraph Company.

**Jubilee of the Belgian Telegraphs.**—The Belgian State Telegraph authorities propose to celebrate the fiftieth anniversary of the introduction of telegraphy into Belgium on September 9th. An exhibition of historic telegraphic apparatus will be held.

**Standards of Thermal Efficiency.**—Prof. D. S. Capper and Mr. Henry Davey have been added to the committee appointed by the Institution of Civil Engineers to consider the question of a standard or standards of thermal efficiency for steam engines.

**Appointment.**—The Professorship of Mechanical Engineering at Finsbury Technical College has been conferred on Mr. Dalby, of Cambridge. Owing to this appointment, the post of Demonstrator of Mechanism and Applied Mechanics at the University of Cambridge has been rendered vacant.

**The New York Electrical Exhibition.**—"Sold, but we have others," was the announcement which appeared on a card on one of the large Brush arc light machines that formed part of the exhibit of the Brush Electric Company, of Cleveland, at the recent Electrical Exhibition in New York.

**Cable Interruptions and Repairs :—**

| | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique | Dec. 19, 1895 |
| Monte Alegre—Santarem | May 5, 1896 |
| Lourenco Marques—Durban | July 13, 1896 |
| Nagasaki—Gutzlass | July 22, 1896 |

**A One-Candle Hundred-Volt Lamp.**—The Société d'Encouragement recently offered a prize of 2,000fr. for an incandescent lamp of 1 c.p, 100 volts, $\frac{1}{20}$th of an ampere. It found itself unable to make an award, but an *encouragement* of 1,000fr. has been given to MM. Javaux and Nysten, and a similar sum to M. Solignac.

**Definition of a Boiler Explosion.**—According to an official report, made by a number of German experts, a boiler explosion is thus defined: "The rupture of the walls of a boiler during operation of such an extent as to cause, owing to the escape

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of water and steam, a sudden equalisation of the pressure within and without the boiler."

**Heriot-Watt College, Edinburgh.**—The Session 1896-97 for day classes at this College extends from October 6th to June 4th. The classes provide courses suitable for students who have previously passed through the curriculum of a secondary school, and include mechanical engineering, electrical engineering, physics and chemistry. The Principal of the College is Prof. F. Grant Ogilvie, M.A., B.Sc., F.R.S.E.

**Institution of Mechanical Engineers.**—The summer meeting of the Institution of Mechanical Engineers will be held in Belfast, and will commence on the 28th inst. Among the Papers to be read, those of special interest for electrical engineers are: "Electric Lighting in Belfast," by V. A. H. McCowen; "Rope Driving," by A. Combe; and "A Description of the Alumina Factory at Larne Harbour," by J. Sutherland. The factory at Larne, it will be remembered, is for the purification of bauxite, preliminary to its shipment to the Falls of Foyers, for electrolytic reduction to aluminium.

**The Willans Patent.**—On Tuesday last Mr. J. C. Graham applied to the Judicial Committee of the Privy Council (consisting of Lords Macnaghten, Davey and Hobhouse, and Sir Richard Couch) for leave to add a supplementary paragraph to the petition for the prolongation of the Willans and Robinson patent, No. 4,901 of 1882, for improvement in high-speed engines. The learned counsel said that in the petition as it stood no reference whatever was made to the fact that foreign patents had been granted, and that it was not until within the last few days that the solicitor heard for the first time that foreign patents had been obtained. The application, which was unopposed, was not for leave to alter the petition, but to add a supplementary paragraph stating that foreign patents had been granted. Leave was given to add the paragraph.

**Lightning Fatalities.**—During a heavy thunderstorm, at Bexhill, on Wednesday afternoon last week, a young carman met with his death. The thunder had been heard in the distance all the afternoon, and at 5 o'clock the storm, accompanied by a downpour of rain, was over the town. At that hour a young man was driving a horse attached to a water cart down the Hastings-road, sitting on the cart. He was seen to suddenly fall, and the horse at the same time fell down. An examination of the body showed that the lightning probably entered the top of the head. A nosebag on which the man was sitting at the time of the fatality was found to have a hole burnt through it, and the front part of the cart was charred.—During a storm which passed over Durham on Thursday last week, a boy was killed by lightning while playing cricket at Sunnyside, near Crook.

**A Large Battery Station.**—According to the *Electrical Engineer* of New York, a water power of about 3,000 H P., situated about eleven miles from Hartford, U.S.A., is to be used to drive Westinghouse multiphase alternators, the power to be transformed at the falls to 10,000 volts and transmitted on a pole line to the Hartford Electric Light Company's station in Hartford, Conn., where it will operate motors, driving shafting, to which will be belted arc lighting machines, and from which point alternating current will be distributed for incandescent lighting. From the station the current will be carried to the storage battery station at a pressure of 2,000 volts, where it will be transformed to 240 volts and put through a rotary transformer for charging the battery, which will be operated on the three-wire system. The battery, it is said, will consist of no fewer than "140, 10,000-ampere-hour" chloride accumulators, the largest such plant in the world.

**The Central Technical College.**—At a meeting of the Council of the City and Guilds of London Institute, held on Monday, the diploma of "Associate of the City and Guilds of London Institute" was conferred on the following matriculated students, who have this year successfully completed a full course of instruction at the City and Guilds Central Technical College:—(Civil and Mechanical Engineering:) W. Gore (Siemens Medal), V. Cooper, A. M. MacColl, J. S. Wilson, B. Price, D. H. Bayley, R. F. Baker, I. Barry, M. G. Weekes, C. E. H. Salmon, L. Temple, D. J. Jaffe, H. J. Saunders, H. M. Kirkby, J. A. Jones, A. Kenrick, A. B. Buckley, G. S. Perry, G. H. Mair. (Applied Physics and Electrical Engineering:) E. Ray (Siemens Medal), C. A. Taylor, I. Braby, G. A. Maquay, G. W. D. Ricks, P. A. Tucker, E. Morgan, Y. V. E. Watlington, C. Barber, P. F. Rigden, J. F. Collard, W. Phillips, J. F. Pringle, C. E. Vance, H. J. Gridley, H. F. Hesse, M. J. Scears, W. F. Daniel, W. Steuart. (Applied Chemistry:) T. M. Lowry, E. F. Renwick, T. H. Pope, W. S. Gilles, A. J. Shelton, N. F. Deerr, H. C. Sayer, S. G. S. Panisset.

**Electric Lighting by Artesian Wells in America.**—One of the novel electrical developments of the West, says an American journal, has been the operation of electric lighting plants by means of artesian wells. The latest of these is at Chamberlain, S.D., situated on what is known as the artesian well basin, in the central portion of that State. The well is 8in. in diameter and 675ft. deep, and the water rushes up through sections of iron pipe, which penetrate through the strata of granite to the underlying body of water. The pressure is so great that if reduced to a 2½in. stream by a nozzle, the water shoots up to a height of 262ft. In the Chamberlain plant, the volume of water is reduced to a stream about 3in. in diameter, which impinges on the buckets of a well-known type of Western wheel. This wheel is mounted on a shaft which carries a large driving pulley, which in turn is belted to a 500-light alternating-current machine. The regulation is simple, and is dependent upon raising or lowering the water nozzle at the wheel, and the power is thrown off entirely by swiveling the nozzle, so that the water discharges altogether under the wheel buckets, and runs out through the waste pipe.

**The Transformer Sub-Station Fatality.**—The facts with regard to the recent fatal accident to an employée of the City of London Electric Lighting Company are, we are informed, very simple. The unfortunate man Chisholm was assistant foreman of transformer stations, and was replacing a main in the terminal of a fuse-box after testing, when he touched the upper terminal in the fuse-box, which was connected to the high-pressure mains. Chisholm had the usual insulating rubber gloves by his side, but neglected to put them on, and he could only have made contact with the live terminal by holding pliers in his hand, as the terminal was enclosed in a porcelain box. Resuscitation by artificial respiration was immediately applied, and medical assistance was promptly at hand, but the shock proved fatal. Notwithstanding these facts the Coroner's jury yesterday, after a short deliberation, returned a verdict of "Accidental death," and added the following rider: "We think the City of London Electric Lighting Company have not taken proper precautions to prevent their employées meeting with accidents of this character; and they also wish to express their opinion that the men are not properly paid. They also consider that written notice of the danger should be posted at every station." The deceased was receiving 32s. a week.

**Douglas Southern Electric Tramway.**—The opening of the Douglas Southern Electric Tramway took place last week. The length of the line at present constructed is 2¾ miles. The gauge is 4ft. 8½in.; the rails are of steel, 65lb. to the yard; the sleepers are also of steel, and, with the fastenings, weigh 55lb. each. Chicago rail bonds are used. At present it is a single line, with eight loops. One of the features of the line is that there is hardly a straight line in it. There is not a level spot on the whole road, and the worst gradient is 1 in 16. There are three bridges of 120ft., 240ft. and 110ft. in length respectively. The trolley wires are carried on steel poles with brackets. The cars are open, and there are two storeys, with garden seats at the top; they are constructed to carry 78 passengers. The whole of the work has been carried out by the General Traction Company. The line opens out some of the finest cliff and marine views in the Isle of Man. The road is for the most part cut out of the face of the cliffs, and hundreds of feet below the waves break against one of the boldest coasts in the United Kingdom. Lovely bays and inlets indent the coast line from Douglas Head to Port Soderick, which is the route followed, and the serpentine character of the line constantly reveals fresh and striking prospects.

**Annual General Meeting of the German Electro-Chemical Society.**—This gathering of one of the youngest and most active of technical societies took place on June 25th, 26th and

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27th, at Stuttgart, some hundred members attending. Illness and urgent business prevented certain of the most noteworthy exponents of electro-chemistry from appearing, the meeting being thus somewhat shorn of its expected interest. Such Papers as were read were not especially enlightening, but a few of the matters touched on may be briefly noted. Thus Prof. Nernst gave an interesting account of several improved instruments of precision designed to aid the work of the electro-chemist. The most notable of these is a new form of quadrant electrometer carrying its own source of charge—a dry pile of such minute dimensions as to be suspended by a quartz fibre. The growing tendency to adopt an alternating current for certain electro-chemical processes makes it highly desirable that the worker should be equipped with reliable measuring instruments adapted for determining all those values which are already accurately estimated in the case of an uni-directional current. Such apparatus is being gradually designed. X-rays and accumulators inevitably found a place for exposition and discussion, and the assembly finally devoted itself to festivity in that whole-souled way which is usually deemed to be exclusively British.

**Water-Power Utilisation at Fresno.**—The *Journal of Electricity* of San Francisco recently contained a well-illustrated description of a water-power plant on the San Joaquin river, in the Sierras. The turbine house is situated at the bottom of a high, steep mountain, and the reservoir is on the summit; this gives a fall of 1,411ft. to the turbines, which are Pelton wheels of solid construction. The water for the reservoir is conveyed by wooden chutes and earthwork ditches over a distance of seven miles. The area of the reservoir is eight acres, and the capacity suffices for about six days' supply. From the reservoir to the turbine house the water is conveyed in pipes, arranged in three sections. The uppermost section, 960ft. in length, is of riveted steel plate, and has a diameter of 24in.; the intermediate section, 400ft. in length, consists of lock-joint welded pipe, with lead joints, and is 20in. in diameter; the lowest section is 1,800ft. long. and 20in. in diameter, and consists of lap-welded pipe, with rubber-packed flange joints. A statical pressure of 609lb. per square inch is developed at the bottom of the fall. The Pelton nozzles are $1\frac{1}{8}$in. in diameter, and the velocity of the jet is 9,200ft. per minute. The jets strike at an angle of 45deg. with the horizontal, and the turbines are governed by deflecting the jets, so as to make them partially or wholly miss the vanes. There are three 57in. Pelton wheels, each carrying 27 vanes and running at 600 revolutions per minute. On each wheel shaft is a 60in. flywheel, weighing 6,000lb. These three wheels are each direct-coupled to a 340-kilowatt three phase generator, developing a pressure of 700 volts at a frequency of 60 revolutions. Besides these sets there are two small Pelton wheels for supplying the supplementary power required by the governors. The electric power from the polyphase generators is transformed up to 11,000 volts in the station. It is then transmitted by aerial lines to the sub-station at Fresno, where a batch of transformers has been erected. Three of these transformers, each of 125 kilowatt capacity, deliver current at 115 volts for the glow lamp supply; three transformers, each of 75 kilowatt capacity, deliver current at 1,000 volts for power purposes; and a third set of three 40-kilowatt transformers sends power at 3,000 volts to the outlying districts.

**White Metal Bearing Surfaces.**—"White metal," says Mr. R. Davison in a Paper recently read before the Institute of Marine Engineers, "has come into very extensive use, and is applied with advantage to nearly all wearing surfaces, particularly crank and main shaft bearings, guides, and valve faces. In some cases, however, such as in cross-head and pump-link brasses, it does not appear to give such satisfactory results. This may possibly be accounted for by the comparatively small amount of movement in the latter cases, and consequent incomplete lubrication. In white-metalling a new bearing, a good plan is to have the bearing cast with longitudinal recesses or channels about $\frac{3}{4}$in. apart, and a circumferential recess at each end of the brass of the same depth as the other recesses and into which they lead. The bearing should be well heated, and the white metal poured into the channels so as to fill them and stand $\frac{1}{32}$in. above when finished. It will now be seen that the white metal in the end channels serves to keep the lubricant from running out of the bearing. The bearing is then bored and dressed in the usual way. One of the smoothest bearings I have ever seen was that of a crank shaft fitted with brasses hexagonally shaped on the outsides to fit the ordinary pedestal and cap. These brasses, no doubt from a point of economy, had been cast with these rectangular holes in the top half brass. I remember having to assist in stripping this shaft, and, on removing the cap, a small quantity of oil was found retained in each of the holes mentioned. This, I think, goes to prove that when sufficient bearing surface is provided, it is of advantage, when metalling, to keep the recesses closed, by forming the circumferential end channel described above. With old worn bearings, in which the thickness will not permit of recesses being formed, the first step is to have them thoroughly cleaned and tinned. This cannot be done too carefully in order to obtain a satisfactory job. The metal may then be applied in strips, or to the whole surface, if deemed necessary. It is usual to well heat the bearing in all cases when applying the white metal, to avoid the risk of the metal getting loose when cooling. If this is done, and proper precaution is taken in the tinning, I am confident that there is no likelihood of this taking place, and consequently see no necessity for drilling dowel holes, as is sometimes done, with the object of drawing the metals well together. Those who are inclined to be timid in trusting to tinning operations alone may possibly be relieved of their doubts by the following instance. A large wrought-iron half strap for a paddle-wheel was tinned on its inner surface, afterwards laid in loam, and white metal poured from a ladle into the space prepared for it. It was then taken out of the mould and left to cool. When preparing it for machining, the points of the straps were found to have closed towards each other to such an extent that it was necessary to take a cut over the face of the joint to make it straight. This alteration in shape can only be accounted for by the cooling process. The white metal, being so much hotter than the strap, had contracted to a greater extent, and so caused the deflection. This also, I think, goes to show that the tenacity of the white metal to that to which it may be affiliated is very great. With cast-iron blocks it may be prudent to have a shoulder on the sides next the joints to support the white metal, or even to drill dowel holes. Tunnel bearings, which have not been previously fitted with white metal, can be dealt with in a similar manner to worn brass bearings."

**Contemporary Electrical Science.**—In the current number of *Wiedemann's Annalen*, W. Duane, an American, describes a new magnetic phenomenon. Discs and cylinders of glass, sulphur, ebonite, paraffin, or quartz, when suspended between the poles of a strong electromagnet with their axes at right angles to the lines of force, experienced a decided damping of their oscillations every time the magnet was made. The effect is not due to an influence upon the suspending threads, nor to induced currents, but is at present unexplained. It was the same whether the bodies were paramagnetic or diamagnetic. G. Schwalbe proves that vapours arising from an electrified liquid are incapable of discharging the liquid or conveying away any portion of its charge. Alfons Cohn discusses magnetically hard and magnetically soft bodies, the former being bodies which hinder the propagation of a magnetic field, the latter those which permit it. A conductor carrying a current was taken through hollow cylinders made of various substances. A solution of ferric chloride, which may be regarded as absolutely soft iron, exerted no influence upon the propagation of the field due to the current. Soft iron also proved a magnetically soft body. But steel diminished the field, especially of feeble currents, in proportion to its thickness and to its mechanical hardness. Max Wien describes self-induction coils made of copper wire wound on bobbins of serpentine. They were standardised by Maxwell's method with the aid of the optical telephone. He claims that they are accurate to within $\frac{1}{10}$th per cent. of their nominal value, and practically uninfluenced by time and ordinary changes of temperature.

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## THE CAPILLARY ELECTROMETER IN THEORY AND PRACTICE.*

BY GEORGE J. BURCH, M.A.

(*Continued from page 382.*)

The excellence of these electrometers depends on the shape and dimensions of the capillary. The following explanation may therefore be found useful. When a glass tube heated in the middle is drawn out, the walls of the central reduced portion are approximately parallel for a certain distance. Between this cylindrical part and the unaltered tube at each end is a portion the bore of which tapers rapidly at first and then more slowly, passing insensibly into the parallel walled capillary. If a tube so drawn out is fixed vertically, and some mercury poured into it, the mercury will be forced by its own weight some little distance down the tapering part, until stopped by the action of its surface-tension. On increasing the pressure with the apparatus described in Fig. 2, the top of the mercury column will be forced lower, but the meniscus at the bottom of the column will move through a much greater distance, owing to the small diameter of the tube at that part. The total increase of pressure on the lower meniscus will therefore be greater than that communicated to it from the pressure apparatus by the additional length of the mercury column in the electrometer tube. As the less tapering parts of the capillary are approached, this effect becomes greater and greater, until a point is reached beyond which the meniscus cannot be pushed without danger of its running down into the cylindrical portion, when the mercury will continue to flow till the tube is empty. To use such a tube for the capillary of an electrometer, it must be cut off at some point short of that at which the mercury begins to run through without further increase of pressure. If the section is made too close to the neutral point, the instrument will be very sensitive, but troublesome to use, on account of the difficulty of stopping the flow when once it has been established. On the other hand, if the capillary is cut off too short, the sensitive part will be sacrificed.

But although any tube thus drawn out can be cut so that it will act as an electrometer, it does not follow that it can be made into a good one. To ensure definiteness of response to a difference of potential it is essential that friction should be avoided. The working portion of the tube must therefore be as short as is consistent with a good shape. For this purpose I draw the tube down to a diameter of about 1mm, keeping the walls fairly thick, and just before putting the instrument together I soften the middle of this part in a very small flame, and draw it out 15mm. or 20mm. Thus the actual capillary is not more than 5mm. to 10mm. long. As the instrument is always used under the microscope, with a power of from 20 to 400 diameters, this length is amply sufficient. The end of the tube should be cut clean across. A splintered orifice impairs the action of the instrument.

Capillaries which are to be used horizontally should be less tapering if equal sensitiveness is desired. Those which point vertically upwards should be of equal bore throughout the working portion. As they can be made of constant sensitiveness and constant capacity for all positions of the meniscus, they are useful for some kinds of work; but the time-relations of the excursion are more complicated, and they are, therefore, not so well fitted for the production of photographic records.

In all downward-pointing instruments, sensitiveness to small differences of potential is gained both by using a smaller capillary, and by making it taper less rapidly. In either case the movement is rendered slower, but from a different cause. With a smaller tube, the internal electrical resistance is greater; but with a capillary of wider bore, made equally sensitive by being more nearly cylindrical, the electrostatic capacity of the instrument is increased, and it may take longer to charge although the resistance is less. Small inequalities in the tube produce a greater disturbing effect on the excursions, and the meniscus is more sensitive to mechanical vibrations. There is, therefore, a limit beyond which the diameter of the tube cannot profitably be increased. On the other hand, a very fine tube is liable to get clogged, and although it is very little affected by jars or vibrations, it is not nearly so sensitive to electromotive changes of short duration. Moreover, the pressure-tube has to be wired on to the capillary, and sooner or later leakages occur. Practically, I prefer tubes that require a working pressure of about 20cm. and do not care to go above 30cm. or below 10cm. After a little practice it is easy to draw capillaries of any desired diameter.

When not in use the instrument should be invariably short-circuited. For class work a spring key, held open by the student during an observation, is very useful. Should all the mercury run out of the capillary the electrometer is hopelessly ruined, as it is impossible to get rid of the sulphuric acid which immediately enters. But by having a sufficient quantity of mercury in the upper tube to completely fill the lower tube in case of such an accident, this risk may be obviated. The mercury may then be cautiously sucked back by a negative pressure until it refills the capillary, taking care to stop before any acid enters. Should the supply run short at any time fresh mercury may be introduced with a fine pipette, inserted in the top of the upper tube after disconnecting it from the pressure apparatus.

Sometimes crystals form in the capillary. If these cannot be expelled they may be decomposed by electrolysis, using a P.D. of about 0·5 volt, and making the capillary the cathode. Inasmuch as this process tends to form crystals at the anode, these must be carefully washed out of the U-tube and fresh acid substituted. Old electrometers in which no crystals are visible are often much improved in this way. They must be subjected to the action of the current for an hour or more.

The pressure should be invariably taken off when the instrument is left. The weight of the column of mercury in the tube itself is sufficient to keep the acid from creeping up, and if the meniscus is allowed to stand continually in the working portions of the capillary the mercury is likely to stick whenever it passes that part.

A good instrument should respond easily to $\frac{1}{30000}$th of a volt.

If the meniscus recedes when the electrometer is on short circuit it is a sign of leakage in the pressure tubing. If it "creeps" up or down when the circuit is open there is an E.M.F. somewhere, either due to a dirty contact or to the acid in the electrometer having crept past the mercury to the platinum wires; the latter defect is fatal. If when a charge has been communicated to it and the key is open, the mercury gradually returns to zero, the insulation is defective. Not more than 5 per cent. of the charge should escape in half-an-hour. If made with clean and pure materials an electrometer should remain in good order for several years.

Induction shocks, strong enough to be felt, exert a very deleterious effect; the sudden jar appears to disintegrate the glass where the meniscus touches it, causing the mercury to catch as it passes along the tube, though no mark can be seen. But a step-down transformer with a couple of cells on the primary may be used with impunity. The capillary electrometer is not affected by ordinary magnets, nor by proximity to an arc light, but wires in circuit with it should not be carried near high-tension alternating currents.

### *Physical Constants of the Capillary Electrometer.*

Both from the point of view of the manufacture of the capillary electrometer and of its application as an instrument of research, Prof. Lippmann's Paper left a great deal to be done. The question of the electrical capacity of the instrument and of its resistance, and of the time relations of its excursions, were as yet untouched. I determined to attack these problems systematically by the experimental method.

The point to be first determined was whether any leakage of current could be detected through the instrument itself after the meniscus had ceased to move under the action of a difference of potential. I joined up a high-resistance galvanometer of great sensitiveness, and the electrometer, in series in the derived circuit of a potentiometer. The galvanometer being short-circuited, I made the battery connection, and

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MSS. received October 17, 1895.

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waited till the meniscus of the electrometer had come to rest in the new position corresponding to the P.D. employed. I then opened the short circuit of the galvanometer. There was no deflection. But on increasing or diminishing the E.M.F. of the derived circuit, there was a temporary current one way or the other while the meniscus was in movement.*

The corresponding problem was this: Does an electrometer which has been charged to a certain P.D. lose its charge when disconnected from the source of electricity? I found that it does not, if the external insulation is good, but that owing to the necessary presence of the dilute sulphuric acid, perfect insulation is not easy to attain. Still, a displacement of the meniscus through 50 divisions of the eye-piece micrometer was maintained for more than an hour with a loss of less than one division. We are led, therefore, to the conclusion that the capillary electrometer, although its circuit is composed entirely of conductors, does not transmit a current, but merely receives a charge as though it were a condenser. But there is no visible dielectric between the mercury and the acid. I have left an instrument for a whole day under the strain of an E.M.F. of half a volt, and not a trace of hydrogen could be detected in the capillary.

The next point was to determine the capacity of the electrometer and its relation to the form of the tube. The following method was adopted. A standard condenser was charged to a known P.D. by means of a potentiometer. It was then suddenly connected with the uncharged electrometer, causing the meniscus to move from zero to a position corresponding to the E.M.F. of the charge communicated to it. The actual value of this E.M.F. was found by switching the potentiometer on to the electrometer circuit, and shifting the rider till the meniscus was adjusted to the observed position. From these data the capacity of the electrometer was calculated by the usual formula. Double break keys were used, and they and the commutators were arranged like the keys of a piano, so that the operations could be conducted with great rapidity.

The results of a large number of experiments with about 40 instruments may be summed up as follows:—

1. The narrower the tube the smaller the capacity. The greater the sensitiveness the greater the capacity.

2. As in most cases the capillary tapers less rapidly towards the tip, and is consequently more sensitive in that part, so also the capacity of most electrometers is somewhat greater when the meniscus is near the tip than when it is farther from it.

3. The capacities of the instruments examined ranged from 0·1 microfarad to 30·0 microfarads—from 0·5 to 2·0 giving the best results.

4. The electrical capacity as thus measured is that of the part of the capillary at which the meniscus comes to rest under the influence of the charge, and may be greater or less than that of the point from which it started to move.

5. With this proviso, the capacity is entirely independent of the potential difference of the condenser charge, which may be as great as can be safely employed, or as small as can be accurately measured.

6. The capacity is the same for any given part of the tube, whether the zero be above it, so that the condenser charge causes the mercury to fall; or below it, so that a similar charge in the reverse direction causes the mercury to rise, so long as it comes to rest when charged at the same part of the tube in both cases.

7. The capacity can be measured equally well by causing the charged electrometer to share its electricity with an uncharged condenser of known capacity.

8. Some capillaries are equally sensitive through a considerable portion of their length. In such cases the capacity is constant throughout the same part.

9. The capacity of a newly made electrometer usually, though not always, increases during the first few days. After about a week it becomes constant. I am inclined to ascribe this to the presence of air or gas condensed on the surface of the glass.

It is evident from these experiments that the capillary electrometer may be regarded for all practical purposes as a condenser possessing a definite electrical capacity for each position of the meniscus, and that this capacity is independent of the potential difference of the charge, which is a function of the change of pressure necessary to keep the mercury stationary in that position.

The change of level of the end of the mercury column produced by putting it in connection with a constant current is due to the flow of a measurable quantity of electricity. It also involves the performance of a definite amount of work, namely, in lifting the column of mercury from one position to the other, in altering the shape and area of the meniscus, and in overcoming friction. Evidence of the effect of friction can be observed in electrometers of which the tube is not perfectly clean, but otherwise I was unable to detect it.* The shape of the meniscus while at rest in any given portion of the tube is not visibly different under the action of a difference of potential in either direction, its outline projected on a screen with a magnification of 250 diameters remaining unaltered. The difference of section area in the working portion of the capillary of a sensitive electrometer is also small compared with the variation of the length of the mercury column. Putting P for the total pressure, $l$ for the distance through which the meniscus is moved, and $r$ for the radius of the tube, we may say that, approximately,

$$\pi r^2 l \, P = \alpha \, C \, V,$$

where V is a very small difference of potential and C is the capacity of the tube at the point where the meniscus stops, and $\alpha$ is a constant depending on the instrument used. But the working pressure varies inversely as the radius of the capillary. Writing therefore $\frac{1}{P} = r$, and omitting constants, we find that $_P$ is proportional to the work done, and proportional also to the quantity of the charge C V. I determined this ratio for a large number of instruments, and found it to be fairly constant, in spite of the great differences in sensitiveness, diameter and electrical capacity of the capillaries employed.

*Resistance.*

The resistance of the circuit has not the same effect upon the capillary electrometer as upon a galvanometer. It simply diminishes the rapidity of the movement without in the least reducing its extent—unless, of course, the instrument is partly short-circuited by defective insulation. This being so, it is impossible to measure the resistance of the electrometer by the ordinary methods.

When a difference of potential is communicated to the instrument, the meniscus moves with a gradually-diminishing rapidity to its new position of rest, which is attained only after the lapse of an appreciable, but indefinite, time. The time required to fully charge the instrument cannot be measured. But the time of half-charge—*i.e.*, when the P.D. between the terminals of the electrometer is half that of the source, is well defined, and easy to measure. I effected it, in the first place, by means of a rheotome arranged so as to close the circuit of a potentiometer, and break it again after a known fraction of a second. The duration of the closure was varied until the excursion produced by it was equivalent to that given by a constant P.D. of half the strength. I then added a resistance of 100,000 ohms to the electrometer circuit and found that a longer closure was necessary to produce the same excursion, namely, that of the half-charge. The total quantity of electricity being the same in each case, it was possible from these data to calculate the "equivalent resistance" of the electrometer. This varied, in the different instruments, from 90,000 ohms to 700,000 ohms. It is convenient in practice to know the "equivalent resistance" of an electrometer, especially when high resistances have to be used or a shunt introduced. But the actual resistance varies from point to point of the tube, and necessarily so, since it is due, to a considerable extent, to the low conductivity of the dilute acid contained in the portion of the capillary not occupied by the mercury. But it is not wholly due to this. I found by a series of careful measurements of the time of half-charge, with the zero position of the mercury at different distances from the

* I found afterwards that Fleischl had tried this in 1879.

* Fluid friction affects the velocity, but not the extent of an excursion.

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tip of the tube, that the "equivalent resistance" does not vary so rapidly as it should do if it depended solely on the resistance of the sulphuric acid and the mercury. Some other cause—probably mechanical—conditions the velocity of the movement, so that the equivalent resistance at any given part of a capillary would be expressed by the formula

$$R = r(L + l),$$

where $l$ = the distance of the meniscus at any moment from the tip of the tube, and L is a constant of the particular instrument employed.

With an electrometer adapted for the production of photographic records, the determination of the equivalent resistance for any given position of the capillary is extremely simple. Two normal excursions are photographed, one with say 100,000 ohms in circuit, and the other with no resistance, or if the electrometer is affected by overshooting, with a resistance of 10,000 ohms. The angle of inclination of each curve at corresponding points is then ascertained in a way that will be subsequently described, by measuring their respective subnormals. Let the subnormal to the first curve be N, and let that to the same part of the second be N′,

then $N - N' : N' :: 100{,}000 \text{ ohms} : R,$

where R = the equivalent resistance of the electrometer at that point. This method has been used by me in the Physiological Laboratory, Oxford, ever since July, 1890.

*(To be continued.)*

## TRUE RESISTANCE.

BY ROLLO APPLEYARD.

There is one view of the problem of the electric arc which may be worth the attention of those who are trying to interpret experimental work of recent publication. We have been given a concise statement of the conditions which engender the so-called "negative resistance." We have been told that it occurs in arcs formed between solid carbons, simultaneously with back E.M.F. The first analytical step is to consider the correctness or otherwise of predicating "resistance," under any circumstances, of an arc; leaving out of the question, for the time being, the lesser issue, as to whether the algebraic *sign* of the assumed resistance is positive or negative.

That which we are in the habit of calling "resistance," and generally represent by R in electrical formulæ, is a conception derived from our experience of homogeneous metallic conductors; *i.e.*, it is a quality of a particular class of conductors. Its most pronounced characteristics are its independence of the current flowing; its independence of the potential of the conductors; and its positive sign. While, however, this conception of this physical quality is primarily derived from our experience of homogeneous metallic conductors, it may probably be rightly extended to some other substances—*e.g.*, to electrolytes, and perhaps dielectrics—on the ground that these obey the same law in the conduction of currents of electricity as metallic conductors, viz., that the current is proportional to the E.M.F. applied, and is in the same direction as the fall of potential. But when conducting mechanisms such as gases, conductors by convection, or arcs are concerned, we are not justified in predicating this quality of resistance of them, without such experimental grounds as justify us in the case of electrolytes.

And when, by assigning the quality of resistance to a conductor, we find that this involves the resistance having a *negative* sign, we should be prudent to retrace our steps and our language.

No one denies that the arc has a certain quality in virtue of which energy is transformed in it by the passage of a current. We may, of course, represent this quality by R, or by any symbol we please. Without proof we are not justified in speaking of it in connection with the arc, in the same sense as that in which we speak of the *defined* "resistance" of a homogeneous metallic conductor.

The truth is, we have no rigorous *definition* of resistance except as an attribute of homogeneous metallic conductors; the "arc" controversy seems to have arisen from the neglect of this fact. The term has been decoyed into the interpretation of results quite foreign to it. Even with the *positive* sign, "true resistance" has no proven right in equations concerning the arc.

## THE PRODUCTION AND UTILISATION OF OZONE.

The persistency with which inventors have tried to avail themselves of the remarkable properties of ozone is more conspicuous than is the measure of success which they have achieved. None have been more diligent and ingenious than Mr. Andreoli, and some of his latest devices are now being made and exhibited by the Electric Ozone Syndicate (Limited), a body which is appealing more particularly to the medical profession. The apparatus shown is of two types. In one, rows of points are opposed, with no intervening dielectric save air; in the other, an electrode is enclosed in a vacuous glass envelope, which is surrounded by concentric rings, with radial points looking inwards towards the axis of the glass tube encircled by the rings. This annular structure constitutes the other electrode, and is made of aluminium.

Air driven between the points and the outer surface of the glass envelopes has a portion of its oxygen converted into ozone by the usual action of the silent discharge. The apparatus is pretty and compact, and is constructed in various forms for the administration of highly dilute ozone as an inhalation or for purifying the air of private rooms and public buildings.

With the therapeutic action of ozone we have nothing to do; it is a question for the physiological chemist (should he think it worth while), and, empirically, for the physician. As to the apparatus we may, however, be allowed to speak. It is not necessary to do more than remind our readers that the best type of ozoniser used by chemists for the preparation of ozone in the greatest quantity and highest attainable concentration has an absolute dielectric septum (of glass) between the two coated surfaces. Further, it is sought to avoid all contact of the ozone with any oxidisable material such as a common metal. Consequently, the apparatus usually has the form of two concentric glass tubes with conducting coatings on their remote surfaces, and entirely out of contact with the ozone, which is confined to passage through the annular space defined by the concentric glass tubes. The use of points is regarded as non-essential or injurious. It will be seen that the design of the apparatus shown by the Electric Ozone Syndicate is diametrically opposed to these canons. Therefore, before the new apparatus can be received as an improvement on what is old and well known, it is requisite that we should be provided with proof that the departure from recognised principles is of advantage. In a word it must be demonstrated that with a given output of electrical energy a larger quantity of ozone is prepared than by the usual apparatus. Until such proof is forthcoming discussion is supererogatory.

## THE GENEVA EXHIBITION.

(FROM OUR OWN CORRESPONDENT.)

In common with everyone else who has visited the Geneva Exhibition, I was struck with the excellence of the arrangements of the various departments and exhibits. One is pleasurably surprised at the absence of a confused mixture of mechanism and music hall, so common in many other Exhibitions. Naturally I directed my attention to the mechanical side of the Exhibition, and especially the electrical department. Considering the new and extensive utilisation of the water-power of the Rhone, which has been made by the City of Geneva, it was generally supposed that the Exhibition would be a great success from the electrical point of view. The power thus derived and transmitted all over the Exhibition grounds plays a very prominent part, and constitutes in itself one of the most important exhibits. The principal electrical engineering firms of Switzerland have also made very fine displays of their manufactures. One of the most important

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stands is that occupied by the Cie. de l'Industrie Électrique of Geneva. This leading firm is well known in connection with the Thury plant which it manufactures, and which it has installed at Genoa and in a number of other important transmission plants. The exhibits of this firm include a collection of continuous-current dynamos from $\frac{1}{5}$th to 250 H.P.; a 150 ampere generator for series transmission, which drives a number of motors in the Raoul Pictet pavilion; a two-phase synchronous motor, wound to deliver also at will continuous current when working as a rotary transformer; a compound-wound tramway generator, driven by belt; together with a number of other generators for supplying power to the crane in the machinery hall, to the intramural railway, to the motors driving the pumps for the illuminated fountains, and to other motors in various parts of the Exhibition. The Cie. de l'Industrie Électrique has also on view several arc lamps on the Grazier system, which together with a number of Schuckert lamps are almost exclusively used for lighting the Exhibition grounds.

The exhibit of the Oerlikon Maschinenfabrik comprises a number of dynamos and motors. A vertical steam engine made by this firm drives a four-pole continuous-current generator. There is also on exhibit at this stand a portion of a very large field magnet, for an immense machine which will be direct-coupled to a slow-speed steam engine. It may not be generally known that this firm makes its own castings, whether of steel or cast-iron. Throughout the Exhibition a number of induction motors made by this firm are used for driving various exhibits. The motor generally used develops about $\frac{1}{5}$th H.P., and is designed for a frequency of 30 to 35 $\sim$ per second. Exhibits are also made by the electrical firms of Alioth, of Basle, and the Société Suisse, of Neuhausen. The latter shows a pretty collection of tramcars. The intramural railway, which is laid in and about the grounds of the Exhibition, works with the current supplied through one rail and returned through the other. The rails are supported on wooden insulating pieces; but these afford only very poor insulation, and in wet weather the leakage amounts to 50 amperes, though the pressure is only 100 volts!

## THE ELECTROMAGNETIC THEORY OF DISPERSION.*

BY H. VON HELMHOLTZ.

A satisfactory explanation of dispersion based upon the electromagnetic theory of light appears to me to be still completely wanting. It is quite evident that any such explanation must take into account the ponderable masses embedded in the ether, because dispersion of light is one of those phenomena which, like refraction, electric conduction, the accumulation of free electricity, and the formation of magnetic poles, never occur in the free ether of a vacuum, but only in, or at the boundary of, space containing ponderable matter in addition to the ether. Now the mathematical theory of Maxwell shows clearly that ponderomotive forces must act in the ether when it transmits electrical oscillations, and such forces can set in motion heavy atoms which lie in the ether. If the heavy particles are not themselves electrified, these forces will be proportional to the *squares* of the electric and magnetic moments (displacements) of the oscillating ether, and will thus have the same magnitude and direction for negative values of these quantities as for positive values. The forces will therefore attain their maximum value twice, and their minimum value twice, during each vibration, so that they cannot usually produce or maintain oscillations corresponding to a simple period.

It is only when the material particles possess charges that the periodic change of electric moments in the ether can produce ponderomotive forces of equal period. The corresponding assumption, that the embedded atoms may possess only north or only south magnetism, I set aside as too improbable. On the other hand, electrolytic phenomena represented by Faraday's law of electrolytic equivalents long ago led to the theory that electric charges of definite magnitude are accumulated at the centres of affinity (*Valenzstellen*) of chemically combined ions; these are sometimes positive, sometimes negative, but have always the same absolute value for every centre of affinity of every atom.

Although this theory again assumes electric charges to be carried by material bodies, it is in no wise at variance with Maxwell's mathematical statement of his theory. For his theory admits the possibility of an invariable charge in certain elements of volume in insulators, and Maxwell's equations express that in every redistribution of motion, either of electricity, magnetism or matter, the quantities remain unaltered, even though they are to be regarded, according to his interpretation of the phenomena, as constants of integration and not as real quantities.

This does not prevent the forces which emanate from these ions as centre from spreading into space, and altering with changes in the position of the molecules, just as Maxwell's equations require.

The only thing required by the electrochemical theory which has not been already provided for in Maxwell's equations, is the possibility that these centres of electric force may be transferred during chemical decompositions from one ion to another; the process being accompanied by great expenditure of energy as if they were carried by a material particle attracted to the centres of affinity of different ions with different forces.

If the ether surrounding a pair of combined ions is traversed by electric forces and thereby dielectrically polarised, the oppositely charged ions will be subjected to stresses in the direction of the lines of force, that is, to two forces of equal magnitude but opposite in direction, which together form a couple; this couple will not set the centre of mass of the molecule in motion, but it will tend to lengthen or shorten the electrical axis of the molecule and to deflect it towards or away from the direction of the lines of force.

[In the following investigation the symbols* used have the same meanings as in Maxwell's treatise (*Electricity*, Vol. II. Cf. § 618, Third Edition); but the electrical moments per unit volume, which are mathematically analogous to Maxwell's "displacement," are denoted by $f$, $g$, $h$, and the components of magnetic induction are called a, b, c, to distinguish them from certain constants which appear in the equations.] In a former Paper† the electrical moments or components of dielectric polarisation were considered as depending only on the electric forces P, Q, R, and were taken proportional to these forces. The free electricity which might possibly exist at isolated points, the volume-density of which was given by—

$$\rho = \frac{\partial f}{\partial x} + \frac{\partial g}{\partial y} + \frac{\partial h}{\partial z}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

was there useful in determining the distribution and direction of the moments. It did not, however, include that electricity which causes the polarisation of the elements of volume. In the equations of motion of the present case, therefore, the electrical moments which are due to the electric charges of the ions must be separated from those of the free ether, because they are of variable magnitude and direction, and may be affected by forces other than electric, such as damping, friction, &c., &c.; we shall denote them by f, g, h, per unit volume. Such a space, filled with ether and pairs of ions, would be exactly analogous to the interior of a magnetised body, on the old view that each molecule is a bipolar magnet. Since the laws of distribution of magnetic and electric forces for a steady state as deduced from Maxwell's theory agree perfectly with those required by Poisson's theory, which postulates magnetic molecules and action at a distance, the mode of calculating the energy per unit volume, according to that theory, may be applied here to a space with a molecular distribution of electricity. I have proved in a former Paper‡ that the phenomena of dielectric polarisation and of ponderomotive force of such polarised masses lead to the same value or the energy.

According to the theory here presented, our pairs of ions differ from the dielectrically polarised molecules of insulating substances only by the possession of mass and inertia; consequently, they are not always in the position of equilibrium but oscillate about it, so that f, g, h, can vary independently of $f$, $g$, $h$, and the potential energy of the electrification depends on the former three quantities as well as the latter. I have preferred, instead of starting from Maxwell's equations, to introduce the new quantities into the equations which I derived by applying the principle of least action to electrodynamics, because we are thereby saved the trouble of considering certain reactions necessarily present in this somewhat complex system of forces, and the number of independent and doubtful hypotheses is considerably reduced.

Following Poisson and Maxwell, let us consider the electric force which is necessary in order to produce a moment f per unit volume in a substance consisting of bipolar molecules, as proportional to the moment, so that—

$$P = \frac{1}{\theta} f, \quad Q = \frac{1}{\theta} g, \quad R = \frac{1}{\theta} h. \quad . \quad . \quad . \quad . \quad (2)$$

* Translated, with notes, from *Wiedemann's Annalen*, XLVIII., pp. 389-405, 723-725, 1893, by James L. Howard, D. Sc., University College, Liverpool.

* Helmholtz uses different symbols, which are not so familiar to English readers. The final equations involve only relations between coefficients and Helmholtz's coefficients are retained.—*Trans.*

† "On The Principle of Least Action in Electrodynamics," *Wiedemann's Annalen*, XLVII., pp. 1—26, 1892.

‡ "On The Forces Acting on the Interior of a Magnetically or Dielectrically Polarised Body," *Wiedemann's Annalen*, XIII., pp. 385—400, 1881.

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In these equations $\theta$ is a constant, at any rate within certain limits of the dielectric stress. If we denote by $\delta f$, $\delta g$, $\delta h$, vanishingly small changes of these quantities, we have

$$P\delta f+Q\delta g+R\delta h=\frac{1}{2\theta}\delta[f^2+g^2+h^2]. \quad . \quad . \quad (3)$$

The left-hand side of this equation is obviously the work which the polarising forces have done in altering the moments, and therefore the right-hand side of the equation represents the change of energy produced by polarisation; the applicability of the expression is not limited (as in my former Paper) to the case in which equilibrium exists between the polarising forces and the polarisation produced by them.

Let us suppose the movable molecules, the moments of which we have denoted by f, g, h, to be embedded in a continuous medium of dielectric capacity $\kappa$, so that its moments and electric stresses are connected by the equations

$$f=\kappa P,\ g=\kappa Q,\ h=\kappa R.$$

The value of the electrostatic energy will be—

$$W_e=\iiint dx\,dy\,dz\left\{\frac{f^2+g^2+h^2}{2\kappa}-\frac{ff+gg+hh}{\kappa}+\frac{f^2+g^2+h^2}{2\theta}\right\}. \quad (4)$$

If the ether between the molecules is supposed free from polarisable ponderable substance, we must write $\kappa=\frac{1}{4\pi}$.*

The second, or magnetic, portion of the energy, $W_m$, is independent of the presence of the ions, because the latter need not have a greater magnetic permeability than the ether, the differences being usually very small. The presence of permanently magnetised matter need not be considered. Hence

$$W_m=\iiint\frac{dx\,dy\,dz}{2\mu}\left\{a^2+b^2+c^2\right\}$$

$$=\iiint\frac{dx\,dy\,dz}{2\mu}\left\{\left(\frac{\delta G}{\delta z}-\frac{\delta H}{\delta y}\right)^2+\left(\frac{\delta H}{\delta x}-\frac{\delta F}{\delta z}\right)^2+\left(\frac{\delta F}{\delta y}-\frac{\delta G}{\delta x}\right)^2\right\}, \quad (5)$$

where a, b, c, are the components of magnetic induction, and F, G, H, those of vector-potential.

The third, or electromagnetic, part of the energy, T, results from the time-variation of the electric moments $f$, $g$, $h$, and from the motion of the ionic charges $\rho$. Neglecting some terms of the third order of small quantities we obtain

$$T=A\iiint dx\,dy\,dz\left\{F\left(\frac{\delta f}{\delta t}+v_x\rho\right)+G\left(\frac{\delta g}{\delta t}+v_y\rho\right)+H\left(\frac{\delta h}{\delta t}+v_z\rho\right)\right\}, \quad (6)$$

$v_x$, $v_y$ and $v_z$, being the components of ionic velocity.† $\rho$ is zero everywhere except at the points where the ionic charges exist; their velocities will, therefore, enter into the equation. Since the electric forces which act on them are pure couples, the centre of mass of the molecules must remain at rest, and therefore

$$\frac{\delta f}{\delta t}=v_x\rho,\ \frac{\delta g}{\delta t}=v_y\rho,\ \frac{\delta h}{\delta t}=v_z\rho, \quad . \quad . \quad . \quad . \quad (7)$$

which gives

$$T=A\iiint dx\,dy\,dz\left\{F\frac{\delta}{\delta t}\left(f+f\right)+G\frac{\delta}{\delta t}\left(g+g\right)+H\frac{\delta}{\delta t}\left(h+h\right)\right\}. \quad (8)$$

Finally, for the mechanical work done during the motion we must write, with a negative sign, the kinetic energy and friction of the disturbed ions.

$$R=-\frac{1}{2}\iiint m_1\left[\left(\frac{\delta f}{\delta t}\right)^2+\left(\frac{\delta g}{\delta t}\right)^2+\left(\frac{\delta h}{\delta t}\right)^2\right]$$
$$+\iiint\left[f r_1+g r_2+h r_3\right]dx\,dy\,dz. \quad . \quad (9)$$

In this equation $m_1$ is the mass of an ion, and $r_1$, $r_2$, $r_3$, are the components of the friction force which does not undergo variation. Their values may be written

$$r_1=k_1\frac{\delta f}{\delta t},\ r_2=k_1\frac{\delta g}{\delta t},\ r_3=k_1\frac{\delta h}{\delta t}. \quad . \quad . \quad . \quad (10)$$

If we now investigate the conditions of least action, viz., that

$$\delta\{W_e+W_m+T+R\}=0, \quad . \quad . \quad . \quad . \quad . \quad (11)$$

we find (1) for variations of $f$, $g$, $h$—

$$\frac{f-f}{\kappa}=A\frac{\delta F}{\delta t},\ \frac{g-g}{\kappa}=A\frac{\delta G}{\delta t},\ \frac{h-h}{\kappa}=A\frac{\delta H}{\delta t}, \quad . \quad . \quad (12)$$

from which we obtain, by differentiation with respect to $t$ of $a=\frac{\delta H}{\delta y}-\frac{\delta G}{\delta z}$, &c. (Cf. equations 5).

$$\left.\begin{aligned}A\frac{\delta a}{\delta t}&=\frac{\delta}{\delta y}\left(\frac{h-h}{\kappa}\right)-\frac{\delta}{\delta z}\left(\frac{g-g}{\kappa}\right)\\ A\frac{\delta b}{\delta t}&=\frac{\delta}{\delta z}\left(\frac{f-f}{\kappa}\right)-\frac{\delta}{\delta x}\left(\frac{h-h}{\kappa}\right)\\ A\frac{\delta c}{\delta t}&=\frac{\delta}{\delta x}\left(\frac{g-g}{\kappa}\right)-\frac{\delta}{\delta y}\left(\frac{f-f}{\kappa}\right)\end{aligned}\right\} \quad . \quad . \quad . \quad (13)$$

(2) For variations of F, G, H,

$$\left.\begin{aligned}A\frac{\delta}{\delta t}\left(f+f\right)&=\frac{\delta}{\delta z}\left(\frac{b}{\mu}\right)-\frac{\delta}{\delta y}\left(\frac{c}{\mu}\right)\\ A\frac{\delta}{\delta t}\left(g+g\right)&=\frac{\delta}{\delta x}\left(\frac{c}{\mu}\right)-\frac{\delta}{\delta z}\left(\frac{a}{\mu}\right)\\ A\frac{\delta}{\delta t}\left(h+h\right)&=\frac{\delta}{\delta y}\left(\frac{a}{\mu}\right)-\frac{\delta}{\delta x}\left(\frac{b}{\mu}\right)\end{aligned}\right\} \quad . \quad . \quad . \quad (14)$$

(3) For variations of f, g, h,

$$-\left(\frac{f}{\kappa}\right)+\frac{1}{\theta}f-A\frac{\delta F}{\delta t}+m_1\frac{\delta^2 f}{\delta t^2}+r_1=0,$$

which, combined with (10) and (12), gives

$$\frac{2f}{\kappa}=\frac{\kappa+\theta}{\kappa\theta}f+m_1\frac{\delta^2 f}{\delta t^2}+k_1\frac{\delta f}{\delta t}. \quad . \quad . \quad . \quad . \quad (15)$$

with similar equations for $g$ and $h$.

For the sake of brevity we may write

$$\frac{\kappa+\theta}{2\theta}=a^2,\ \frac{\kappa}{2}m_1=m,\ \frac{\kappa}{2}k_1=k, \quad . \quad . \quad . \quad . \quad (16)$$

so that the equations become

$$\left.\begin{aligned}f&=a^2 f+m\frac{\delta^2 f}{\delta t^2}+k\frac{\delta f}{\delta t}\\ g&=a^2 g+m\frac{\delta^2 g}{\delta t^2}+k\frac{\delta g}{\delta t}\\ h&=a^2 h+m\frac{\delta^2 h}{\delta t^2}+k\frac{\delta h}{\delta t}\end{aligned}\right\}. \quad . \quad . \quad . \quad . \quad (17)$$

---

*System of Plane Waves Propagated along the Axis of x.*

$$\text{Let}\quad \left.\begin{aligned}g&=B e^{in(t+px)},\ c=C e^{in(t+px)},\ g=b e^{in(t+px)}\\ f&=h=a=b=f=h=0\end{aligned}\right\}. \quad (18)$$

Equations (13) and (14) give for the values of the coefficients

$$\left.\begin{aligned}p\frac{(B-b)}{\kappa}&=A C\\ \text{and } A(B+b)&=C\frac{p}{\mu}\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (19)$$

while (17) gives

$$B=a^2 b-m n^2 b+i n k b. \quad . \quad . \quad . \quad . \quad (20)$$

If we put $b=h$ B, so that $h=\frac{1}{a^2-m n^2+i n k}$, equations (19) give

$$\frac{p}{A}\frac{1-h}{1+h}=\frac{\kappa\mu A}{p} \quad . \quad . \quad . \quad . \quad . \quad (21)$$

It is obvious, from the way in which it enters into equations (18), that $1/p$ is the velocity of propagation of the waves. Unless $k=0$, its value will be complex; this, as is well known, indicates a damping of the waves.

In order to make the physical meaning of this expression more clear, and to separate the real and imaginary parts, it may be noticed that the velocity of propagation $V_0$ in free ether is given by

$$V_0^2=\frac{1}{A^2\kappa\mu}. \quad . \quad . \quad . \quad . \quad . \quad (22)$$

We may write, therefore,

$$p=-\frac{q}{in}+\frac{1}{V}, \quad . \quad . \quad . \quad . \quad . \quad (23)$$

so that V is the real velocity of propagation of the waves under consideration, and $q$ is the coefficient of damping per unit length of their path. Equation (21) then becomes

$$p=-\frac{q}{in}+\frac{1}{V}=\frac{1}{V_0}\sqrt{\frac{1+h}{1-h}}, \quad . \quad . \quad . \quad (24)$$

where
$$\frac{1+h}{1-h}=\frac{a^2-mn^2+ink+1}{a^2-mn^2+ink-1}.$$

Assume

$$\left.\begin{aligned}a^2-mn^2+1&=\rho_0\cos\theta_0,\\ a^2-mn^2-1&=\rho_1\cos\theta_1,\\ kn&=\rho_0\sin\theta_0=\rho_1\sin\theta_1,\end{aligned}\right\} \quad . \quad . \quad . \quad (25)$$

---

* The quantity $\kappa$ is $\frac{1}{4\pi}$ times Maxwell's K. Hr. R. Reiff has pointed out (*Wied. Ann.*, LV., pp. 82-94, 1895), that equation (4) differs from the corresponding equation obtained by Helmholtz in his memoir of 1881 (*l.c.*), and afterwards found by Goldhammer, Ebert, and Drude. The difference consists in the inclusion here of the term $\frac{1}{\kappa}(ff+gg+hh)$, which is apparently the portion of the energy due to the presence of the charges f, g, h, in the free ether. Helmholtz introduced it without comment, and Reiff considers it incorrect. He has traced the consequences of omitting it.—*Trans.*

† A is the work done when a conductor conveying unit current cuts one line of force

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$\rho_0$ and $\rho_1$ being always taken positively, and the angles $\theta_0$ and $\theta_1$ in the first two quadrants, so that their sines are always positive. Substituting these values, we obtain

$$\left.\begin{aligned} p &= \frac{1}{V_0}\left(\frac{\rho_0}{\rho_1}\right)^{\frac{1}{2}} \cdot e^{\frac{1}{2}i(\theta_0-\theta_1)}, \\ \frac{q}{n} &= \frac{1}{V_0}\left(\frac{\sin\theta_1}{\sin\theta_0}\right)^{\frac{1}{2}} \cdot \sin\tfrac{1}{2}(\theta_0-\theta_1), \\ \text{and} \quad \frac{V_0}{V} &= \sqrt{\frac{\sin\theta_1}{\sin\theta_0}} \cdot \cos\tfrac{1}{2}(\theta_0-\theta_1). \end{aligned}\right\} \quad . \quad . \quad . \quad (26)$$

The last of these equations is the index of refraction of feebly damped waves on passing from ether containing movable molecules into free ether. It should be noticed that the term containing the square root must have the same sign in the last two equations. The values of the tangents are

$$\tan\theta_0 = \frac{k\,n}{a^2 - m\,n^2 + 1}, \quad \tan\theta_1 = \frac{k\,n}{a^2 - m\,n^2 - 1},$$

$$\text{or, taking } N^2 = \frac{a^2+1}{m}, \qquad P^2 = \frac{a^2-1}{m}, \quad . \quad . \quad . \quad (27)$$

$$\tan\theta_0 = \frac{k}{m\,N}\cdot\frac{1}{\frac{N}{n} - \frac{n}{N}}, \quad \tan\theta_1 = \frac{k}{m\,P}\cdot\frac{1}{\frac{P}{n} - \frac{n}{P}}. \quad . \quad (28)$$

These show that $\theta_0$ is a right angle when $N = n$. Now, N is the value which $n$ will take if the phases of the electric displacements $g$ in the ether, and g in the molecule, are in the same direction, and the oscillations take place without friction under the influence of the mutual attraction between $g$ and g, expressed by the constant $a^2$.

If $a^2 > 1$, so that P is real, P denotes another and smaller rate of vibration which would occur when the two electric forces act so as to oppose each other.

The values found for the two tangents in equations (28) show that when the coefficient of friction $k$ is very small the tangents can only have finite values if their denominators are nearly zero; that is, if $n$ is nearly equal to N or P. If this is the case we have for $n = P$, $\theta_1 = \frac{\pi}{2}$, and for $n = N$, $\theta_0 = \frac{\pi}{2}$.

The ratio of the two tangents is $\tan\theta_1 \tan\theta_0 = (N^2 - n^2)/(P^2 - n^2)$. As the greater values of the sine correspond to greater values of the tangent, and since for angles near 0 or $\pi$ the ratio of the sines is the same as that of the tangents, it follows that the factor $\sin\theta_1 \sin\theta_0$ in equations (26) has the value $N^2/P^2$ for $n = 0$, and is, therefore, greater than unity, whereas for $n = \infty$ we have $\sin\theta_1 = \sin\theta_0$.

This factor will increase until $n = P$, and will equal unity when $n^2 = \frac{1}{2}(P^2 + N^2)$; it will then further decrease until $n = N$, and finally, when $n$ is very great, it will again increase, until for $n = \infty$ it once more reaches the value unity.

We have already seen that $V_0/V = n$ is the refractive index for passage from free into loaded ether, while

$$q = \frac{q}{n}\,V \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

is the coefficient of damping per wave length of the vibrations considered; its value is given from equations (26), namely,

$$q = \tan\tfrac{1}{2}(\theta_0 - \theta_1), \quad . \quad . \quad . \quad . \quad . \quad (30)$$

$$n^2(1+q^2) = \frac{\sin\theta_1}{\sin\theta_0} = \frac{\rho_0}{\rho_1}.*$$

For small values of $k$ it will be seen from the previous work that the angle $\frac{1}{2}(\theta_0 - \theta_1)$ is very small when $n = 0$; it increases somewhat rapidly until its value reaches nearly $\pi/2$, and at $n = N$ has fallen at the same rapid rate to its former value. Both for $n = 0$ and $n = \infty$ its sine is very small, but for values intermediate between $n = P$ and $n = N$ the sine is nearly unity; consequently, according to equation (30), there will be great absorption between the two lines.

The values of the refractive index are given by $n = \sqrt{\frac{\sin\theta_1}{\sin\theta_0(1+q^2)}}$;* throughout the region of great absorption they will be reduced below the value $\sqrt{\sin\theta_1 \sin\theta_0}$. But we have seen that the latter expression has higher values on the less refrangible edge of the absorption band ($n < P$) than on its more refrangible edge ($n > N$). This accounts for the *anomalous dispersion* of the colours which remain visible at the edges of the absorption band.

In the case of colourless transparent bodies, for which the refractive indices are generally found, no marked absorption is observed in the visible part of the spectrum; if absorption exists it must be outside the visible limits. The course of the curve of refractive index and frequency, as given by the greatly used formula of Cauchy, agrees with the portion of our curve for values of $n$ smaller than $n = P$. The absorption bands of such bodies must therefore be usually looked for in the ultra-violet. It is clearly not impossible for molecules to have several periods of vibration, which would furnish several absorption bands and refractive properties of corresponding complexity.

It is to be noted that in regions of great absorption, where the factor $\frac{1}{2}(\theta_0 - \theta_1)$ is very small, our theory admits the possibility of a refractive index smaller than unity, *i.e.*, of velocities greater than in free ether. According to the researches of Herr Kundt, this is the case with certain metals.

*Case of P imaginary.*—The cases in which $a^2 < 1$, and where P is consequently imaginary, indicate a different behaviour. In such cases $\tan\theta_1$ is always negative, so that $\theta_1 > \pi/2$ and increases with $n$; if $k$ is small $\theta_1$ differs but little from $\pi$. The changes of $\theta_0$ are the same as in the case of $a^2 > 1$. As soon as $n$ passes the value N, $\theta_0$ will rapidly approach $\pi$. The expression $(\theta_0 - \theta_1)/2$, which was previously a little less than a right angle, becomes small when $n > N$, and the damping then becomes feeble, so that the corresponding waves can be seen. The refraction will sink to a minimum in the neighbourhood of $n = N$, where the rays begin to be visible; it will then increase again, and at $n = \infty$ will have the value $n = 1$. Substances with this type of refraction have not yet been discovered.

*Difference of Phase.*—We may remark that from equations (20) and (25) it follows that $\frac{b}{B+b} = \frac{e^{-i\theta_0}}{\rho_0}$,

while equation (19) gives $\frac{B+b}{C} = \frac{p}{A\,\mu}$.

Combining this with

$$p = \frac{1}{V_0}\sqrt{\frac{\rho_0}{\rho_1}} \cdot e^{\frac{i}{2}(\theta_0 - \theta_1)}$$

we obtain $\frac{b}{C} = \sqrt{\frac{\kappa}{\mu\,\rho_0\rho_1}} \cdot e^{-\frac{1}{2}i(\theta_0+\theta_1)}$.

This equation shows that a difference of phase exists between the magnetic oscillation and that of the molecule, amounting to $\frac{1}{2}(\theta_0 + \theta_1)$. The ratio of their amplitudes is given by the first factor $\sqrt{\kappa\,\mu\,\rho_0\rho_1}$. The quantities $\rho_0$ and $\rho_1$ cannot become zero, but for small values of $k$ they become very small both when $n = N$ and $n = P$.

Equation (20) shows that there is a difference of phase between the oscillation of the electrical moments and that of the ions. If we write

$$a^2 - m\,n^2 = \rho_2 \cos\theta_2,$$
$$k\,n = \rho_2 \sin\theta_2,$$

then $\frac{b}{B} = h = \frac{1}{\rho_2} \cdot e^{i\theta_2}$

The ratio of amplitudes becomes a minimum when $n^2 = \frac{1}{2}(P^2 + N^2)$.

Violent oscillations of this nature might possibly be able to tear the ions from their combinations, especially if the substance has an electrostatic charge, and with all substances exhibiting strong absorption at the boundary of the ultra-violet we might be able to obtain the phenomenon observed by Hertz—that electricity is discharged under the influence of ultra-violet radiation. The fact that negative electricity escapes more easily than positive must be attributed to a peculiar structure of the negative ions.

*Behaviour of Perfectly Transparent Media.*—If the absorption coefficient $k = 0$, $h$ is real, and the velocity of propagation

$$V = \frac{1}{p} = V_0\sqrt{\frac{1-h}{1+h}}$$

is then real. The first factor of this expression, $V_0 = 1/A\sqrt{\kappa\mu}$, is the known velocity of light in continuous ether, while for real values

$$\frac{1+h}{1-h} = \frac{a^2 + 1 - m\,n^2}{a^2 - 1 - m\,n^2}.$$

This factor is positive, and the ratio $V/V_0 = 1/n$ is consequently real, if either $mn^2 < (a^2 - 1)$ or $mn^2 > (a^2 + 1)$. The first case gives a constant index of refraction for very slow oscillations, and the velocity of propagation is in transparent non-absorbing media slower than in vacuum. The second case gives constant index of refraction for very rapid oscillations, and the index is always less than unity. The former case corresponds with the phenomena observed in the best known very transparent media.

If we notice that $a^2/m = N^2$ is the square of the oscillation-frequency of the ether free from ions,† then

$$n^2 = \left(\frac{V_0}{V}\right)^2 = \frac{\left(N^2 + \frac{1}{m}\right) - n^2}{\left(N^2 - \frac{1}{m}\right) - n^2}. \quad . \quad . \quad . \quad (31$$

* These equations were afterwards altered by Helmholtz but are correct in their original forms, which are here retained.—*Trans.*

* In equations (18) the term due to the ions is $\mathbf{g} = b\,e^{i(t + p\,x)}$. This vanishes if $b = 0$, in which case $h = a^2 - m\,N^2 = 0$, giving $N^2 = a^2/m$.

† The value obtained by Herr Reiff, by omitting the middle term in the expression for the electrostatic energy is

$$n^2 = \frac{\left(N^2 + \frac{1}{m}\right) - n^2}{N^2 - n^2}.$$

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Since the wave-length $\lambda = V/n$, we can write

$$(V^2 - V_0^2)\left(N^2 - \frac{V^2}{\lambda^2}\right) + \frac{1}{m}(V^2 + V_0^2) = 0.$$

$$V^4 - V^2\left(N^2\lambda^2 + V_0^2 + \frac{\lambda^2}{m}\right) + \left(N^2\lambda^2 V_0^2 - \frac{\lambda^2 V_0^2}{m}\right) = 0$$

$$V^2 = \tfrac{1}{2}\left(N^2\lambda^2 + \frac{\lambda^2}{m} + V_0^2\right) \pm \sqrt{\tfrac{1}{4}\left(N^2\lambda^2 + \frac{\lambda^2}{m} + V_0^2\right)^2 + \left(\frac{\lambda^2 V_0^2}{m} - N^2\lambda^2 V_0^2\right)}.$$

As $V^2 < V_0^2$, we must take the lower value of the expression. If we regard $\lambda^2 V_0^2 \left(\frac{1}{m} - N^2\right)$ as a small quantity and expand the square-root expression, we obtain

$$V^2 = \frac{V_0^2\lambda^2\left(N^2 - \frac{1}{m}\right)}{N^2\lambda^2 + V_0^2 + \frac{\lambda^2}{m}} = \frac{\left(N^2 - \frac{1}{m}\right)}{\frac{N^2}{V_0^2} + \frac{1}{\lambda^2} + \frac{1}{m V_0^2}}$$

$$\left(\frac{V_0}{V}\right)^2 = \frac{N^2 + \frac{V_0^2}{\lambda^2} + \frac{1}{m}}{N^2 - \frac{1}{m}}. \quad . \quad . \quad . \quad . \quad (32)$$

This formula approximates to that of Cauchy, at any rate, for media with small dispersion, in which case $V_0/\lambda$ can be considered small in comparison with N. The square root can then be found approximately by the binomial theorem, and we have, if $n = \alpha + \beta\lambda^2$

$$\alpha = \frac{N + \frac{1}{2mN}}{\sqrt{N^2 - \frac{1}{m}}}; \quad \beta = \frac{\frac{1}{2}\frac{V_0^2}{N}}{\sqrt{N^2 - \frac{1}{m}}} \; *$$

## Polarisation by Refraction.

*Electric Oscillation in the Plane of Incidence.*—For an incident beam making an angle $a$ with the normal, let the plane of incidence be that of $x$, $y$, and let the amplitude of the magnetic oscillation be C parallel to the $z$ axis; the electric oscillation then lies in the plane of incidence, and its amplitude is given by equations (19) and (23)

$$\frac{B}{C} = \frac{1}{V A \mu (1 + h)}.$$

The angle between these oscillations and the axis of $y$ is equal to the angle of incidence $a$, and their component along the $y$ axis is therefore

$$y = B\cos a = \frac{C\cos a}{V A \mu (1 + h)}$$

The boundary conditions are given by equations (12) and (13), by expressing that the differential coefficients with respect to $x$ do not become infinite at the boundary; that is, that the quantities differentiated do not become discontinuous. Hence the values of $(g - g)/\kappa$, $(h - h)/\kappa$, $b/\mu$ and $c/\mu$ must be the same on both sides of the bounding surface. If we denote quantities which refer to the middle of the incident, reflected and refracted waves, by the suffixes 1, 2, 3 respectively, we have for the values at the boundary

1. Incident wave.

$$\frac{g_1 - g_1}{\kappa_1} = \frac{B_1 - b_1}{\kappa_1}\cos a; \quad \frac{c_1}{\mu_1} = \frac{C_1}{\mu_1}.$$

2. Reflected wave.

$$\frac{g_2 - g_2}{\kappa_1} = -\frac{B_2 - b_2}{\kappa_1}\cos a; \quad \frac{c_2}{\mu_1} = -\frac{C_2}{\mu_1}.$$

3. Refracted wave.

$$\frac{g_3 - g_3}{\kappa_3} = \frac{B - b}{\kappa_3}\cos\beta; \quad \frac{c_3}{\mu_3} = \frac{C_3}{\mu_3}.$$

According to equation (19) we have, with the different suffixes,

$$\frac{B - b}{C} = \frac{A\kappa}{p} = V.A.\kappa;$$

or $$\frac{B_1 - b_1}{\kappa_1} = C_1 V_1 A; \quad \frac{B_2 - b_2}{\kappa_1} = C_2 V_1 A; \quad \frac{B_3 - b_3}{\kappa_3} = C_3 V_3 A.$$

The boundary conditions thus give

$$\left.\begin{aligned}(C_1 + C_2)/\mu_1 &= C_3/\mu_3, \\ \text{and} \quad (C_1 - C_2)/V_1\cos a &= C_3 V_3\cos\beta.\end{aligned}\right\}$$

As the phases of the waves at the bounding surface $x = 0$ must succeed each other at the same rate in both media, we have as is well known,

$$\frac{V_1}{\sin a} = \frac{V_2}{\sin\beta}.$$

And the above equations give

$$\frac{\mu_3}{\mu_1}.\ (C_1 + C_2)\cos\beta\sin\beta = (C_1 - C_2)\cos a\sin a.$$

Since $\mu_3$ and $\mu_1$ are nearly equal in ordinary colourless transparent media, we can put their ratio equal to unity, so that

$$C_1(\sin 2\beta - \sin 2a) = -C_2(\sin 2\beta + \sin 2a).$$

Hence $C_2 = 0$, if $\sin 2\beta = \sin 2a$. This is the case when $a + \beta = \frac{1}{2}\pi$; the reflected wave is then extinguished. The value of the polarising angle agrees with Fresnel's law *for all colours*.

*Magnetic Oscillation in the Plane of Incidence.*—The amplitudes of the oscillations may again be denoted by $C_1$, $C_2$, $C_3$, and those of the electric oscillation by $B_1$, $B_2$, $B_3$. The boundary condition for the magnetic oscillations is

$$\frac{C_2 - C_1}{\mu_1}\cos a = \frac{C_3}{\mu_3}\cos\beta,$$

and for the electric oscillations

$$\frac{B_1 - b_1}{\kappa_1} + \frac{B_2 - b_2}{\kappa_1} = \frac{B_3 - b_3}{\kappa_3}.$$

Since $(B - b)/\kappa = C.V.A$, the latter equation gives

$$(C_1 + C_2) V_1 A = C_3 V_3 A,$$

or, putting $\mu_1 = \mu_3$ and $V_1/V_3 = \sin a/\sin\beta$,

$$(C_1 + C_2)\sin a.\cos\beta = (C_1 - C_2)\cos a.\sin\beta,$$

$$C_1\sin(\beta - a) = C_2\sin(\beta + a),$$

which is Fresnel's value for the intensity of the reflected light in the other plane of polarisation.

Whenever absorption occurs we have, as is well known, elliptic polarisation of the light. Its laws can be deduced without difficulty from the preceding theory.

---

Substances which are good insulators would be the most likely ones to show no damping, that is $k = 0$. I therefore requested Herr Mahlke, assistant at the Reichsanstalt, to compare with observations formula (31), which may be written for shortness $n^2 = (a^2 - u^2)(\beta^2 - u^2)$, where $a^2 = N^2 + \frac{1}{m}$ and $\beta^2 = N^2 - \frac{1}{m}$. He used Fraunhofer's observations on turpentine and those of Verdet on carbon bisulphide, choosing the values of the refractive index for the Fraunhofer lines B and H in order to determine the two constants, while Ångstrom's numbers were taken for the oscillation frequencies.

| Line. | Refractive index of turpentine. | | Refractive index of carbon bisulphide. | |
|---|---|---|---|---|
| | Observed. | Calculated. | Observed. | Calculated. |
| B | 1·4704 | 1·4704 | 1·6114 | 1·6114 |
| C | 1·4715 | 1·4715 | 1·6153 | 1·6147 |
| D | 1·4745 | 1·4744 | 1·6261 | 1·6240 |
| E | 1·4784 | 1·4783 | 1·6403 | 1·6368 |
| F | 1·4817 | 1·4813 | 1·6526 | 1·6487 |
| G | 1·4883 | 1·4881 | 1·6755 | 1·6728 |
| H | 1·4938 | 1·4938 | 1·6956 | 1·6956 |

The observations on turpentine agree so well with our theory that any deviations may be ascribed to experimental errors. The greatest discrepancy amounts to less than 1/3700, which is smaller than the differences existing between the most recent measurements of wave length by different good observers.

The numbers for carbon bisulphide show greater deviations of a systematic character, so that probably we cannot neglect the absorption in this case.

In order to make the somewhat complicated nature of the phenomena more intelligible in the case where absorption is present, Herr Mahlke has constructed the curves of the figure.

The unbroken lines $f b$ and $b i h$ represent by their ordinates, reckoned from the line $a c$, the values of the refractive index $n$ for $\alpha = 5$, $\beta = 4$, $k = 0{\cdot}1$, as the frequency of oscillation $n$ increases proportionately to the horizontal distances along $a c$. The curve $a b$ and $b c$, formed of alternate lines and points, shows the value of the absorption-factor $q$ for equal lengths traversed by the waves. At $a$, $n = 0$; it increases beyond $c$ to infinity, and has the values $n = \beta$ at $l$, and $n = a$ at $k$. The cusps of both curves are broken off at $b$, as they are too high for the figure, but they do not extend to infinity.

* Helmholtz's equations are $\alpha = \frac{N + \frac{1}{mV_0^2}}{\sqrt{N^2 - \frac{1}{m}}}$; $\beta = \frac{\frac{1}{2}\frac{V_0^2}{N^2}}{\sqrt{N^2 - \frac{1}{m}}}$. By a slip in the mathematics he has written $1/mV_0^2$ for $1/m$ in formula (32), but after making this correction I have been unable to verify his result. The expressions here given were derived by assuming $N^2$ large in comparison with $1/m$.—*Trans.*

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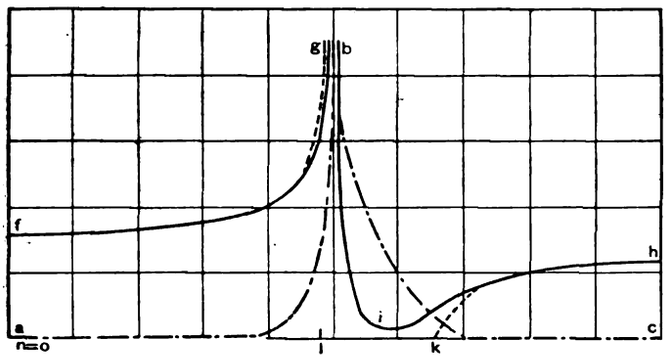
Finally, the dotted lines show the course of the curve when $k=0$, so far as it is separable from the curve for $k=0{\cdot}1$. This curve consists of two separate portions, $f\,b$ and $k\,h$, the first of which corresponds with the variations of refractive index in very transparent, colourless bodies.




The behaviour of platinum, iron, nickel and bismuth would be representable, according to Kundt's observations, by the portion of the curve between $b$ and $i$, with $n>1$ and anomalous dispersion. Silver, copper and gold, on the other hand, would be represented on the part of the curve below $i$, or on the ascending portion between $i$ and $h$, with $n<1$ and zero or normal dispersion.

## OBSERVATIONS ON ATMOSPHERIC ELECTRICITY AT THE KEW OBSERVATORY.*

BY C. CHREE, D.SC.

The primary object of the investigation was to arrive at a more exact interpretation of the records obtained with the Kew electrograph, and to devise improvements, if possible, in the conditions under which it works. The electrograph curves are intended to give the value of the potential at the point in the air where a water jet issuing from a long pipe breaks into drops. The proximity of a tall building has naturally, however, a large influence on the potential, so that no direct estimate could be made of the true potential gradient, *i.e.*, the increase in potential per unit of height in the open. It was also doubtful how local a significance the potential measurements might have.

To throw light on the first of these points, some preliminary experiments were made, which may be regarded as verifying Prof. Exner's experimental conclusion that a building under normal conditions reduces the potential in its neighbourhood precisely as if it formed an integral part of the earth's surface. Subsequently four series of observations were made, each extending over several weeks. The respective seasons were November—December, 1894, March—April, June—July, and October—November, 1895. The observations were taken with a portable electrometer of known scale value, at one or two approximately constant hours, at five or six stations on or near the Observatory. One was the top of a pillar 3¾ feet high, situated at an open spot some 56 yards distant from the Observatory; a second was in a position similar to that occupied by the end of the pipe of the water dropper. The other stations were stands or stonework on the roofs of the Observatory and a lower adjacent building. The highest station was about 66ft. above the lowest.

The ratios of the individual readings at the other stations to the corresponding ones on the pillar first mentioned were calculated, and their mean values found for each of the four series of observations, readings taken at two different hours being treated separately for some purposes. The mean values of the several ratios proved to be approximately constant. The results, in short, were consistent with the view that such general phenomena as diurnal or annual variation of potential got out with the same instrument at the several stations would show a good agreement.

A similar comparison was made between the potentials deduced from the electrograph curves and the readings taken on the pillar. The agreement here throughout any one of the four series, taking every thing into account, was but little inferior to that obtained when the portable electrometer readings on the pillar and at the station near the water jet were under consideration. Discrepancies, however, presented themselves in this case between the mean ratios for the four seasons, and even to a less extent between the mean ratios for the two hours during the same series of observations. This was at least partly due to defects in the water dropper brought to light by the investigation, and which certain changes are being introduced to remedy. The conclusion arrived at is that, supposing it possible to maintain uniform the conditions under which the electrograph works, the curve readings when multiplied by a constant factor may be expected to give close approximations to the true diurnal and annual variations of potential gradient, near the ground at any spot in the open within a short distance of the Observatory.

The values of the several meteorological elements, at the times of the observations with the portable electrometer, were derived from the Observatory records, and studied with a view to test the existence of any differential action on the water dropper and portable electrometer, or at stations on the roof and near the ground. The evidence for and against such influences is fully discussed.

The meteorological data thus accumulated afforded the opportunity of carrying out a searching investigation into possible connections of the several meteorological elements and the potential gradient. Attention was particularly directed to data bearing on Exner's theory, which connects potential gradient with density of aqueous vapour through a definite formula, departures from which are to be regarded as abnormal and due to disturbing causes. Special attention was also devoted to the possible influence of bright sunshine in reducing the potential gradient, in consequence of the theory proposed by Elster and Geitel. It is pointed out that when observations from all seasons of the year are combined, and treated promiscuously, the nature of the annual variations must lead to a certain amount of agreement between results deduced by a method of grouping such as Exner's and any judiciously selected formula which associates low potential gradient with high vapour density, high temperature, or long and intense sunshine, If any such intimate relation subsists between potential gradient and vapour density as Exner supposes, it ought to show itself when the observations combined together are taken during a short period at any given season of the year, and are restricted to a fixed hour of the day. The four series of observations, each of which possessed a convenient variety of climatic conditions, were thus treated separately, and were further subdivided into forenoon observations, usually about 10:30 a.m., and afternoon observations, usually about 4:30 p.m.

The results of the investigation seem far from favourable to Exner's hypothesis. They afford a certain amount of general support to Elster and Geitel's theory, inasmuch as on an average potential seemed lower after long previous sunshine. The evidence, however, in favour of a connection between high potential and low temperature, high barometric pressure, low wind velocity, and anti-cyclonic conditions generally, seems about equally strong. In each case notable exceptions appeared to any general rule.

It is not professed that the scope of the observations was sufficiently extensive to warrant the adoption of any positive conclusion as to the true operating cause or causes of variations of potential. It is hoped, however, that the treatment of a considerable variety of observations from a critical standpoint may prove to be of more permanent value than the addition of one to the already considerable number of existing theories.

Abstract of Paper read before the Royal Society.

## THE DAVY-FARADAY RESEARCH LABORATORY.*

Scientific investigators have long needed a central laboratory where researches can be carried on without interruption, and have urged the establishment of a national physical laboratory for the United Kingdom. Twenty years ago the Duke of Devonshire's Commission recognised the advantages which our national industries would derive from physical and chemical investigations, and pointed out the need of a more generous recognition of such research by the State. Since then the Physikalische Reichsanstalt, at Charlottenburg, has been established, and through the facilities it offers Germany is reaping a rich harvest of natural knowledge; but so far as State recognition is concerned, we have made little advancement. True, a Committee of the British Association has considered the question of a national physical laboratory, and another Committee is now reconsidering it; but there is no immediate prospect that any recommendations they might make will induce the Government to give a substantial grant, either for the extension of an existing institution in the direction of facilities for research, or for the establishment of an institution on the lines of the Reichsanstalt. For the perspicacity which sees in pure scientific research a means of developing industries, and which is content with knowledge accumulated, whether the practical bearings are apparent or not, we have to go to Germany, where many of our national industries have gone as a consequence of neglect by our Government.

Fortunately for British science, individuals occasionally arise who see how severely investigation is handicapped on account of the lack of organisation and encouragement by the State. One such benefactor is Dr. Ludwig Mond, whose munificent gift to the Royal Institution of a laboratory for physical and chemical research was

* From *Nature*.

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announced two years ago. We are now able to state that on June 12th Dr. Mond formally transferred to the managers of the Royal Institution the freehold of No. 20, Albemarle-street, adjoining that Institution, for the purpose of the laboratory of research in pure and physical chemistry referred to in our announcement, to be known as the Davy-Faraday Research Laboratory of the Royal Institution. In order to make the building suitable for this purpose, Dr. Mond has carried out very extensive alterations. He has also equipped the laboratory with the necessary apparatus, appliances, &c., for carrying on delicate investigations in physical and chemical science. An idea of the generous nature of Dr. Mond's endowment may be obtained from a statement of rooms included in the new Institute.

The laboratory contains:—

*On the Basement.*—A room for thermochemical research; a room for pyrochemical research; mechanics' workshop; room for electrical work; battery of 26 accumulators; constant temperature vaults; boiler house and store rooms.

*On the Ground Floor.*—A room for research in organic chemistry; a room for research in inorganic chemistry; a fire-proof room for experiments in sealed tubes; a balance room; entrance hall and cloak room.

*On the First Floor.*—The Honorary Secretary's room; a large double library connected with the library of the Royal Institution.

*On the Second Floor.*—A museum of apparatus.

*On the Third Floor.*—Seven rooms for research in physical chemistry.

*On the Fourth Floor.*—A room for inorganic preparations; a room for organic preparations; a photographic room; four rooms for researches in physical chemistry.

*On the Roof.*—An asphalted flat with a table, gas and water.

All the floors are connected by a hydraulic passenger-lift.

Dr. Mond has not only furnished the laboratory with the most modern instruments and appliances for researches in pure and physical chemistry, but he has also placed in the hands of the managers of the Royal Institution an ample annual endowment, so that the laboratory may be maintained in a state of thorough efficiency, the object of the donor being to give every assistance and encouragement within the limits of the endowment to scientific workers.

The laboratory (the affairs of which will be managed by a Laboratory Committee appointed by the managers of the Institution) will be under the control of two directors, who will be aided in the work by competent assistants. The managers of the Royal Institution have appointed as directors Lord Rayleigh and Prof. Dewar. It is intended to open the laboratory for work by the middle of October. The trust deed provides that no person shall be admitted to the laboratory as a worker who has not already done original scientific work, or in the alternative, who is not, in the opinion of the Laboratory Committee, fully qualified to undertake original scientific research in pure or physical chemistry; and that no person shall be excluded from admission by reason of his or her nationality or sex. Admission to the laboratory, and the supply of gas, water and electricity, as far as available, will be free of charge; but any person using the apparatus will be responsible for any damage done while in his possession.

Applications for admission are to be made to Mr. Robert L. Mond, Honorary Secretary to the Laboratory Committee, at 20, Albemarle Street.

The conditions of Dr. Mond's endowment are as liberal as the gift itself, and we have no doubt that the results which will follow will demonstrate the importance of both as means of advancing science. We regard the foundation of the laboratory as marking a most important step in the history of British science; for it provides a means whereby the edifice of scientific knowledge can be built up by master hands. British Governments are said to base their assistance to science mainly on the principle of helping voluntary effort. Perhaps, now that Dr. Mond has shown what can be done, the Government will show its interest in science by establishing a similar laboratory of a national character.

**X-Rays.**—According to Mr. Jackson, of King's College, the light emitted by the platino-cyanides under the influence of X-rays when examined by the spectroscope, proves to be a light corresponding to the element acting as base. The pale yellow light of the barium platino-cyanide, and the bluish light of the potassium platino-cyanide, are respectively the light of barium and of potassium. This in view of Helmholtz's investigation of 1893, published elsewhere in to-day's issue, is a point of the utmost significance, since it shows that we are dealing with vibrations not of the molecules but of some of the constituent atoms. X-rays, as Prof. Silvanus Thompson recently pointed out in an address at Oxford, "apparently can touch the atom within the molecule and set it into vibration."

## COMBINED ELECTRIC LIGHTING AND TRACTION PLANTS.*

BY JOHN HESKETH (BLACKPOOL) AND JOHN H. RIDER (PLYMOUTH).

From the time when Corporations commenced the supply of electrical energy for lighting purposes up to the present, it has been continually and emphatically stated and proved that the one thing operating against its cheaper production is the smallness of the load factor or percentage period of use of the plant. Many suggestions have been made as to means whereby this great drawback of cost could be overcome, but none have found such favour as the one for providing a load for the plant during the hours of daylight—in other words, to provide a constant or nearly constant load. In every business large output, with the minimum of plant, means cheap supply, and in the case of electrical supply large and uniform demand undoubtedly is the one thing needed to reduce its cost. All this has long been admitted, and no claim is made by the present writers to originality either in the reasoning or application. Indeed, to all engineers interested in electrical supply it must be as dreary as a twice-told tale. But there may still be many in the governing bodies, the councils of our Corporations, who have not accepted and absorbed the fact, and carried it out to its logical conclusion and practical application. The tendency during recent years to municipal control of local transit offers an excellent opportunity of pointing another object lesson, and adding a further example to the many already adduced, of the way in which electrical supply may be cheapened by judicious foresight and careful application of our present knowledge.

Many Corporations at the present time own, but do not work, their tramways, and in the near future it may be safely prophesied that those Corporations who willingly lease their lines will be in a minority. In almost every instance at present the lessee provides the motive power, generally horses, to deal with the traffic on lines constructed by the lessors. Therefore, when the time for a revision comes, and Corporations begin to work their lines themselves, they will probably be left to provide a complete equipment of new rolling stock and motive power. That electricity will be considered is certain; that it will be adopted in many instances is equally certain. But there still remains one very important question to decide in connection with the generating plant, and that is, Shall the plant be separate and distinct, or shall it be combined with a plant for electric lighting? In many cases the plant for electric lighting will already exist, most probably on a system unsuited for direct application to tramway purposes; and the tendency may be to say that as the purposes are distinct, then keep the plants separate and distinct. To show that this tendency is wrong is the object of this Paper.

Whether two separate systems be used in the one building, or whether both plants be identical, the combination has already been carried out to a practical issue in America, Europe and elsewhere. That it has not been hitherto done in England is due rather to force of circumstances than a lack of appreciation of the practicability and importance of the combination. In cases where low-tension direct-current systems are in use for lighting the question is very simple. If the voltage employed for lighting be unsuited for tramway purposes, a motor transformer can efficiently be used. This also holds good for an alternating high-tension system; in fact, be the voltage or current of the lighting plant what it may, motor transformers can be arranged to supply a suitable current for the tramways, generally continuous at 500 volts. There can be no doubt in anyone's mind as to the possibility of the combination, and it would result in cheapened supply for both purposes. Such a combined plant, worked economically, ought to produce current for all purposes at from 1½d. to 3d. per unit, according to the demand. This is simply due to the combined load factor being a very good one. Were the load factor of a lighting station equally good, the cost of production would be equally low. This is demonstrated in more than one instance in practice. Indeed, it seems almost useless repeating the arguments in favour of it, so sure are they, and so strong has the evidence up to the present been in favour of such a scheme. To quote from a recent publication:—

"This has been realised on the Continent, where in several large towns the tramway companies are buying current from municipal electric light works. The lowest price paid is at Geneva, where the tramway company guarantees a minimum consumption of 500,000 units per annum, and pays 1·15d. per Board of Trade unit.

"Hamburg is another example of a tramway company buying current from the lighting station. In this case the tramway company guarantees a minimum annual consumption of 2,500,000 units. The lighting company has to pay a fine of 9·6d. for every car mile which the tramway company may not be able to run owing to any failure of the power plant. The total expenses of the tramway company, including depreciation, maintenance, interest on bonds, sinking fund, &c., are only 3·95d. per car mile.

* Paper read before the Municipal Electrical Association.



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"Hamburg has, so far, the largest electric tramway system in Europe, and its success is an accomplished fact. The management state in the last annual report that the introduction of electric traction has without the slightest doubt very much improved the earning capacity and diminished the working expenses of the system; further, that on the lines where electricity has superseded horses the number of passengers carried has increased more than 32 per cent. and the receipts have increased nearly 35 per cent."

At Havre, too, the tramway company buys current from the lighting company, and at 1·75d. per unit. In all these cases it must be evident that it is of advantage to both supplier and supplied to continue the arrangement, or it would ere this have ceased. The same reasons hold good for the introduction of such systems into our municipal undertakings.

The question as to the system on which the combinations should be made is a most important one, which we will now briefly consider. We may have (*a*) a separate and distinct tramway plant within the same station buildings as our lighting plant, and under the same management and control; or (*b*) we may utilise the existing lighting machinery by various methods.

If we adopt the former, we shall require separate engines and generators, and also additional boilers, which, however, may be worked in conjunction with the existing boilers and steam pipes. In other words, we shall require nearly as much extra plant as though the tramways were being worked from a distinct station. The only advantages will be that the existing buildings (enlarged) and the existing lighting staff and management will be available. It is clear that this must be so when we remember that the tramway load will not conveniently shut down as darkness comes on, and that for a few hours each day, chiefly during the winter months, the whole of the lighting plant will be required for lighting purposes, and during this time the tramcars will have to be driven as well.

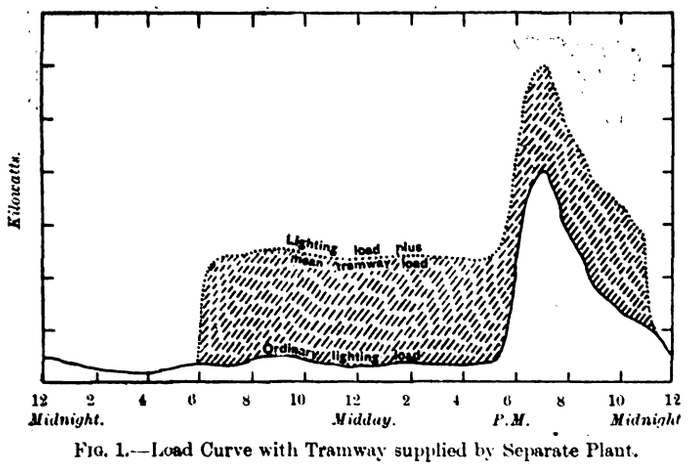


FIG. 1.—Load Curve with Tramway supplied by Separate Plant.

The effect of this combination will therefore be to give an excellent day load (after 6 a.m.), but it will also increase the "peak" by an equal amount. Fig. 1 endeavours to show this in a rough way. This is a great improvement on the load factor of the station, but cannot we go one better? If we utilise the existing machinery of the station for driving the cars, we must in the first place supply a current suitable for tramway purposes, and in the second place provide power for running the cars during the time of the heavy lighting load. As mentioned earlier, if the ordinary station supply be not suitable for direct use, we may obtain anything we want by means of rotary transformers—*i.e.*, by coupling a continuous current generator to a continuous current motor in the case of a direct current supply, and to an alternating current motor in the case of an alternating supply. The combined motor generator could be conveniently placed in a sub-station close to the tramways, and should be provided with a specially designed heavy flywheel, in order to minimise the effect of the starting of the cars upon the station machinery. The power required for driving the cars during the period of heavy lighting load may be obtained from accumulators. These should be of sufficient capacity to drive the cars for, say, five hours. The actual number of hours they would be required would vary with the time of year, but in the depth of winter it should not be more than this, while in the summer months it would be very small indeed. These accumulators would be charged directly from the station machinery, if suitable, or from the same motor generators which supply the cars in the day time.

A sample winter day's working would be somewhat as follows, viz:—11 p.m. to 6 a.m. (seven hours). Car traffic stopped. Motor generators charging accumulators at full rate. Only small lighting load. 6 a.m. to 5 p.m. (11 hours). Cars running. Motor generators supplying current for cars in parallel with accumulators, which would then be fully charged. Accumulators helping to furnish such sudden heavy demands as may be required, and also being partially charged when cars were only taking small current. Full steady load could thus be kept on motor generators and station machinery all day. Only small lighting load. 5 p.m. to 10 p.m. (five hours). Cars running. Motor generators stopped or running light. Accumulators supplying entire current for cars. Heavy lighting load. (As explained above, the actual demand upon the accumulators would depend on the time of year and the requirements of the lighting load.) 10 p.m. to 11 p.m. (one hour). Cars running, but gradually ceasing. Lighting load going off. Motor generators helping to drive cars, and gradually increasing until full power could be put on for charging the accumulators.

Fig. 2 shows the effect of this method of working, and it should be compared with Fig. 1. Not only is the load factor a splendid one, but the maximum output of the station is reduced to the maximum demand of *either* the lighting or the tramway load (whichever is the greater), and not to the sum of them. The actual shapes of the curves in Figs. 1 and 2, and the effect of the tramway load upon the system, will of course depend entirely upon local conditions, and will probably vary in every case.

The use of accumulators in the manner described would have the great incidental advantage of rendering the car service independent of a temporary breakdown of the plant, either in the case of a motor generator or any part of the generating machinery. The fields of both motor and generator could be excited by current from the accumulators, and the latter could also be used, in alternating-current systems, to run the plant up to synchronous speed before switching on to the high-tension alternating mains. The accumulators would also help (in conjunction with the heavy flywheel on the motor generator) to lessen the effect of the starting

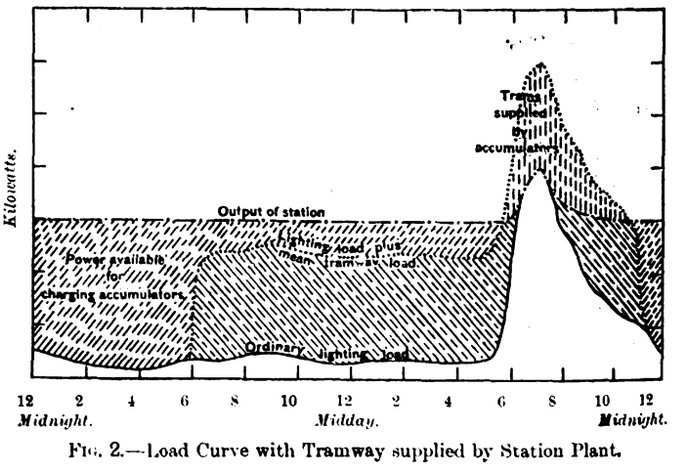


FIG. 2.—Load Curve with Tramway supplied by Station Plant.

of the cars upon the station machinery, so that the station load would only vary slowly, and that to a small extent, with a fair number of cars running.

It may be asked, "Where is the accumulator which will do all this?" We all know that accumulators have been tried for traction purposes, with disastrous results, but in such cases they have been carried *on the cars*, and have had to do the entire daily load. In the scheme suggested the accumulators are stationary, are subject to no jolting or other mechanical strains, and are under skilled supervision at all times. Instead of being called upon to drive the cars the whole day through, they would only, at the outside, have to do about 25 per cent. of the total work, and that only for a few months in the year. On the average about 15 per cent. would be their share. The sudden rushes of current on starting the cars would be partly met by the heavy flywheels on the motor generators, so that the life of the accumulators should be fairly good.

So far as prime cost is concerned, there is very little to choose between this arrangement and the former. The motor generators would cost about as much as their corresponding power in direct-acting steam plant, while the accumulators could be purchased for the money otherwise expended in spare steam plant, boilers, pumps, pipes, boiler seatings, and extended station buildings. But in the annual running expenses there would be some economy, particularly with respect to the boilers. If a distinct plant were used for the trams, steam would have to be kept up all day in sufficient boilers for the full tramway and lighting loads, as all the power would be required when darkness came on. This would mean both a larger chimney and also more stokers, while the fuel and water consumption would be increased. The motor generators being simply rotary machines, there would not be the same wear

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and tear as on the separate steam-engine plant, while a 10 per cent. to 15 per cent. charge should maintain the accumulators, particularly as makers will now enter into maintenance rates for lighting cells at only 4 per cent. per annum.

The question of a good day-load, and consequently cheapened production, is of such vital importance to our industry, that it will repay every attention which can be given to it. That a combined station is the right thing there can be no doubt. As to which system the combination should be carried out upon, there may be differences of opinion, and it is to bring out those differences of opinion that this Paper is laid before you.

DISCUSSION.

Mr. ALBERT GAY (Islington) thought there would be some difficulty in combining lighting and traction plants in London, but in the provinces it would be a very simple matter, because in the country the tramways very seldom run through more than one parish, whereas in London they often run through as many as half-a-dozen; and when these trams were under the control of the London County Council he saw very great difficulty in the electric lighting station of a particular parish undertaking the supply of electricity. They were looking forward to the time when electricity would be a much more keen competitor of gas than it was just at present; but even now, he thought, the gas companies were feeling the effects of electrical supply much more than they cared to admit. It seemed to him that the object of the Paper was to show how to cheapen electricity, and there appeared to be only one means of doing this, and that was the combined system suggested, because if they were going to put in special plant for the supply of electricity for the trams, he did not see how they were going to cheapen electricity for lighting purposes. There seemed only one feasible plan to him, and that was the combination of the two. It had been suggested that the use of motor transformers and heavy flywheels would very largely overcome the shocks to the machinery experienced when starting the cars. He did not think this would overcome the difficulty, because on a system running 50 or 60 trams there would be a dozen or more cars starting at the same time. He hoped something would be done to make the thing possible, if only for the sake of the provinces; but so far as London was concerned, it would have to take a back seat.

Mr. S. Z. FERRANTI agreed with Mr. Gay as to the difficulty in supplying current to trams from lighting stations. In the provinces it was quite a different matter, because there only electrical difficulties stood in the way. Taking a continuous-current station with a supply at, say, 400 or 440 volts, like Manchester, he thought experience went to show that it would not be possible to work a tramway system from such a station—at any rate, without special plant. He thought such a system would be sure to make the lights pulsate so much that it would be considered altogether inadmissible by the customers taking the lights. The only way, he thought, would be to use motor transformers with very heavy flywheels, and run the motors at a very great speed, so that a great storage of energy could be obtained.

Mr. C. H. WORDINGHAM (Manchester) said that as Mr. Ferranti had referred to Manchester, he was glad to avail himself of the opportunity of saying something. He saw serious difficulties in connecting the tramways to the lighting mains, but did not think it necessary to put in the motor generators of the type that Mr. Ferranti spoke of. Another difficulty had been pointed out to him, and that was that running as they did with an earthed middle conductor, it would not be possible to use the rails as a return, because they had two poles earthed, the middle and the outer pole, and that in itself was sufficient to prevent them using the lighting mains for traction.

Mr. E. MANVILLE felt a considerable personal interest in the matter, because two local authorities with which he was concerned had arranged to give very large amounts of power at a very low charge. One was the Shoreditch Vestry, which had signed a contract for the supply of electricity at 1½d. per unit to an underground railway for lighting its stations, to the extent of about half a million units per annum. That supply was purely a day load, the railway company providing accumulators for continuing the supply during the time of heavy load. The other was the Corporation of Swansea, where they had made a contract to supply a minimum of 400,000 units per annum to a maximum of 750,000 units per annum, at a price varying from 2d. to 1½d. per unit, according to the quantity used, and they have proposed to continue the supply during all the hours the tramway company required it. They did not expect any difficulties as regards interference with the supply of electricity for lighting purposes, since the two systems, so far as mains were concerned, would be entirely independent. Referring to Hamburg, that city had the most advanced electric traction system he knew of. They had at present 350 motor cars running. The trams were supplied by the lighting company at 1d. per unit for six million units per annum. That 1d. per unit included 0·71 for cost of production, the balance being interest and sinking fund.

Mr. W. ARNOT (Glasgow) did not see why the Vestries should not supply the current to the tramways passing through their districts. Mr. Manville had referred to Hamburg, but had confined himself to the commercial side of the question. He had had the privilege of being there himself a little while ago, and in the new station which was now open they ran off direct the generators and had no motor-generators at all. They had large marine type triple-expansion engines coupled direct to 600-volt generators for the traction work, and to machines of a smaller voltage for the lighting, and they could couple all these machines together for running the cars if necessary. They had separate feeders for tramways and separate feeders for lighting. He did not think it possible to run trams from the electric lighting circuits and wires. He failed to see why the same plant should not do for both purposes, not at the same time, but the same plant would do in both cases if necessary.

Mr. P. DAWSON said he could not see why both electric lighting and tramways should not be run from the same central station, but he thought the distribution should be separate. This was the opinion that was held by all the central-station engineers who distributed current for lighting and traction purposes. He had visited all the important towns in the United States and Europe. In Rome they had a battery of accumulators, the only object of which was to run the trams during a few hours in the evening.

Alderman HIGGINBOTTOM (Manchester) said he had been looking forward to the time when they would have electric traction in conjunction with their electric light in Manchester. He agreed with the speakers who said that they should have separate mains, but use the same plant. One thing was certain, and that was they had made up their minds that electricity should be the motive power in the future to work the trams in Manchester.

Mr. W. M. MORDEY did not agree with the authors that the two systems could be worked together, but he did agree with some of the previous speakers that a large part of the plant could be put to work on the double system, though not, perhaps, simultaneously. He thought that accumulators would be of considerable use in this connection. He believed in accumulators, but he liked to have as little to do with them as possible. If they only recognised the fact that accumulators were not *very* good things, and took them for what they were worth, they would make a right use of them.

Alderman ELLIS said at Portsmouth they were negotiating with the tramway company with the idea of purchasing the interest and rights and leasing them back again at a rental, the Corporation providing the current at something like 1½d. per unit.

Mr. H. D. WILKINSON agreed with Messrs. Dawson, Mordey and Arnot that the distributing portion of the system should be kept distinctly separate. He thought it had been overlooked that the use of motor generators would perform very useful functions in answering the Board of Trade regulations. The authors' suggestion of the use of motor transformers to overcome fluctuations was a most excellent one, but he thought it was yet a question whether the fluctuations would not be carried through a motor transformer and back again to the engine. The authors suggested the use of accumulators for preventing the fluctuations affecting the lighting, and he also thought this a very good suggestion.

Councillor PEARSON (Chairman of the Bristol Electric Lighting Committee) said they had a very successful tramway in operation. He did not think it was wise, seeing that the Council had put something like £100,000 into the speculation and was ready to put more into it, to allow a company to manufacture in their midst an article that they were manufacturing, and he had suggested that the tramways should be compelled to take their current from the Corporation; but the Corporation refused to support his proposal. However, they had supported another proposal of his, that the whole question of electric traction should be referred to a Committee, which should be empowered to employ special assistance for advising them, and to report upon the whole subject of electric traction to the Council, and that no further schemes on the part of the tramways should be permitted until the Council had been advised by the Committee. He had been appointed Chairman of that Committee, and they had sought professional assistance from Mr. Preece. He thought it would be best for the Bristol people to keep their lighting load separate from their traction load, especially as their lighting was done on the alternate current and their traction on the direct-current system. He had to look at the question from a ratepayers' point of view, because if he did not he would not have the opportunity of taking any interest in electric traction for any length of time. The Tramway Company were supplying a public want, which he thought should be supplied by the Corporation, and he hoped their electrical engineers and advisers would enable them to do the job at a price which would compare favourably with that of the Tramway Company's scheme

Mr. RUTHVEN MURRAY (Worcester) agreed that if they were going to combine electric traction with the central station the plants would have to be separate. At Worcester their largest motors were 30 H.P. Besides these they had on order and installed 12 motors of different sizes. Last year they supplied about 130,000 units to motors at about 1d. Had they had plenty of water in the river it might have paid the works' costs, but seeing that they had to work a great portion of that time with steam they lost a good bit of money. He believed that with alternate-current plant it would be easier to get good regulation if they had combined plants than if they had direct-current plant. At Worcester they always knew by telephone when the motors were going on; if this was not so, it would be a very serious matter. With regard to the question of motor-generators, it appeared to him that if they had a heavy fly-wheel on the alternator, that ought to serve instead of a heavy fly-wheel on the motor-generator. It was said in America that the lighting part of a business was sacrificed to the traction. He thought we did things in a rather better fashion in this country.

Mr. J. H. RIDER, in reply, said there seemed to be a misunderstanding as to the exact subject of the Paper. A large number of speakers had said that they should keep their tramway load on distinct feeders. They had not suggested anywhere in the Paper that they should use the same cables. He thought the speakers generally had agreed with him that combined plant was possible; and while some speakers had thought the fluctuations would form a very great disadvantage, others who had had experience did not think so. They did not wish to get the credit for the suggestion of using a heavy fly-wheel for getting over the fluctuations. The suggestion was first made by Mr. Ferranti. He thought accumulators would have to be used if they were going to get all the advantages of the combined plant. If they had separate and distinct plants they would have to have extra boilers. If engineers would do him the honour of a visit to Plymouth at some future date, he hoped to be able to show them a combined plant.



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## A NATIONAL SUBMARINE-TELEGRAPH MEMORIAL.

We are glad to see that ready response has been made to the suggestion put forward in these columns last week, that the time has come when we should commemorate in a fitting manner the most distinctively British achievement of the many momentous achievements of the memorable century now drawing to its close.

At the meeting of the shareholders of the Eastern Telegraph Company yesterday afternoon (the first gathering of shareholders since Sir JOHN PENDER'S death), Mr. NEWTON, Mr. BAINES and others warmly urged that there should be some permanent national commemoration of the inception of submarine telegraphy; and the Marquis of TWEEDDALE, himself for so many years intimately associated with submarine cable undertakings, naturally gave a hearty welcome to the idea. Owing, no doubt, in a large measure to the satisfactory position enjoyed by the Eastern Telegraph Company and the consequent pleasant monotony of its Directors' reports, less than one per cent. of the shareholders attend these semi-annual gatherings in the City; but we feel assured that the project which was so successfully launched yesterday will meet with cordial and general approval, not only among the shareholders of the Eastern Telegraph Company, but among the shareholders of the numerous submarine cable concerns born of English pluck and English capital.

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But it is not those who have provided the capital who have alone benefited by the vast network of cables which rests to-day on the bed of the ocean. A modern cynic is said to have remarked, when called upon to give suitable expression to his joy at the completion of the telegraphic communication between England and India, What is the use of people being able to speak to India when they have got nothing to say? A sharp sarcasm; not without its uses as an antidote to undue elation in regard to the engineering feats of the nineteenth century. But, apart from the makers of epigrams, who will deny the fundamental nature of the changes wrought in our habits, in our daily lives, aye, and in our modes of thought, by the advent of submarine telegraphy? To say that there has been loss as well as gain is merely to say that this great enterprise was carried out by human agencies, and has been made use of by human beings. Were it all loss and no gain, from the purely sociological point of view, submarine telegraphy would none the less be a famous victory of mind over matter, an exploit that will live in history, and a great event in the glorious annals of the Anglo-Saxon race. It is no fault of the submarine telegraph that the federation of the world seems no nearer to-day than it did fifty long years ago; humanity, not telegraphy, must bear the blame.

But turning away from the great question as to whether or no we are the happier for submarine telegraphy—a question which has a fascination for many minds mainly because it is practically insoluble and so largely a matter of definition—the bottom fact remains that we have taken the telegraph for better or for worse. The social fabric, as we know it to-day, could not continue without a full and a frequent use of those insignificant-looking lines that connect continent with continent and capital with capital. What the modern newspaper would be without its daily tale of telegrams from all parts of the globe it is difficult to imagine. Contrast the meagre and belated accounts of the great battles and events of the first half of the century, to be found in contemporary broadsheets, with the columns of the leading daily papers immediately after the ill-fated raid of Dr. Leander Starr Jameson. Again, the colossal financial transactions of our great mercantile houses could not by any possibility be carried on without the aid of submarine cables; and the vast army of shipowners, merchants, and brokers, and indeed the entire industrial community, whose business necessitates swift and sure communication with the commercial centres of the world, are indebted in an immeasurable degree to the submarine cable for the success of their schemes. Surely it is not too much to expect that these and others will freely aid a National Memorial of an achievement which so vitally concerns them.

Submarine telegraphy, it must never be forgotten, has done much to make possible Imperial Federation; indeed, without our present means of instant intercourse with the confines of the Empire this grand conception would to-day still be in the "region of smooth and idle dreams." And yet another great consequence of the submarine telegraph is that England, though it still remains "a precious stone set in the silver sea," has altogether ceased to be insular in regard to communication with the rest of the world. And again, powerful as is our navy, it is no exaggeration to say that its power, offensive and defensive, is increased tenfold by the fact that no fleet, no squadron, no vessel, is for long out of touch with the brain of the Empire. There are three things vital to our greatness—if not to our existence—as a nation. These are our credit, the envy of the civilised community; our foreign trade, which makes this little island the centre of a world-wide commerce; and our control of food stuffs, a control daily becoming of more and more importance to us. We do not suggest that our supremacy in these respects is solely due to our telegraphic connections, but beyond question the fact that London is the centre of the international telegraph system gives England a precious advantage in the industrial struggle, and this, in conjunction with our shipping, enables us to direct to our ports the surplus harvests of the East and West.

These, inadequately expressed, are a few of the reasons why, in our judgment, the passing away of the little band of leaders most closely associated in the public mind with this great enterprise, should be seized upon to commemorate the electrical union of the Anglo-Saxon race, which has spread its beneficent sway over America and Australasia, Asia and the dark continent of Africa.

## REVIEWS.

**Submarine Cable Laying and Repairing.** By H. D. Wilkinson, M.I.E.E. (London: "The Electrician" Printing and Publishing Company.)

With the knowledge that English engineers and electricians are responsible for the laying and maintenance of nine-tenths of the world's cables, it is certainly surprising that hitherto no English treatise dealing technically with the subject has appeared until the publication of Mr. Wilkinson's book. Submarine cable work cannot be said to be an uninteresting branch of engineering, nor can it be accepted that no advances have been made in it, as numerous improvements in the construction, testing, laying and repairing of cables have been introduced of late years.

Cable making and laying is by some even now regarded as something akin to a "secret process;" and those who have learnt their business at the cost of years of experience apparently hesitate to give to the beginner and the world generally the benefits and results of their study and work. We all recognise in the fullest way the beauty and value of practical experience; but if the young engineer in training for this work can learn his business in five years instead of in ten, an important advantage is secured both by him and the profession generally. With the book under review at his disposal and the facts digested, the student has a better chance of doing this than those who have previously entered the telegraph service and who now rather jealously guard whatever special information they have acquired.

We have read "Submarine Cable Laying and Repairing" with interest and pleasure; and, with so much to be said in its praise, it seems ungracious to draw attention to statements, some of which, though obvious slips, should not remain uncorrected. Mr. Wilkinson has curiously inverted the natural order of events by placing the chapters in the following order:—Chapter I.—The Cable Ship On Repairs. Chapter II.—Types of Cable Ships. Chapter III.—The Localisation of Faults. Chapter IV.—The Laying of Submarine Cables.

On the first page of Chapter I. we are immediately sent to sea to make a repair, and, as the necessary operations are undertaken, instructive and explanatory comments are given of the gear employed and the routine generally followed in the conduct of the work. The various grapnels in use, each designed for some special purpose, are well illustrated, and their respective merits and points explained. Perhaps that which is least familiar and of most interest is the cutting and holding grapnel designed by Mr. F. R. Lucas; the principle and management of this grapnel is fully dealt with. The dynamometer, grappling ropes, grappling, buoys and buoy ropes, stoppers, jointing and splicing of cables, picking up gears, the buoying of bights, and, finally, the slipping of final splices, are not only exhaustively described in the letterpress, but they are also illustrated by well-chosen plates. Amongst such a mass of sound information, we think that the suggestion on page 30 that grappling can be and is done at the rate of two or three knots an hour is misleading; the ship by going

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over the ground at this speed undoubtedly increases the difficulties of an ever difficult operation. Perhaps, however, we are to assume that Mr. Wilkinson here refers to the possibilities when grappling in very shallow water and with a new cable to recover. On page 48 the following paragraph is found:—"Seven leading types of cable, as manufactured by the Telegraph Construction Company are represented in Fig. 27 to actual size." Presumably, through an oversight, all these cables, with the exception of Type B', are shown as if they were of the alternate hemp and wire type, which is certainly not the case. May it be suggested that these types incorrectly shown should in a future edition be altered, or a footnote explaining the matter appended? On the same page and later in the book the impression is conveyed that all modern cables are "brass taped;" we feel sure that this remark is only intended to apply to the types laid in shallow water, the core of deep-sea cables is still unprotected from the teredo, as this pest does not affect depths exceeding 300 or 400 fathoms.

Chapter II. tells the history of the progress made in the design of cable ships and their equipment. The particulars of the earliest form of picking up gear, Fig. 85, and the modern machinery placed on the s.s. "John Pender," Figs. 99 and 100, indicate the development that has taken place in this direction. It may be accepted that the ease and rapidity with which repairing work is now successfully accomplished, is not only due to the fact that more is known about the conduct of the work, but that it is in no small degree due to the facilities which mechanical engineers have placed at the disposal of those in charge of these operations.

In addition, Mr. Wilkinson discusses and remarks upon the general arrangements of the earlier and of the modern cable-laying and repairing ships. In respect to these a quantity of useful data is put before his readers. An appendix to this chapter describes the improved gear lately fitted on board the new Japanese cable ship "Okinawa Maru."

The author has done good work in Chapter III. In it we find clear and concise statements as to the relative value of the different methods of testing now employed for "The Localisation of Faults," and as to the tests which may be most depended upon, and the recent developments by which accuracy in locating both high and low resistance faults is attained. Mance's test, Kennelly's break test with appendix, earth overlaps, loop tests, and the tests used whilst laying cables, are thoroughly investigated and explained.

The examples and diagrams of the necessary connections all help to give a clear understanding of the respective tests and of the most advantageous manner of conducting them successfully. Under the heading of "Shipboard Galvanometers," after a description of Lord Kelvin's marine galvanometer, we note that here and on page 387, a detailed description is given of the instrument designed by Mr. H. W. Sullivan for use at sea. Mr. Wilkinson's tests of this instrument show it to possess a high figure of merit for galvanometers of its class; and he remarks that its deadbeatness and wide range of adjustment render it useful for board ship work: it may be added that those who have had personal experience of its performance at sea speak of the instrument as a decided success. An improvement in the ordinary marine galvanometer devised by Messrs. Weatheral and Clark, is also described; without impairing the sensitiveness of the instrument, they have, by a damping device, secured both deadbeatness and facility in balancing.

Several pages are usefully devoted to a description of the method of determining the capacity of laid cables by the "Gott Test." The merits of this test and the mode of applying to it the necessary correction are clearly stated. But, speaking of the ordinary charge and discharge test, Mr. Wilkinson says on page 240, "The apparent capacity of these sections is found to be *greater* than the sum of the capacities of the core lengths." This is an unusual result, as, when capacity tests are made on lengths of, say, 250 or 300 knots by the charge or discharge methods, the apparent capacity is almost invariably *less* not *greater*. Capacity tests by the "throw" method on laid sections of cable approaching 1,000 knots in length we all agree to be valueless; but this is not the case when dealing with coiled cables of similar length—the writer has by the ordinary "throw" obtained the practically correct value of the capacity of a coiled cable of 1,000 knots (both ends being joined to the galvanometer, as in Fig. 128). The working speed, however, through this same length of cable and under the same conditions was only about *one-fourth* of its actual speed when laid out. In this context the equation given on page 241 is inapplicable. In a coiled, iron-sheathed cable the magnetic induction is important, and a factor representing it would obviously have to be introduced into the expression; but even where self-induction is negligible, as in a laid cable, the formula and table of Prof. Fleeming Jenkin's book is intended only to apply to the *current* at the distant end when the latter is to earth. Mr. Heaviside says in his "Electrical Papers," Vol. I., page 51, "Broadly speaking it takes about four times as long for the potential to nearly attain its maximum when the end is insulated, as it takes for the current to nearly attain its maximum when the end is to earth."

Finally, Chapter IV. records a considerable amount of technical information respecting the design, manufacture, and laying of submarine cables. The laws regulating the design of the core are clearly expressed; but in ordinary cases the probable insulation resistance of the cable when laid and affected by temperature and pressure does not influence the selection of the weights to be given to the conductor or insulator. The ruling factors are the speed of working required, and the most economical means of attaining this speed with provision for the mechanical safety of the core. We confess, moreover, that we do not follow Mr. Wilkinson in the rules he gives for determining the lay of the sheathing wires (p. 291) for the armour of a cable. The constant of 4½ins. multiplied by the circumference of cable equals "length of lay" does not coincide with practice, except in regard to deep-sea types; the lay of the sheathing wires in the heaviest types of cable manufactured rarely exceeds 18in., whereas an application of the rule results in a lay of 30in. for shore ends. The description of the machinery and processes incidental to cable manufacture, shipment and laying should be read by all beginners, especially those sections of the book treating of the landing of shore ends and the surveying of the route, in which the improved sounding gears with detachable sinkers, deep-sea thermometers, and all the apparatus employed, are carefully described.

It is difficult for a writer to select his material so that every reader may be satisfied, and find exactly all the information he requires; but we should have liked to have found expression of opinion by Mr. Wilkinson as to the best type of deep-sea cable for repair work, and also as to the outer serving with which such cable should be protected.

Those now interested or likely to be interested in the work of cable laying and repairing will not only find this volume of much practical use, but we think that they will hold themselves indebted to Mr. Wilkinson for placing upon record in the way he has done such a large amount of valuable data. The illustrations in each chapter are numerous, and Mr. Wilkinson is to be congratulated upon their selection.

ARTHUR DEARLOVE.

## THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 315.*)

*Method 2 (Varley's Method).*—The connections for this method are shown in Figs. 19 and 20, Figs. 19B and 20B representing a Post Office pattern bridge. The method is very convenient when a resistance-coil bridge is used, but it cannot be employed with a stretched wire bridge.

The connections are first made as in Figs. 19A or 19B. These are the same connections as for a copper-resistance

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test, with the exception that the + pole of the battery is connected to earth instead of to M. The values of the "proportional coils" $b = 1{,}000$ and $a = 10$ are those usually the best for the cases which occur in practice. The battery key, which is now T, is depressed before the galvanometer key S. On breaking contact, the key S should be allowed to rise before the key T.

$d$ is adjusted until balance is obtained, and the readings $a$, $b$ and $d$ are noted.

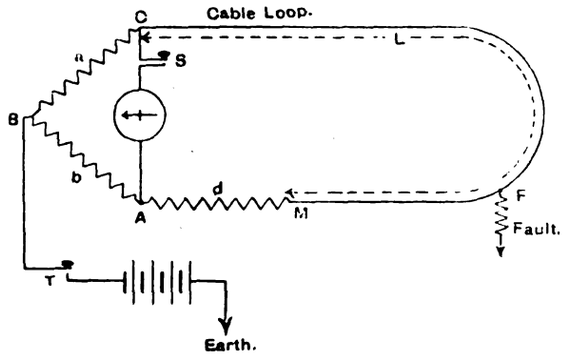


FIG. 19A.

Then the + pole of the battery is disconnected from earth and connected instead to M; the connections then being Figs. 20A and 20B—in fact, connections for a copper resistance test. The copper resistance of the loop is then measured in the usual manner, and its value L is noted.

The distance of the fault from M is then calculated from the formula

$$\frac{l\,(b\,\mathrm{L} - a\,d)}{\mathrm{L}\,(b+a)}, \quad \ldots \quad (22)$$

$l$ being the length of the loop.

The ends of the cable-loop should then be reversed, the + pole of the battery again disconnected from M and earthed, and the bridge again balanced. From the new readings and from the copper resistance already measured, the distance of

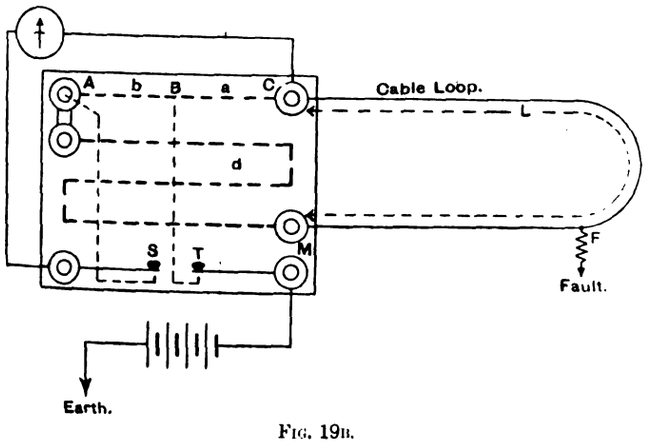


FIG. 19B.

the fault from the other end of the loop is calculated. If the positions indicated only differ slightly, their mean may be taken as correct. If there is a big difference between them, the connections and contacts must be examined, and the tests repeated.

It has been assumed that the leads have been included in calculating the equivalent length of the loop. They can be allowed for in the test if preferred; this is especially convenient when the loop is of one size of cable throughout, and also when the leads have a different temperature to the cable.

After measuring the resistance L of the loop and leads together the leads are disconnected, and the resistance of each is measured separately. We will call $m$ the resistance of the lead connected to the end M, and $c$ the resistance of the lead connected to C.

Then $\mathrm{L}' = \mathrm{L} - m - c$ is calculated, and the formula for the distance of the fault from the M end of the *cable* is

$$\frac{l}{\mathrm{L}'}\left(\frac{b\,\mathrm{L} - a\,d}{b+a} - m\right), \quad \ldots \quad (23)$$

$l$ being now the length of the loop from cable end to cable end, without leads.

*Example.*—One of two 7/18 S.W.G. cables, laid side by side, developed a fault, the insulation of the other remaining perfect. The cables at the far end were connected to 7/20 S.W.G. cables, the connection being in a junction box and not conveniently accessible. At the station end the 7/18 cables ran straight to the switchboard. The instruments available were a Post Office pattern portable Wheatstone's bridge and a

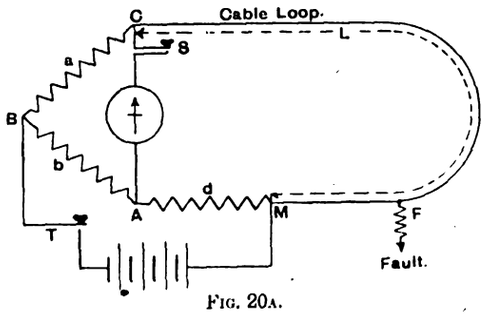


FIG. 20A.

reflecting galvanometer. The cable was not required for a few hours, and was therefore disconnected from the rest of the circuit.

The length of each 7/18 cable was 1,358 yards.

The length of each 7/20 cable was 5 yards.

The length of 7/18 cable which would have the same resistance as the 10 yards of 7/20 cable, would be

$$\frac{10 \times 0{\cdot}00180}{0{\cdot}001018} = 18 \text{ yards nearly.}$$

0·00180 and 0·001018 being the sectional areas of 18 and 20 S.W.G. wire respectively.

The length of the loop was therefore taken as 2,716 + 18 = 2,734 yards.

The ends of the 7/20 cable were short-circuited, and the station ends of the 7/18 cable were connected up to the bridge

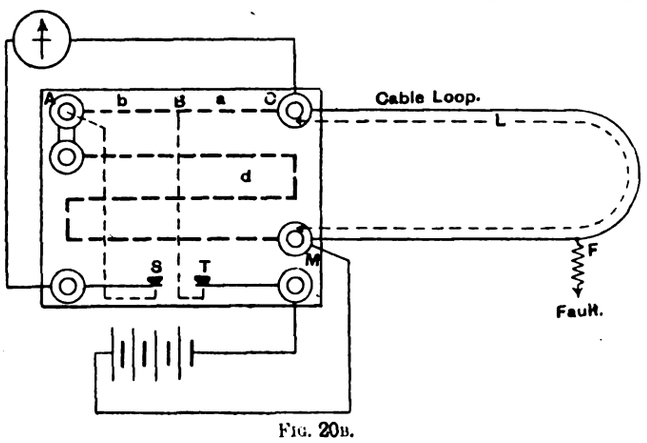


FIG. 20B.

as on the diagram Fig. 19B. The wires used to connect the cable ends to the instrument were two pieces of 14 gauge house-wire of equal lengths.

*Test.*—1. Connections as Fig. 19B. Cable 1 connected to M; cable 2 connected to C.

$$b = 1{,}000 \qquad a = 10.$$

Balance obtained for $d_1 = 467{\cdot}4$.

2. Connections as Fig. 20B. Copper resistance of whole loop (including connecting wires), 5·368 = L.

3. Copper resistance of the two leads connected in series, 0·042.

4. Reconnected as Fig. 19B, but with ends of cable reversed —viz., cable 2 connected to M, cable 1 connected to C.

$$b = 1{,}000 \qquad a = 10.$$

Balance obtained for $d_2 = 64{\cdot}4$.

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[NOTE.—The ordinary Post Office pattern bridge only reads to ohms. The last figure in each case was obtained by "comparative deflections." For instance, in the last test, when 65 ohms was unplugged, the galvanometer spot deflected 12 divisions to "less," and when 64 ohms was unplugged it deflected 7 divisions to "more." The fraction to add to 64 was therefore $\frac{7}{7+12}=\frac{7}{19}=0{\cdot}4$ nearly.]

Working these results out:—

$L'=L$ *minus* the resistance of the two leads—*i.e.*, 5·368 − 0·042 = 5·326.

$$\frac{b\,L-a\,d_1}{b+a}=\frac{5{,}368-4{,}674}{1{,}010}=\frac{694}{1{,}010}=0{\cdot}687$$

subtracting the resistance of one lead, 0·021

we get 0·666

To obtain the distance of the fault from the station we must multiply by $\frac{l}{L'}$, *i.e.*, by $\frac{2{,}734}{5{\cdot}326}$ ($l$ being the length of the loop).

Hence, the distance of the fault from the end of cable 1 is

$\frac{2{,}734}{5{\cdot}326}\times 0{\cdot}666=342$ yards

$$\frac{b\,L-a\,d_2}{b+a}=\frac{5{,}368-644}{1{,}010}=\frac{4{,}724}{1{,}010}=4{\cdot}677$$

Subtracting the resistance of one lead, 0·021

we get 4·656

Therefore the distance of the fault from the station end of cable 2 is $\frac{l}{L'}\times 4{\cdot}656=\frac{2{,}734}{5{\cdot}326}\times 4{\cdot}656=2{,}390$ yards.

The distance from the end 1, calculated from this latter test, is the length of the loop *minus* 2,390 yards, *i.e.*, 2,734 − 2,390 = 344 yards.

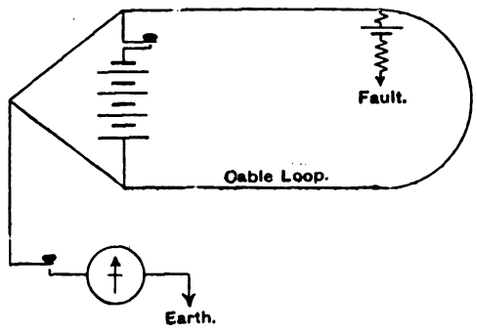


FIG. 21A.

The cable was therefore examined at 343 yards from the station, this being the mean between 344 and 342.

There are two important bugbears to be dealt with, in considering the application of the two preceding methods—(1) "False zero" and (2) contact resistances.

In telegraph work most localisation tests are taken "to false zero." That is to say, the galvanometer key—not the battery key—of the bridge is first depressed; a certain deflection occurs, chiefly due to earth currents, and the bridge is considered balanced if this deflection is again obtained when both galvanometer and battery keys are down. Now in a loop of electric light cable there are no earth currents; but there is usually an uncalled-for electromotive force due to a small primary battery being automatically set up at the fault. The electrodes are copper, and either lead, iron or the zinc of the galvanised iron wires, if the cable is so armoured; the electrolyte is dampness—in fact dirty water. On examining the various diagrams (Figs. 18 to 20) it will be seen that this electromotive force is actually in the battery circuit and not in either of the four arms of the bridge. It is simply between the point F and earth. Not only, therefore, is it unnecessary to balance the bridge to false zero, but absolutely wrong. Any deflection obtained on depressing the galvanometer key alone is usually due to leakage to earth from the instruments themselves. This leakage is removed by dusting the instruments, and then applying a little benzine or benzoline to the insulating parts with a soft brush or piece of rag. If a leakage current can still be observed in the galvanometer it is due to leakage across the battery key, and being in the battery arm of the bridge it will disappear when the bridge is balanced; therefore it is of no importance.

If the battery leads pass too near to the galvanometer there may be a deflection on depressing the battery key before

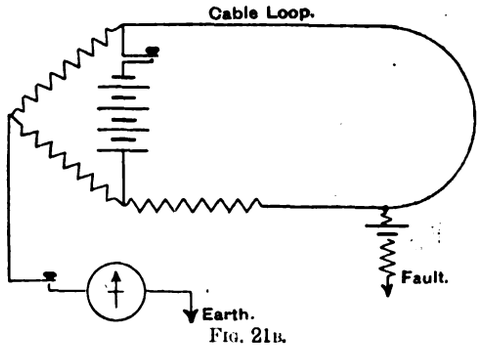


FIG. 21B.

the galvanometer key is down. This is due to the inductive effect of the current in the battery circuit. The effect is removed by leading the battery wires further from the instrument, or, if this is impracticable, one can balance to this false zero, depressing the battery key first as usual.

The connections shown in Figs. 21A and 21B are often recommended. They are just Figs. 18A and 19A with the positions of the battery and galvanometer interchanged. This arrangement is sometimes excellent for telegraph work; but

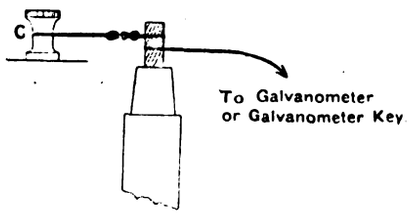


FIG. 22.

for electric light circuits it is not. On depressing the galvanometer key a current is sent through the galvanometer by the electromotive force in the fault, so that it is necessary to balance to a continually-changing false zero.

These remarks as to false zero only hold when the loop is disconnected from the charged portion of the network. The conditions for localising faults during working are different, and they will be discussed later.

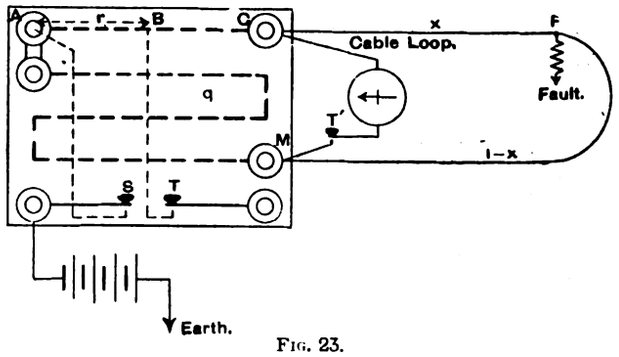


FIG. 23.

Contact resistances must be made as small as possible, and care must be taken to have them in the right place. Most of the errors, in localising faults by loop methods, are due to the resistance of the connections being disproportionately high. All cable ends must be sweated; or else the end must be untwisted, each individual strand well scraped, and the end twisted up again. When it is possible to connect the cable directly to the bridge it should always be done. Suppose the connection is so made, one end of the cable loop being con-

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nected to the terminal C of the stretched-wire or resistance coils. Usually the resistance of the cable arm is smaller than the resistance of the adjacent arm. If so, the galvanometer must be connected as in Fig. 22, so that the contact resistance is not added to the cable arm of the bridge. In such a case, when a Post Office pattern bridge is used for Murray's method, it is well not to use the key on the instrument, but to have an independant galvanometer circuit. For instance, Fig. 18B would be altered to Fig. 23. On the other hand, when the loop is a long one, and of a small-sized cable or wire, and a stretched-wire bridge is employed, the stretched wire may have a lower resistance than the cable loop. In this case the galvanometer must be connected direct to the terminal of the stretched wire, so that the contact resistance is in the cable arm.

When leads are used between the cable loops and the bridge the contacts between the leads and the cable ends must be as good as it is possible to make them. A soldered contact is an excellent one.

*(To be continued.)*

ERRATA.—On page 314, column 2, near the top, for $\frac{l'}{L-m-cm}$ read $\frac{l'}{L-m-c}m$. Also, on page 315, column 2, line 6 from top, for Fig. 17B. read Fig. 18B.

## ON HYPERPHOSPHORESCENCE.*

BY SILVANUS P. THOMPSON, D.Sc., F.R.S.

The recent researches of H. Becquerel † on the emission by compounds of uranium and by metallic uranium of invisible radiations which very closely resemble those discovered by Wiedemann ‡ and by Röntgen,§ and which yet unquestionably consist of transverse vibrations, are of so great importance that any experiments upon the same line, however incomplete, are of interest to physicists.

In January last the writer and his assistant, Mr. Miles Walker, were repeating Röntgen's now familiar experiments on the production of photographic shadows by the emanations from Crookes's tubes, and were casting about for means to shorten the long exposures then necessary, when the idea occurred to them which has independently suggested itself to many other experimenters—namely, that of employing fluorescent substances in contact with the photographic film to hasten the photographic action by the emission of rays of a visible sort when stimulated by the X-rays. Accordingly, having prepared sheets of paper or of aluminium covered with fluorescent material, they tried the effect of inserting them in some cases below the glass plate, in other cases above the glass plate with the fluorescent surface next the film, and in yet other cases above the plate, but with the fluorescent surface outside. The materials so tried were sulphide of calcium, finely-powdered fluor-spar, sulphide of zinc (natural blende), sulphide of zinc (artificial), fluoride of uranium and ammonium, and sundry platino-cyanides.

When sheets of paper or aluminium covered with these were placed face down upon the sensitive film, so that the X-rays were compelled to pass first through them, some results were obtained tending to show that the method might have some advantages; but the resulting negatives were always patchy and irregular. The most striking effect, however, was quite unexpected. Care had been taken to keep these prepared sheets of fluorescent material in the dark for a sufficiently long time for all visible phosphorescence or persistent fluorescence to disappear. This, in the case of the sulphide of calcium, required many hours. The powdered fluor was also heated beforehand. Nevertheless, though no visible phosphorescence was present, the sensitive films were fogged by rays emitted from these materials. Fluor-spar and the platino-cyanides did not produce any noticeable fogging, however. Even after being kept six weeks in darkness the sulphide of calcium is very active in the emission of rays that will affect a photographic plate.

While these experiments were in progress other experiments were begun, to ascertain if from any other sources, such as sunlight or the light of the arc lamp, any rays could be obtained having, like the X-rays, the power of penetrating opaque bodies. From the arc lamp, with an exposure of about two hours, shadows of pieces of metal were obtained on a photographic plate through a piece of pine-wood several millimetres thick; but aluminium was found to be totally opaque to everything radiated from the arc and to sunlight.

While the experiments on fogging were still in hand there was published the observation of M. Henry on the effect of sulphide of zinc in apparently augmenting the transparency of aluminium to X-rays—an observation which had an obvious bearing on that which was under investigation. A number of small portions of the fluorescent substances with which we were experimenting were then placed upon the front of a sheet of aluminium about 0·5mm. thick, behind which was a gelatino-bromide plate (a Cadett's "lightning" plate); and these were left for several days upon the sill of a window facing south to receive so much sunlight (several hours, as it happened) as penetrates in February into a back street in the heart of London. On developing the plate it was found that behind those spots where portions of uranium nitrate and uranium ammonium fluoride had been placed, photographic action had taken place through the aluminium sheet. No very distinct effect had been produced by the other substances. On communicating these observations to Sir G. G. Stokes he drew the writer's attention to the similar observations of M. Becquerel with respect to uranium salts, observations which have since been so remarkably extended. While agreeing with the Röntgen rays in the property of penetrating aluminium, zinc, and other opaque materials, and in exercising photographic actions, the Becquerel rays differ in the circumstance that they can be refracted and polarised. Whatever the Röntgen rays may eventually prove to be, the Becquerel rays consist of transverse waves of an exceedingly high ultra-violet order.

The circumstance that the strongest fluorescent effects are found in the compounds of two metals having such heavy atomic weights as platinum and uranium, when correlated with the other circumstance that the absorbing power towards X-rays is greatest in elements of the greatest atomic weights, naturally suggests a new application of the law of reciprocity between emission and absorption. If that law can hold good in the phenomena of the Röntgen rays, or of the closely-related Becquerel rays, one would argue that the best substances to employ as emitters of such radiations would be those substances which absorb them most freely. Now the property of emitting Röntgen rays has been observed in many substances, but always under the stimulation of the cathodic discharge. In Röntgen's original research glass was the radiator. Porter and Jackson independently found platinum foil to be superior. Roiti has found porcelain and mica also to serve. The writer has observed Röntgen rays to be emitted from the following substances exposed to cathode discharges:—calc-spar, apatite, rubies, sapphires, diamonds, uranium glass, scheelite, tourmaline, a phosphorescent enamel containing 60 per cent. of sulphide of calcium, sulphide of zinc (hexagonal blende), zinc, aluminium, copper, iron, magnesium and platinum. Of the metals in the above list, iron and platinum appeared to work better than copper, aluminium, or magnesium. The low melting-points of the last two render them unsuitable. Metallic uranium would have been tried had it been possible* to obtain a specimen; but all inquiries in London proved fruitless. Of the other substances named, the phosphorescent materials seemed to have some advantages over ordinary glass, but they are not so convenient to manage as the metals. Apatite was tried because, consisting as it does chiefly of phosphate of lime, it was thought that the X-ray emitted from its surface could be more certainly absorbed by bone than are the X-rays emitted from denser materials, such as platinum.

At an early stage of these investigations the use of a fluorescent screen revealed the fact that the relative transparency of flesh and bone differed with different materials used as emitters, and depended also upon the degree of exhaustion. The necessary inference that the X-rays are not all of one kind, but are heterogeneous, was announced by the writer about the same time† that the same conclusion was drawn by MM. Benoit‡ and Hurmuzescu from other causes. To the rays emitted from apatite, bone was indeed found to be more opaque than to those emitted from platinum. But apatite, when subjected to the cathode discharge, continues to give out gases which after a very few seconds spoil the vacuum; and the tube containing apatite as an anti-cathode could not, consequently, be used except attached to the pump. Glass was found to be more transparent to X-rays emitted from platinum than to X-rays emitted in the same tube from glass.

The extraordinary property exhibited by the uranium compounds of emitting a persistent invisible radiation that will pass through aluminium and produce photographic action would suggest that these rays are identical with Röntgen's, were it not that Becquerel's success in reflecting, refracting, and polarising them proves that they are more akin to ultra-violet light. The latter does not indeed penetrate aluminium, but it has long been known that ultra-violet rays penetrate films of silver, which, though thin, are thick enough to reflect all visible kinds of light. It would seem to be proved, then, that Becquerel's rays differ from the known

* From the *Philosophical Magazine*.

† *Comptes Rendus*, CXXII., pp. 559, 790, &c.

‡ *Zeitschrift für Elektrochemie*, II.; p. 159 (August, 1895).

§ *Sitzungsberichte der Würzburger Physik-medic Gesellschaft*, 1895.

* [While these lines have been going through the press, a specimen of metallic uranium has been given me by Mr. C. Vautin. It emits X-rays freely under the cathode discharge.—S. P. T.]

† *Comptes Rendus*, CXXII., p. 807. ‡ *Ibid.*, CXXII., p. 779.



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ultra-violet in degree rather than in kind, being rays of higher frequency and shorter wave-length. That their properties are intermediate between those of ultra-violet and of the Röntgen rays furnishes a strong presumption that the latter also differ only in degree, and are an extreme species of ultra-violet light. It should not be forgotten that so far back as 1857 M. Niépce de Saint Victor observed many cases in which an object, an engraving on paper or a figured piece of porcelain or marble, immediately after exposure to sunlight, was found capable of giving a photographic impression to a sheet of paper prepared with chloride of silver, with which it was placed in contact. He even used, after exposure to light, cardboard imbibed with salts of uranium or with tartaric acid, and found such to be capable of emitting rays that were photographically active. There was no attempt made, however, to investigate the possibility of transmitting these invisible radiations through opaque bodies.

The phenomenon of persistent emission of these invisible rays by the uranium compounds long after any electrical or luminous stimulus has ceased to be applied would seem, therefore, to bear the same relation to the transient emission of them in the Crookes tube as the persistent emission of visible light by phosphorescent bodies does to the transient emission of light by fluorescent bodies. Hence the writer ventures to give to the new phenomenon thus independently observed by M. Becquerel and by himself the name of *hyperphosphorescence*. A hyper-phosphorescent body is one which, after due stimulus, exhibits a persistent emission of invisible rays not included in the hitherto recognised spectrum.

## THE DUODECIMAL SYSTEM.*

When the opponent of the metric system has exhausted all his arguments in support of the plea that an intolerable inconvenience would attend a change from our present weights and measures, he usually shifts his ground and asserts that what we really need, if any alteration be made, is the duodecimal system. Undoubtedly he is right in preferring 12 to 10 as a basis of numeration, but the suggestion comes very lamely from a person who has been magnifying the difficulties attending the introduction of new methods of measurement. The trouble that would be caused by the introduction of the metric standard is a mere bagatelle compared with that which would follow the adoption of a different basis of arithmetical computation from that which has been in vogue since—and, indeed, before—the dawn of history. Some of our correspondents have lately sent us (see pages 451 and 550 of our last volume) multiplication tables having 8 or 12 as their foundation, but we do not think that they realise how insufficient their attempts are to meet the requirements of the case. Dealing with the latter case, which is the one we are now considering, it is evidently insufficient to introduce two new numerals, ⊔ and 1 Z, and to retain all the old ones, since the value of these latter would be altered. From 1 to 9 they would suffer no change of significance, but immediately that limit was passed confusion would reign supreme. For instance, while 8 would have the same value as now, 18 would represent 20 of the present notation, that is, $12+8$. Again, 28 would represent $2\times12+8=32$, 38 would equal $3\times12+8=44$, and so on. Higher numbers would exhibit still greater divergence from the old meaning. The figure 118 would signify $1\times144+1\times12+8=164$, 1188 would be $1\times1,728+1\times144+8\times12+8=1976$. Still worse examples can be found. Such a quantity as 0⊔0⊔ would mean $10\times1728+11\times144+10\times12+11$.

In a country that had no records the introduction of such a system would be quite easy. But we are the heirs of the ages, and have a vast patrimony of knowledge that would become depreciated by the change. We should be like the unwary tourist who pays a trifling bill in a Mediterranean port by putting down a napoleon and in return receives a handful of silver. The first time he tries to pass a piece he is met by the remark that that particular coinage does not pass. Examination then shows him that specimens of every neighbouring currency have been palmed on to him, and he finds that the money-changer deducts a penny off the face value of each before he will replace it with current coin. It must be remembered that quantities expressed in decimal notation cannot be converted into their duodecimal equivalents by any process of subtracting a percentage. Except in simple cases, the conversion cannot be carried on mentally, but must be done on paper by means of repeated divisions by 12. All the numerical results of scientific research would require to be altered with the new notation, and the elaborate tables of calculated results which are possessed by engineers and others would become almost valueless, and often it would be as easy to recalculate any particular example as to reconvert it. No doubt there are plenty of industrious computers, and also numberless enterprising publishers who would hurry to lighten our difficulties, but it must be remembered that first editions of books of figures always contain errors that may lead to most costly mistakes. Who would like to risk the stability of a bridge on the accuracy of a new book of logarithms got out to the base 12? It is only after years of use and numerous editions that full confidence can be placed on such a publication.

Engineers, however, take readily to changes when they see the necessity of them. Their career is a prolonged attack on new problems, and as a rule they welcome novel weapons of attack, provided they are more effective than the old ones. It is the general community that needs to be considered in the present case. If the duodecimal system were introduced, we should have our familiar numerals bearing their old significance when they stood in the position of units, and a new significance when they were in any other position. The figure 6, for instance, would be the friend of our youth, but 60 would be an utter stranger, assuming the name and carrying the face and habiliments of a former acquaintance. If this latter were dead and buried, the embarrassment would be great enough, but the first time we took up a book we should meet him, and then the question would arise as to which Dromio was confronting us, the elder or the younger. We are told that metrical measures are beyond the comprehension of the masses, but at any rate they have an individuality of their own which prevents them from being confounded with any others. No one reading that a piece of land is 100 metres long can make the mistake of imagining it to be 100 yards. The man who is invited to partake of half a litre of beer will not expect half a pint. The applewoman who was metaphorically flung at the heads of a deputation from the Decimal Association would not expect 20 kilogrammes to be the equivalent of 20lb. The very names are so many danger signals to put people on the alert, and it needs only the slenderest arithmetical knowledge to convert metrical into English measures with sufficient accuracy for the practical affairs of life. The dressmaker would easily comprehend that 10 metres of silk went as far as 11 yards used to do. The working man whose standard of temperance was seven half-pints in the evening would find himself just as "forrad" at closing time on four half-litres, and with less difficulty in keeping count. Even the itinerant female who vends sour fruit to little boys would soon learn that a kilogramme would retail as nine quarter-pounds without any loss to herself. But we very much question whether a senior wrangler could be relied upon to put down a sovereign for an article priced at 18s. As for ordinary folks, even a surgical operation could not put into their heads that a shilling and sixpence were sixteenpence. In years gone by it was averred that the head waiter at Evans's used to say "Sixteenpence, one-and-sixpence," and "Eighteenpence, one-and-eightpence;" but it was only late at night, or rather early in the morning, that he adopted the duodecimal system, and even then he uttered his figures at such a speed that none but a "lightning calculator" could follow him. A customer who could see two Paddy Greens was not likely to have a clear perception of the difference between 10 and 12.

The only possible method by which the duodecimal system could be introduced into daily use would be the use of an entirely new set of numerals. Let us suppose that the first 12 letters of the Greek alphabet were chosen. The next thing would be for us all to learn a new multiplication table. For instance, instead of saying "five ones are five, five twos are ten," and so on, we should say, "$\epsilon$ times $\alpha$ are $\epsilon$, $\epsilon$ times $\beta$ are $\kappa$, $\epsilon$ times $\gamma$ are $\alpha\gamma$, $\epsilon$ times $\epsilon$ are $\alpha\theta$," and so on. We should then be entirely saved from mistaking the new for the old notation, but at what a cost! The greater part of the adult population never would learn the new notation. They would remain hopelessly at sea, and not all the powers of the strongest Government Europe has ever seen could compel them to abandon their old methods of computation. The children might be taught the amended numeration, but most men and women, even those of a high order of intelligence, would find the effort too great to make. Even the interest in cricket would wane if the evening papers announced that Grace had made $\alpha\lambda\theta$ runs, and were not allowed to give the equivalent decimal figure of 251.

The duodecimal system lands us on either horn of a dilemma. We must either use the old figures, and two additional ones, with a significance which is sometimes a new one and sometimes the old one, or we must have a completely new set. Each plan leads to intolerable results. The former would produce endless mistakes and confusion, which would endure for all time. Something might, no doubt, be done to reduce the trouble by the introduction of entirely new founts of type, which showed at a glance that they belonged to the fresh order of things. But the system could not be applied to spoken numbers. If a Chancellor of the Exchequer introducing his Budget set a good example by using the new notation, his hearers would be quite unable to make a mental comparison with the receipts or expenditure of 10 years ago, for they would not have the time to effect the necessary conversion as the speech proceeded. The only possible measure of palliation would be to give all figures twice over, in old and new style, as dates are written in Russia, which means we should have to undergo 50 years' labour before we

* From *Engineering*.

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reaped any advantage of the duodecimal system. The second plan of adopting a new set of figures avoids one source of confusion and introduces another quite as bad. We have all an acquired perception of the value of a numerical quantity from the look of it. Just as we read words without spelling the letters, so, in a minor degree, we take in written quantities at a glance. But with the new notation we should return to the ways of our childhood, and have to patiently spell our way through every quantity we met with. Those of us who are no longer in our youth would have the added disadvantage that our brains are not now in that plastic stage when they easily retain any form impressed upon them, without much conscious effort. Books dealing with figures would become a labour, only to be tackled when the necessity was urgent. The reading of them would be comparable to perusing a work in a foreign language which is not really familiar to us. Very soon the fatigue of giving complete attention to each word as it comes, then mentally finding its English equivalent, and finally seeking the general meaning of the sentence, masters the power of concentration, and the eyes wander over the lines without the mind seizing the meaning.

If the metric system has to await the advent of duodecimal notation in this country, it will never arrive here. The two things have no relation to one another. It cannot be too often insisted that the merit of the metric system is that measures of length, weight, and capacity have a common origin, and are capable of direct comparison. This advantage persists whether the decimal or the duodecimal system be used, and is sufficient to counterbalance many inconveniences. Whatever may be the faults of the decimal system, we contrive to use it for all our important affairs. We reckon our incomes in tens and hundreds of pounds, and it is only in dealing with shillings and pence that we employ other bases of notation. What is good enough for the large sums cannot be so very dangerous for the small ones.

# PARLIAMENTARY INTELLIGENCE.

## THE KIDDERMINSTER AND STOURPORT ELECTRIC TRAMWAY BILL.

This Bill, which has already passed the House of Commons, came before a Select Committee of the House of Lords, presided over by the Duke of Westminster, on Tuesday last :—

Mr. LEWIS COWARD, in opening the case for the promoters, explained that the object of the Bill was to incorporate a company to construct a tramway from Kidderminster to Stourport, a distance of nearly four miles, to be worked by animal or mechanical power. At present communication between Kidderminster and Stourport was by means of the Great Western Railway or by omnibus or car. The railway route was eight miles in length, it took an hour to cover it, and involved a change of carriages. The local authorities were consenting parties to the present Bill, which was a great circumstance in its favour. Turning to the petition of the Great Western Railway Company, who were the only opponents to the Bill, he read the clauses describing the proposed works of the promoters and the railway undertakings of the railway company. Clause 5 of the petition said: "The crossing of your petitioners' Severn Valley Railway on the level is not only most objectionable but may seriously interfere with the safe and efficient working of that railway, and more so if the intended tramway (No. 1) is to be worked by electric power. Level crossings of railways by tramways are at all times attended with a certain amount of risk, and your petitioners submit that there is nothing to justify the proposed crossing of your petitioners' railway on the level, as now proposed." They said the result of the level crossing might be that the Board of Trade would require the railway company to carry the road under or over the level crossing, and they submitted that if any change of this kind was made the expense should be borne by the promoters. He (the learned counsel) described this claim of the railway company as preposterous, declaring that the scheme of the petitioners was a very ordinary one with the powers it sought, and pointing to innumerable Parliamentary measures—some of them passed during the present Session—in which power to cross railways on a level crossing had been given to tramway companies. In Clause 12 of the petitioners' was the following: "Your petitioners submit that it is evident from the clauses of the Bill that it is the intention of the Company to work their tramways by electrical power." Clause 13 set forth, "If the tramways are worked by electric power, unless such power is entirely contained in and carried along with the carriages, the block signalling of your petitioners and their telegraph system may, from the crossing of your petitioners' railway on the level and the proximity of tramways to their railways, be seriously affected and deranged, to the loss and injury of your petitioners and to the public using their railways, and an element of danger introduced which may be attended with most grave consequences." Clause 14 set forth, "Even with the adoption and careful observation of all possible safeguards against the incursion upon railway wires of the heavy traction currents, the degree of safety which at present attaches to the working of the block signals cannot be maintained unless the regulations under which electric traction is to be conducted, and unless the construction of the work is such as to render impossible the incursion of these traction currents into neighbouring wires; and your petitioners submit that the user of electric power, unless such power is entirely contained in and carried along with the carriages, should not be sanctioned; but should the House think otherwise, clauses and amendments should be inserted in the Bill for the protection of your petitioners, their block signalling and their telegraph system, in addition to the clauses required for the protection of your petitioners' bridges and the alteration of the level crossing." These clauses, the learned counsel contended, contained an unheard of proposition, and the answer was contained in clauses from 63 to 72 of the Bill, these being the model clauses settled by the Joint Committee of their Lordships' House and the House of Commons, before whom every interested person, save the Postmaster-General, was represented, including the railway companies, the gas companies and the electric lighting companies. Every interest took part in the discussion, and in the result these clauses were decided on as proper to be put in Bills of this kind. The Joint Committee had reported that they should not insist on the return conductor in the case of an electric tramway being insulated, as it would retard the progress of electric traction. They also said that any difficulty in the case of railway signals could be overcome at little expense by the adoption of an insulated metallic return by the railway companies. The petitioners further said, in clause 15 of their petition: "By clause 27 of the Bill it is provided that the Company shall pay the costs of such additions to or alterations in the metallic circuits of the Great Western Railway Company as the Board of Trade may consider necessary to prevent interference with the signals and apparatus of the railway company by reason of the tramways crossing the bridges and level crossing belonging to the railway company." In reply to this the learned counsel said the promoters had offered to be responsible for this expense.

Mr. E. PARRY, of the Urban District Council of Kidderminster, and Mr. COMBER, another local witness, gave evidence to show that the introduction of the tramway would be welcomed by all the local authorities and inhabitants of the districts it would touch.

Mr. J. L. OWEN, engineer to the promoters, gave evidence as to the character of the works proposed by the promoters. He stated that the line would be well laid out, and that the electric current would be taken along overhead wires, contact with the cars being secured by means of a trolley on a pole. The line could not be worked at a profit if the proposals of the petitioners that the cars should carry the motive power within them were adopted.

Mr. STEPHEN SELLON gave evidence in support of the Bill. He thought that clause 27, which Mr. Coward had declared that the Company would accept, a most extraordinary one to insert in a Bill of this kind. The expense of constructing the metallic circuits should be borne by the railway company.

Some discussion took place as to the admissibility of this evidence.

Mr. POLLOCK, for the petitioners, said the promoters had conceded their liability to defray the cost of the metallic circuits.

Mr. COWARD said he had gone too far in saying that the promoters would defray the cost. The promoters had offered a clause to that effect in the House of Commons, but the petitioners had refused to accept it. He now felt justified in withdrawing the offer.

The Committee cleared the room whilst they remained for some time in private deliberation.

On the readmission of the public,

The CHAIRMAN said the Committee were favourably inclined towards the Bill, but he thought that Clause 27 should remain part of it.

The case for the Great Western Railway Company was then opened.

Mr. THOS HOWELL ROBERTS, traffic manager of the Great Western Railway, spoke as to the danger which would arise of collision between railway trains and tram cars on the level crossing near Stourport. Should a bridge be required the tramway company should contribute towards the cost.

Major-Gen. HUTCHINSON, late of the Board of Trade, who had held an inquiry at Stourport with regard to the level crossing, declared that though the crossing was not considered dangerous now, it might become so if it were used by electric cars. He thought that if a bridge were necessary and the railway company offered to contribute half the cost, that would be a very generous offer.

Mr. INGLIS, C.E., estimated that the cost of the proposed bridge would be about £2,500, and it would be fair for the railway company and the tramway company each to pay half.

Mr. POLLOCK then addressed the Committee for the Great Western Railway Company. He declared that all his clients desired was to secure the safety of the public, and for this purpose they wished to have a bridge constructed over the present level crossing, the promoters and the railway company to contribute equally to the cost. If necessary the railway company would make the Board of Trade arbiters as to the proportionate amounts to be paid by the parties.

Mr. COWARD replied for the promoters.

In the result the Committee found the preamble of the Bill proved, and declared that in the event of a bridge being built over the level crossing the proportion of the cost to be paid by the tramway company should be decided by the Board of Trade.

**The Metric System.**—Sir S. Northcote asked the President of the Board of Trade this week if he would introduce this Session a Bill to deal with the metric system, in order that Chambers of Commerce and other parties interested might have sufficient time during the recess to consider the proposals of Her Majesty's Government on this subject. Mr. Ritchie replied that he would be glad to introduce the Bill, but without any intention of proceeding with it this Session.



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# CORRESPONDENCE.

## THE DISSIPATION OF ENERGY CAUSED BY THE ARMATURE CURRENTS IN ELECTRICAL MACHINERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It appears to me, with all deference to Herr Otto T. Bláthy, that he has not made a very happy interpretation of the elaborate series of experiments which he has been privileged to make. He starts by making an assumption with reference to the practice of dynamo designers which I do not think is warranted. For example, if he will refer to "Dynamo Electric Machinery," fourth edition, pages 792 and 793, he will find two diagrams dealing with the increase of total losses in dynamos and motors with increase of current and speed. These show conclusively, I think, that after allowing for the copper and mechanical losses, the waste power in an armature varies with the hysteresis and eddy currents in definite proportion to the speed and current. Hysteresis varies directly with the speed and with the 1·6 power of the magnetic induction, while eddy currents vary with the squares of these two quantities. These facts are expressed concisely in Steinmetz's well-known law:—Watts $= a \backsim B^{1\cdot6} + b \backsim {}^2B^2$.

I agree with Herr Bláthy that the quantity called by him the "load loss" depends chiefly on the ampere turns carried by the armature and on the speed. Indeed, this may be inferred from an inspection of the formula. He is also correct in supposing that the "load loss" varies as between the first and second powers of the speed; and that the load loss is chiefly spent in the iron core as it is obviously mainly due to the effects of hysteresis and eddy currents therein.

The point of special interest to designers is the relative values of the "load loss" for different types. Few have the chance of experimenting with different types of armatures in machines so large as 110 H.P.; and Herr Bláthy will be conferring much benefit on the profession if he will place on record his figures. For one I am surprised to find that for a given E.M.F. per single turn (presumably per effective conductor) the "load-loss" is independent of the type of winding. I should expect to find some difference more or less marked between the two great classes of ring and drum windings, although the series and parallel arrangements of each would produce no marked difference.

It would also be most interesting to have some particulars of the 30 H.P. experimental alternator, "whose design was outside the limits of commercial machinery," and gave a "load-loss" amounting to 14 per cent. of the total capacity of the machine.

It is obvious, too, that some reference should be made to the position of the brushes and to sparking, if any, in giving figures from tests.

Hoping Herr Bláthy will see his way to oblige his fellow designers, I am—Yours, &c., ALBION T. SNELL.

Suffolk House, London, July 21, 1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The article which appeared in your last week's issue under the above title, by Mr. Otto T. Bláthy, commences with the statement that it is generally assumed that the total loss in a dynamo under load is pretty closely represented by the power required to run the armature light in its magnetic field *plus* the $C^2R$ loss in armature at full load. I think that the fact is that it has been long since generally discovered by those who have had efficiency tests to carry out, that the losses are considerably greater than is represented by the two factors referred to.

There is an air of mystery imported into the article to which one feels very reluctant to subscribe; and while it is no doubt a matter of extreme difficulty or even impossibility to locate all the losses that occur in a machine running under load, there seems little need for such mystery.

The chief losses not taken into account in the formulæ written by Mr. Bláthy, $L_i = L_0 + R I^2$, I should enumerate as follow:—

1. Increase in maximum magnetisation of iron of armature which occurs under the trailing pole tips in the case of a generator due to "cross induction," causing largely increased hysteresis and eddy losses as compared with light load.

2. Uneven distribution of current density in armature conductors passing under trailing pole tip and also in those passing through the region of commutation due to rapidly fluctuating field of varying density, causing increase in effective resistance of said conductors.

3. Eddy currents in end plates of core and adjacent discs due to field produced by end connections of armature winding.

4. Eddies generated in magnets.

5. $C^2R$ losses at contact surfaces between brushes and commutator.

All of the foregoing except No. 3 seem to be put out of court or to be relegated to the negligibles by the summary of results of experiments given in Mr. Bláthy's article; and when it is considered that the end plates and core discs are not laminated in the direction to avoid eddies due to the field generated by end connections, it is evident that this may be a fairly large source of loss. Of course, the amount of it will depend upon the arrangement of the connections and their distance from end plates and other parts which may make up the magnetic circuit, such, for instance, as the shaft.

In the case of the experimental alternator referred to by Mr. Bláthy, I would suggest that a study of the machine from the point of view suggested by No. 3 might throw light on the matter, *i.e.*, with a view to determining to what extent portions of the core or supports are subjected to alternating flux generated by the armature conductors in a direction divergent from the plane of lamination.—Yours, &c.,

Glasgow, July, 1896. W. B. SAYERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The communication of Herr Otto Bláthy on the subject of the dissipation of energy in armatures whets the curiosity, but cannot satisfy it without a further statement of what proportion $R I^2$ bears to $L_0$ in the various machines experimented upon. An increase of the stray watts at full load has always been recognised as due to the increased hysteresis and eddy-currents where the magnetic lines are crowded towards the trailing pole-tips; and this increase may probably amount to 25 per cent. of the same losses at no load. In large machines $R I^2$ may bear but a small proportion to $L_0$, and, therefore, an increase in the most important items of $L_0$ may raise $c$ to considerably more than unity. Such an explanation tallies with the fact that $(c-1) R I^2$ was independent of the nature of the winding, provided the active inductors were similar; and further with the fact that the "load-loss" increased more rapidly than the speed, but less than the square of it (due to part being a loss by hysteresis). But even so, the increase of $c$ from 1 to 2·6 appears abnormal unless the proportion of $R I^2$ to $L_0$ is abnormally low. It is to be hoped that a further communication will give the readers of *The Electrician* more information on this important point.—Yours, &c., C. C. HAWKINS.

Bedford, July 21, 1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with much interest Mr. Bláthy's article dealing with the above subject in your issue of the 17th inst., also your comments thereon. Unfortunately, the existence of the "load loss" cannot be doubted; and though it may be difficult to assign to each part of the machine the exact share for which it is responsible, I think it is pretty clear that the bulk of the loss is due to parasitic currents generated in the armature conductors, in the armature attachments, and in the field magnets. Your suggestion that the short-circuiting of coils by the brushes may explain the phenomenon does not help us, for the simple reason that it is in machines without brushes, namely, alternators, that the loss is greatest. However, it is satisfactory to know that the coefficient $c$ can be reduced to its proper value of 1 by careful study of each detail of construction and by a thorough overhaul of design. I have known it to be brought down to *unity* from the high figure of 7·6. That $c$ is extremely small in the Ganz machine is precisely what, from knowledge of other alternators, I should have predicted, though other of Mr. Bláthy's results are not easily understood. —Yours, &c., W. B. ESSON.

London, 22nd July, 1896.

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## NEGATIVE ACCURACY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Nothing, I fear, save reverence due to so grave and learned a seigneur, would restrain the irresistible tendency to poke fun at Prof. FitzGerald which his delightful letter on page 386 provokes.

Beginning with a dictum worthy, in its sententious wrongness, of the Pilgrim's Scrip, he ends with the very conclusion which I have myself urged, namely, that the use of the term "negative resistance" is to be deprecated by the physicist. True, we arrive at that conclusion by different routes—I by considering the result of applying logical processes of thought to accurate and established definitions; he, by finding that, after advocating convenience and clearness of definition as advantageous, he is landed in a thermo-dynamic quagmire from which he must extricate himself *per saltum*.

Let me deal with Prof. FitzGerald's points in order, taking first his plea for mere convenience of definition. "Convenience and clearness," rather than knowledge, already firmly established, are to decide our definitions in those cases "when the actual dynamics of a phenomenon is unknown." How very misleading such a dictum is, to be sure! The arc being a phenomenon, the dynamics of which is—or, as I should prefer to say, are—unknown, *therefore* we ought not to use such terms as electromotive force or current in their accepted definitions, but should use them to mean anything else we find them handy for, if it seems to give clearness. Well, so be it: and then when we come to some other phenomenon—say, Keely's motor—of which the dynamics is or are unknown, let us abandon Newton's definition of "force," and use that word in some more convenient sense, for instance, to mean kinetic energy, or momentum, as the Keelyites do when they wish to make things clear. Perhaps that, too, would land us in a quagmire.

No, my good FitzGerald, you can't make a vector quantity into a scalar by calling it by another more convenient name, and "adjuvant Thomson effects" are *not* "negative resistances," nor ever can be until the difference between vectors and scalars is abolished—which you can't do by merely stretching a definition.

And what does this mean? "If one were to try and describe it" [*i.e.*, the "very far-fetched quantity" which Messrs. Frith and Rodgers have described as "negative resistance"] "accurately, it would require an even more elaborate description than that of an alternating voltage." Indeed, I fear, it would. But, for accuracy's sake, it might be well to remember that voltage is a vector quantity, while Messrs. Frith and Rodgers's "very far-fetched" item is $d\,V/d\,A$; and being the ratio of one vector quantity to another cannot be a vector quantity itself, but must be a scalar. How convenient, then, how clear, to call it what it is obviously not! Perhaps we shall next hear of the discovery of an alternating resistance. It will, when discovered, have the effect of yielding an alternating current, when a continuous electromotive force (such as that of a battery) is applied to it.

Further, talking of accuracy, it is not I, though Prof. FitzGerald puts it into my mouth, who have said that "a distributed adjuvant electromotive force is indistinguishable from a negative resistance." One is a vector, the other a scalar. The sentence, however convenient or clear it may be, needs two corrections to make it accurate. What I have said is that it is indistinguishable *by ordinary electric tests* from a negative resistance *if that negative resistance is one that varies inversely as the current*. But I certainly showed that there might be other criteria.

And is it quite accurate to put aside as paradoxes the logical issues which I stated, on the ground, forsooth, that I assumed that a negative resistance could exist alone? On the contrary, I expressly considered other cases, in which a negative resistance was put in series or in parallel with real resistances. No doubt, to ignore that too is convenient, and lends additional clearness to the argument in favour of "negative resistance."

But before we go any further afield in discussing this complication, would it not be better to have before us an authoritative description of the actual experiments that have led to these paradoxical results? Having read Messrs. Frith and Rodgers's Paper, and seen their experiments, I feel it to be rather indelicate to discuss them with Prof. FitzGerald, who has not had that advantage; for I shall be greatly surprised if, in twelve months' time, Prof. FitzGerald does not see more clearly than any of us the inherent fallacy of the method that has led to this result.—Yours, &c., SILVANUS P. THOMPSON.

## AN INTERNATIONAL (?) CONGRESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Noticing some paragraphs in the technical press announcing how certain American electricians of high standing were coming over as delegates to an International Electrical Congress, to be held at Geneva in August next, it occurred to me to inquire what questions were to be discussed at this Congress, and who were the British delegates. As a member of the Electrical Standards Committee of the British Association I had heard nothing of any proposals, nor had I any recollection of any delegates being sent by the Institution of Electrical Engineers.

The replies to my queries only add to my bewilderment. Nothing has been heard of the proposed International Congress at the Foreign Office, at the Board of Trade, or at the General Post Office. Mr. Preece, who has attended every Electrical Congress hitherto, has heard nothing of this affair at Geneva, except what he has gathered from the recent press paragraphs, has had no invitation to attend, and is not going. No invitations to send delegates have been received by the Royal Society, by the British Association, by the Physical Society, or by the Institution of Electrical Engineers. Nothing is known of the proposal by any of these bodies, except the Institution of Electrical Engineers, the President of which in February last received from MM. Palaz and Cuénod, of Geneva, a circular, announcing that an Electrical Exhibition would be held in that city, and asking the "patronage" of the Institution for a Congress of Electricians to be held in August. The Council of the Institution on March 26th instructed the Secretary to reply that they had pleasure in granting this request to enrol the Institution as a patron. At the same time a corrected list of members of the Institution was forwarded to Geneva. Nothing more was heard until June 19th, when a circular, also signed by MM. Palaz and Cuénod, dated June 17th, and addressed to "*The Journal* of the Institution of Electrical Engineers, London," was received by Messrs. E. and F. N. Spon. In that circular the following paragraph occurs:—"Invitations to take part in the forthcoming Congress on August 4th are now being sent out, and, with the object of making it more generally known, we take the liberty of asking you to be kind enough to make this known in your next issue." But the invitations appear never to have been sent! So far as I am able to ascertain, not one single English electrician has yet been invited to attend, nor have any of the scientific societies received any subsequent communication.

It is now July 22nd; the "International Congress" is to meet on August 4th. Even if in the interim invitations should be received, it will be impossible for the societies to appoint delegates.

Any decisions of a Congress so composed can carry little weight internationally. Assuredly, England is justified in disclaiming beforehand all responsibility for the acts of a Congress gathered together in so informal a fashion. Yours, &c., SILVANUS P. THOMPSON.

## PROTECTION AGAINST HIGH-VOLTAGE SHOCKS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is really a distressing thing to learn from the papers of another fatality with the alternating current. I refer to the unfortunate case of John Jackson Chisholm, of the City of London Electric Light Works, who met with a fatal accident at the City Depôt on Thursday last. Is there nothing in the way of a safety device other than rubber gloves and a mat to stand upon?

With all the improvements in central-lighting station equipments there appears to be no advance in making an accident impossible since I was an assistant in an alternating-current supply station six years ago; therefore, if you will permit me, I should like to make a suggestion, which, if not practicable in

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itself, might draw some valuable comments from those far and away better acquainted with the subject than I am.

My object is to devise a safeguard for alternating-current employés. I propose a copper flexible, 5ft. long, with the ends soldered to a pair of bracelets. From the centre of this is teed another flexible, any desired length, with a plug connected to the end. The bracelets are fastened to the wrists, making a good metallic contact. The 5ft. flexible runs up the sleeves, and across the back, where the tee is attached; the flexible, which is teed from here, and has the plug upon the end, is pushed into a socket anywhere, and connected to earth—in reality, a human lightning conductor.

Would not some such device have saved this young man's life, notwithstanding the extra danger in summer of the hands and body being moist?—Yours, &c.,

ROBERT BOZON, Engineer-in-Charge.

New Scotland Yard, July 22nd.

## LEGAL INTELLIGENCE.

### Cruto Incandescent Lamp Agency, Limited, v. New and Mayne.

In the City of London Court, Mr. Commissioner Kerr heard this case. The plaintiff Company sought to recover £12 3s. for electrical goods supplied to the defendants.

Mr. BINGLEY, for the plaintiffs, said his clients received an order purporting to come from the defendants' Hull branch, and it was signed by their manager. The manager gave the plaintiffs considerable orders, and a telegram was received from them as well as several letters on their letter paper in reference to the goods under order. The plaintiffs supplied the goods and gave credit, as they supposed, to New and Mayne. When the plaintiffs applied for payment of their account, they were told by the defendants in London that they had disposed of their Hull branch 12 months before to their late manager, and that if he had gone on using their paper, &c., it was not their fault.

Mr. WHATELEY, defendants' counsel, said the defendants could not possibly be held liable for the acts of their manager after he had ceased to represent them, and after he had, in fact, taken over the business from them. They gave their manager three months' notice to terminate the agency, and when that period expired he took over the business. He then gave the plaintiffs the orders now sued upon, and in their names. They knew nothing of the matter.

Mr. BINGLEY argued that if the defendants knew that their manager was using their paper after he had taken the business over, and they allowed him to do so, then they would be responsible for his acts.

Mr. WHATELEY agreed that if they could be shown to have known it, they might be held liable. But that was just what they did not know.

Mr. WATERMAN, the assistant secretary in the plaintiff company's service, stated that it was on August 23rd that he received the orders in question from Mr. Fitzmaurice, whom he understood represented the defendants in Hull. He knew the defendants as electrical engineers, with a branch at Hull. No notice was sent to them by the defendants or any one else that they had parted with their business to their late manager, and they did not see any intimation to that effect in the *London Gazette*. He produced the "Electrical Trades Directory" for the present year to show that the defendants were still purporting to carry on the branch business at Hull.

Mr. WHATELEY said there was nothing to show that the defendants had authorised any notice to appear in the Directory, and which, of course, in any case, was not evidence.

Mr. Commissioner KERR said the plaintiffs could not get over the fact that the defendants themselves had never ordered the goods which were being sued for. That being the case, there must be judgment for the defendants, with costs.

### Lightfoot v. Benson and Smith.

At the Manchester Assizes, on Saturday last, before Mr. Commissioner Dugdale, Q.C., and a common jury, Messrs. Henry and Robert Lightfoot, electrical engineers, Cooper-street, Manchester, claimed damages from Messrs. Thomas Duckworth Benson and Robert Smith, proprietors of the Trevelyan Buildings, Corporation-street, Manchester, for breach of contract in regard to an electric lighting installation. The defendants counter-claimed for damages on the ground of the unsatisfactory character of the work. Mr. Bradbury, counsel for the plaintiffs, stated that in October last the defendants sent out a specification of electrical work to be done in the Trevelyan Buildings to the satisfaction of the architects, Messrs. Clegg and Sons. The plaintiffs sent in a tender to do the work for £255, and that was accepted on behalf of the defendants. In January last, while the work was in progress, the plaintiffs received a letter from Messrs. Clegg and Sons enclosing one from the defendant Smith, which stated that he had received a report from a Mr. Douglas, saying that the materials being used by the plaintiffs in the work were of an inferior quality, and that the installation ought to be removed from the premises. On January 22nd Mr. Douglas came to the plaintiffs, and after saying that the work ought never to have been allowed, asked for another specification. A revised estimate for £544 was submitted by the plaintiffs; but nothing came of this; and on February 11th they received a letter from Messrs. Clegg and Sons requesting them to remove their materials from the building, and expressing their willingness to pay for the work that had been done. A report was afterwards made by an electrical engineer on the work that had been done by the plaintiffs, from which it appeared that the work had been properly carried out. After some evidence had been given, by consent a verdict was entered for the plaintiffs for £70 and costs.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations**

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"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

TENDERS INVITED.—The Mile End Old Town Guardians invite tenders for the supply and erection of electrical plant, laying down electric mains and wiring their premises in Bancroft-road, London, E. Tenders to the Clerk, Mr. William Thacker, by noon of the 30th instant. Further particulars are given in our advertisement columns.

——— Tenders are required for the construction and erection of four electric cranes and accessories, and also for alterations to gantry of an existing crane, on the Town Quay, Southampton. Tenders to the Clerk, Harbour Board Offices, Southampton, by Aug. 10.

——— Tenders are invited for the electric lighting of the Hapton (Lancs.) township from September 1 to April 30, 1897.

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Tenders to the Clerk to the Parish Council, Padiham, Lancs., by August 3rd.

TENDERS INVITED.—The Halifax Guardians invite tenders for electric lighting works at their new infirmary at Skircoat. Tenders to the Clerk (Mr. A. T. Longbottom), Carlton-street, Halifax, by the 13th inst.

——— The Harlow Lighting Committee require tenders for the lighting of the district from September 1st next to April 30, 1897. Tenders must be sent to the Chairman of the Parish Council, High-street, Harlow, Essex, by August 3rd.

——— The Electricity Department of the Whitehaven Town Council invite tenders for the supply of electric light fittings, incandescent lamps, oil, &c., during the ensuing year. Tenders to the Town Clerk, Town Hall, Whitehaven, by 1 p.m. to morrow (Saturday).

——— The Municipal Authorities of Arevalo (Avila) invite tenders for the concession for the electric lighting of the town for 20 years. Tenders to El Secretario del Ayuntamiento de Arevalo, Avila, Spain.

APPOINTMENT.—Mr. G. H. C. Risch has, owing to ill-health, resigned his position as electrical engineer to the West Ham Town Council, and Mr. J. J. Steinitz has been chosen to fill the vacancy.

APPOINTMENTS VACANT.—The Governing Body of the Northampton Institute invite applications for the following positions:—Chief Assistant in the Department of Applied Physics (including electrical engineering), at a salary of £180 per annum; Head of the Department of Mechanical Engineering and Metal Trades, at £250 per annum; and Head of the Artistic Crafts Department, at a salary of £250 per annum. Applications must be sent in to Dr. R. Mullineux Walmsley, at the Institute, St. John Street-road, Clerkenwell, E.C., by Tuesday, the 28th inst. Some additional particulars are given in our advertisement columns.

——— The Plymouth Corporation invite applications for the post of draughtsman and assistant to the Borough Electrical Engineer. Salary £150 per annum, increasing by yearly increments of £10 to £200. Applications must be delivered at the office of the Town Clerk (Mr. J. H. Ellis), Municipal Buildings, Plymouth, by Thursday, the 30th inst. Additional particulars are given in our advertisement columns.

——— The Sunderland Corporation invite applications for the post of resident engineer at their electricity supply station. The engagement will be for four years certain, the salary being £300 for the first year, £350 for the second year, and £400 per annum for the third and fourth years. Further particulars appear in our advertisement columns, and applications must be sent to the Town Clerk (Mr. Fras. M. Bowey), Town Hall, Sunderland, by Tuesday, the 4th prox.

——— The Council of the Durham College of Science, Newcastle-upon-Tyne, invite applications for the post of Assistant Lecturer and Demonstrator in Physics. Stipend £120 per annum. Some further particulars will be found in our advertisement columns, where it will be seen that applications must be sent in by August 29th.

——— The Cape Town and Suburban Electric Lighting Company (Limited) require an Electrical Engineer to manage the electric lighting works of the Company, and to carry out any new constructive works which may be required. Commencing salary, £300. Applications to Messrs. Davis and Soper, 54, St. Mary Axe, E.C., by 31st inst.

——— The Rochdale Corporation require a foreman at the sewage works, part of whose duty will be to look after the electric light plant at the works. Salary £2. 5s. per week. Applications to the Borough Surveyor, Town Hall, Rochdale, by the 28th inst.

PERSONAL.—Mr. C. H. Gadsby, having completed the equipment and putting into service of the Madras electric tramways, on behalf of the trustees for the debenture holders and the Electric Construction Company, has returned to England and has joined the staff of the British Electric Traction (Pioneer) Company.

FRENCH INCANDESCENT LAMP CONTRACT.—The French Admiralty have entered into a contract with Messrs. Gabriel and Angenault for three years for the supply of their make of incandescent lamps to the Department. We learn that this contract is given at a higher price than formerly paid by the French Admiralty for incandescent lamps.

SWITCHBOARD LABELS, &C.—Messrs. Hughes and Co. forward samples of ivory and ivorine switchboard labels, name plates, &c., made in ivory, ivorine, bone and other material.

"SULLIVAN" GALVANOMETER.—We are asked to state that all communications with regard to this instrument should be sent to Mr. H. W. Sullivan, 29, Ladbroke-square, W.

CURRENT WASTE PREVENTERS.—Messrs. Foote and Milne forward circular particulars of Curtis's Patent Electric Current Waste Preventer, which consists of a clock and switch with lever attachment. The lever is claimed to be so arranged that when the switch is off the lever engages with the mechanism of the clock and stops it, and when the switch is on the lever frees the clock, which records the period during which current has been passing.

D. P. BATTERIES.—A new price list is now ready of the well-known D. P. storage batteries, and copies will be forwarded on application to the D. P. Battery Company, 66, Victoria-street, S.W. The list contains up-to-date particulars of the latest form of the battery, together with prices of cells from 130 to 780 ampere hours. Prices are also given of complete battery sets. The usual accumulator accessories are also illustrated and priced. The list of testimonials which accompanies the list gives an excellent record of the life of the batteries supplied for various kinds of work.

ELECTRIC LIGHT, TELEPHONE AND OTHER ACCESSORIES.—Messrs. C. W. Treacher and Co., of 165, Queen Victoria-street, E.C., forward two useful lists, one of electric light material and apparatus, and another of telephones, electric bells, and other accessories. Useful practical hints on wiring, the erection and running of dynamos, and the erection and charging of accumulators, are given in one list, in addition to prices and particulars of a large quantity of apparatus and accessories used in electric light work. In the second list contractors will find of service a diagrammatic view of telephone connections given at the end. A specially useful form of electric gas lighting burner is also shown. These are manufactured by Messrs. Treacher, and have, we learn, a large sale. This catalogue is especially strong in electric bell and indicator sets.

PROTECTION FROM FIRE.—Messrs. Merryweather have recently installed, for the Chelsea Electricity Supply Company, a complete system of hydrants, hoses, &c., at the Draycot-place supply station, and for the Vestry of St. Mary, Islington, a similar installation at the supply station in Eden-grove.

MACHINERY CATALOGUE.—We have received from Messrs. Rosling and Appleby a copy of their new catalogue of "Yorkshire" dynamos and motors, combination plants—both gas and steam—and Clarke's Patent electric coal-cutting machine. The list contains a specification to which the "Yorkshire" machines are built, and full particulars relating to the firm's manufactures. The illustrations are very clear, and convey a good idea of the appearance of the machines.

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ABERDEEN.—The Aberdeen District Committee have decided to grant the application of the Northern Electric Supply Company to supply electric current for lighting the Cults district.

AGRICULTURAL HALL, N.—In conjunction with the Laundry and Sanitary Exhibition to be held from August 24th to September 5th at the above Hall, Messrs. New and Mayne propose holding an exhibition of horseless carriages, electric bicycles, and other recent developments of electrical science in the galleries of the Hall. Particulars and plans of the proposed exhibition can be had of Messrs. New and Mayne.

AYR.—At its meeting on the 13th inst. the Town Council adopted various modifications in the discounts allowed to consumers of electric current supplied from the Council's mains, proposed by the resident engineer, Mr. E. G. Pink. Meter rents have also been abolished. The new system of discounts affects consumers after 9 p.m. Between 9 and 10 the discounts are now 22½ per cent. in place of 20 per cent.; between 10 and 11, 35 per cent. in place of 30 per cent.; and after 11 p.m. discounts are by arrangement. As in London, the price of gas at Ayr differs north and south of the river, the supplies being provided by two companies. On the north side the price is 4s. 2d. per thousand, and on the south 3s. 9d., which seems a high price considering the comparative closeness of the burgh to the Scotch coalfields. With discounts at 35 per cent. for private lighting the electric light is equal to gas at about 3s. per thousand, allowing 8 units per 1,000ft. of gas, which should do much to popularise electric lighting in this district.

BATH.—The Electric Lighting Committee have completed the negotiations for the purchase of the undertaking of the City of Bath Electric Lighting and Engineering Company, and the seal of the Corporation has been affixed to the agreement.

BEDMINSTER.—The Parish Council have asked the Bristol Tramways Company to extend their tramway system to Bedminster. The Company, however, intimate that so long as they are restricted to horse traction it would be impossible to extend the tramays in the direction indicated. The Company intend to apply in the next session of Parliament for power to introduce electric traction on their entire system, and as soon as these powers have been obtained the question of extensions will be further considered.

BRIGHTON.—At a recent meeting of the Lighting Committee, Mr. Arthur Wright, the Borough Electrical Engineer, reported that for the purpose of equalising the distribution of pressure it would be necessary, before next winter, to run inter-connecting mains in certain streets, at an estimated cost of £860. This inter-connecting from the side streets would improve the pressure, and at the same time give the inhabitants opportunities for taking a supply of current. It was decided to carry out Mr. Wright's proposal.

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BRISTOL.—A Local Government Board inquiry will be held on Wednesday next to inquire into the Council's application for sanction to borrow £75,000 for electric light extension purposes.

CARDIFF.—At the last meeting of the Lighting Committee it was stated that there was an equivalent of 12,642 8-c.p. lamps connected to the Corporation electric light mains on June 30th last, an increase of 7,650 in the year. The revenue from public and private lighting for the month of June amounted to £273. 17s. 1d., an increase of £132. 0s. 7d. on the corresponding period of 1895. The Electrical Engineer (Mr. N. Applebee) presented a lengthy report upon the breakdown which occurred on the night of the 27th ult. The report stated that at the time of the accident the two triple expansion engines were running separately on the load, being one on each of the two mains which supply the town. Each engine was developing about three-quarters of its full power. At about 10 p.m. it was found that the big end of the intermediate rod of one of the engines had become heated, and as it could not be kept under the engine was shut down, and its load put on the other machine, which was thereby somewhat overloaded. After a short time the second engine also warmed up, and had to be shut down to ease the bolts on one rod, thereby causing a total extinction. Precautions were, however, being taken to prevent the recurrence of such a mishap.

COVENTRY.—On Tuesday Mr. G. W. Willcocks, M.I.C.E., held a Local Government Board inquiry into the application of the Town Council to borrow £13,000 for carrying out extensions of the electric light works. In support of the application the Town Clerk (Mr. L. Beard) stated that in June, 1894, the Corporation obtained power to borrow £20,000 for electric lighting purposes, and their expenditure had already exceeded this sum by £3,217. The policy of the Electric Light Committee was to economise as far as possible on the first outlay, and they had been advised that the best way of doing so was to construct the buildings and lay the mains on a scale that would allow of extension without fresh disturbance of the streets, and also the extension of the running machinery without serious interference with the buildings. The Corporation therefore put in machinery of only 300 H.P.; and the demand for current had overtaken the capacity of the machinery. After the works had been opened a demand sprang up, and mains had to be laid outside the compulsory area. On January 1st last, when the electricity supply works were opened, they had orders on hand for an equivalent of 1,824 8 c.p. lamps; and at the present time the number of lamps connected was 3,995. The actual capacity of the present station was 7,500 8 c.p. lamps, and extensions were still in progress. They, however, proposed to double the capacity of the works. The department had paid its running expenses. The application might be considered as urgent. The consulting engineer (Mr. R. Hammond) gave particulars of the proposed extensions, and after the Inspector had paid a visit to the station the inquiry closed.

DEVIZES.—Owing to the receipt of an application from Messrs. Brown and May for a concession to enable them to supply electric current in the town, the Town Council have appointed a sub-committee to consider and report upon the electric lighting question generally.

DUNDEE.—Owing to ill-health the Borough Electrical Engineer, Mr. W. H. Brownlee, has been compelled to resign his position. The assistant engineer, Mr. W. M. Tittensor, has been appointed to fill the vacancy temporarily.

EDINBURGH.—The Electric Lighting Committee recommend the Council to carry out certain additions and alterations at the electricity supply station at an estimated cost of between £4,000 and £5,000. The question of the proposed special reserve or depreciation fund has been further considered by the Committee, and, with one dissentient, it was resolved to again report in favour of the scheme. Treasurer M'Crae, however, considered that there was no necessity to create such a reserve fund, and that the whole of the profits on the Council's electric light undertaking should go to the relief of the rates.

ESTON (MIDDLESBRO').—A scheme for the electric lighting of this town has been submitted to the District Council by Messrs. Cox Walkers, who offer to light the streets electrically for a number of years by means of 32 c.p. incandescents at £385. 15s., plus 5 per cent. per annum. The Streets and Lighting Committee are considering the proposal.

ELECTRICITY IN MINING.—The Directors of the New Flat and Crown Gold Mines (Limited), of New Zealand, have, it is stated, under consideration the erection of powerful electrical transmission plant for pumping and winding purposes at their mines.

EMPLOYERS' LIABILITY.—An important action was heard at Birkenhead last week, brought by an employé of the National Telephone Company named Milligan, who sued for £114. 16s. damages for injuries sustained. The action was brought under the Employers' Liability Act, and the plaintiff's case was that the injuries were caused by the defendant company's negligence through their foreman. The plaintiff was at work upon the roof of a house and was ordered to climb up the slates to pass a wire over the roof, and it was contended for the plaintiff that proper appliances could be and should have been provided to enable him to do his work without unnecessary danger. The defendants contended that plaintiff had been guilty of contributory negligence. Ultimately a consultation was held, and a verdict given for the plaintiff for £60, with costs on the £50 scale, was agreed.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from July 15th to July 21st, with the ports of destination:—

*Argentina*—Buenos Ayres, £287 (telegraph wire). *Australasia*—Adelaide, £26; Auckland, £13; Launceston, £61; Melbourne, £849 (including £516 telegraph material); Perth, £273 (telegraph material); Sydney, £264; Townsville, £1.142. *Canada*—Montreal, £30 (telegraph material). *Ceylon*—Colombo, £697. *Chili*—Valparaiso, £40. *China*—Shangai, £542. *Egypt*—Alexandria, £54; Port Said, £64. *Denmark*—Copenhagen, £68. *Holland*—Amsterdam, £228; Flushing, £18. *Hong Kong*, £34. *India*—Bombay, £127; Calcutta, £50; Madras. £86. *Malta*, £53 (telegraph material), *South Africa*—Cape Town, £464; Delagoa Bay, £69 (telegraph material); Durban, £667; East London, £870; Port Elizabeth, £206; *Spain*—Bilbao, £35. *Straits Settlements*—Singapore, £120. *Sweden*—Gothenburg, £325; Stockholm, £160. *Uruguay*—Monte Video, £50.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods to the value of £28 have been exported to—Halifax (Nova Scotia).

GLASGOW.—An important deputation representing the Town Council recently had a private interview with the Postmaster-General on the subject of the telephone. The deputation urged a request that the Government should either take over the working of the telephones or grant a license to the city of Glasgow, so that the Corporation might be able to provide a much more efficient service than the present. The deputation complained of the very unsatisfactory condition of the present service, the result, it was contended, of the single-wire system, and urged further that if the metallic circuit was to be introduced the streets of Glasgow would be practically handed over to the National Company, and to this the Corporation had strong objections. Complaint was made of the cost of the telephone, the Corporation undertaking that if they were given control they would give a better service for £5 than was now given for £10. The Postmaster-General promised to give the views laid before him careful consideration, with especial regard to the request of the Corporation for a telephone licence.

HOLBORN (LONDON).—The County of London and Brush Provincial Company have notified the Board of Works of intention to apply for a Provisional Order for the district.

ISLINGTON (LONDON).—The Vestry have decided to increase the salary of the electrical engineer (Mr. Albert Gay) to £500 per annum, the increase to take effect from 1st January last. Mr. C. H. Yeaman has been appointed assistant engineer, at a salary of £160 per annum; and Messrs. N. Stanilands, H. Knorr and E. Hoadley have been appointed as electricians, at salaries of £104 per annum.——The Vestry have decided to oppose the application of the County of London and Brush Provincial Company for a Provisional Order to enable them to lay certain electric light mains to form connections with adjoining areas of supply.——Plans for the extension of the electricity supply station are being prepared by Mr. A. H. Tiltman, F.R.I.B.A.——Applications have been received by the Electric Lighting Committee for the supply of electric current for lighting Messrs. Carter, Paterson and Co.'s new stabling premises in Graham-street, City-road, and the Presbyterian Church, in Colebrooke-row, and it has been decided to extend the electric light mains to these streets at an estimated cost of £700.

LIVERPOOL.—The City Council have decided to light the plateau in front of St. George's Hall and a portion of Lime-street in the immediate vicinity of the Hall by electricity.

LONDON COUNTY COUNCIL.—Sir Arthur Arnold, Chairman of the Council, in the course of his annual address on Tuesday, said that the future progress of the tramways in London rendered it necessary that some form of electric traction should be largely adopted.

MEXICO.—In our issue of July 10 we notified that the Municipal Council of Mexico require tenders for an electric light installation capable of supplying current to 600 arcs and 150 incandescents for public lighting, the illuminating power of the arc lamps to be between 2,000 c.p. and of the incandescents 50 c.p. Tenders have to be accompanied with a deposit of £1,000, and must be sent in to Señor D. Juan Bribiesca, Secretary, City Council, Mexico, by August 31st. The following particulars of the installation will be of interest:—The contractor is required to furnish a detailed statement of all the mechanical and electrical material of which his installation will consist, as well as a plan of the latter, and to keep such material in good condition during the whole period of the contract. The electric conductors are to be so arranged that the lamps located at

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the corners of thoroughfares shall be on different circuits to those occupying the centres of the streets, to enable the latter to be cut out at certain hours. Duplicate generating plant for operating the dynamos is to be provided, so that no interruption may occur in the lighting. The 1,200 c.p. arcs will be used for the centres of the streets and the 2,000 c.p. for the corners. The contractor is to furnish the inspectors of the City Council with all necessary apparatus and instruments, in order that a test may be made at any given time, the results of the test to be within 15 per cent. of the candle-power set forth for the arc lamps and 10 per cent. for the incandescents, and should any disagreement arise between the contracting parties or their representatives as to the result of the tests or as to accuracy of the measuring instruments, an arbitrator is to be appointed, who shall cause the "trial to be repeated," so that his decision will be that accepted by both parties. The arc lights are to be fixed at a height of not less than 5 metres. The arc lamps are to have "spheric globes," completely frosted, but notwithstanding to be sufficiently transparent to prevent undue loss in the light, and to have "reflectors of convenient shape and dimensions to better distribute the light downwards and to protect the mechanism of the lamp in the rainy season." The contractor can use high or low pressure so long as good insulation is guaranteed, and all proper precautions are taken to safeguard the public, the contractor and not the Council to be responsible for any accident that may occur. Posts or supports for the lamps, "in case these cannot be hung from cables fixed on to the walls of the houses," are to be metallic, and of appropriate form and dimensions, the Council having the right to select the style of posts from models to be submitted by tenderers. Wherever practicable, cables are to be put underground, the contractor to be paid an additional 5 per cent. on all lamps fed from the underground mains. The hours of lighting will be fixed by the Council, and every month a statement of the hours of lighting is to be presented by the contractor, such number of hours being not less than 3,600 per annum for the 2,000 c.p. arc lights and the incandescents, and 1,400 hours for the 1,200 c.p. lights. Carbons of such size and quality must be used "that even in the case of a maximum duration it will not be necessary to substitute them," and the carbons must be changed at times when the traffic will not be interrupted. If the Council's inspector should deem it necessary, in order to facilitate the inspection of the lighting, to place on the circuits automatic apparatus to enable him to verify the statements furnished by the contractor, these must be installed by the contractor. Delay in lighting up, interruption of any or all the lights, or "lack of intensity" of the lights, will entail fines varying from 5 per cent. to 20 per cent. of the amount to be paid for the lighting hours of the respective lamps. Should the "lack of intensity" be more than 50 per cent., or should the hours of no light be such that the fines reach during any month 10 per cent. of the total charge for the lighting, and should this occur two months in succession, the Council have the right, with the approval of the government of the district, to declare the cancellation of the contract, or to acquire the plant and buildings at a valuation to be made by the parties to the contract, the Council being at liberty to make payment in monthly instalments of 5 per cent. of the total sum agreed upon. If the Council does not accept the valuations, it will have the right to administer the lighting service, using the machines, apparatus, wires, or conductors, buildings, &c., and deducting the costs incurred from the monthly settlement referred to, from which account also all fines will be deducted. No alteration in the contract price is to be made on account of any increase in the cost of fuel or from any other cause so long as the efficient character of the lighting is maintained. Any differences of account between the contractor and the Council's inspector is to be settled by the Council. No part of the public installation may be used for private lighting without previous arrangement with the Council, and the supply station, buildings, or other structures erected by the contractor will be subject to police supervision. The duration of the contract is eight years, beginning from the date on which the lighting of the city is commenced. At the termination of the contract, either from effluxion of time or from any other cause, the Council are at liberty to contract either with the same contractor or with another person or company for the future lighting of the city, or it can purchase the undertaking at a price to be mutually agreed upon, or in case of non-agreement, by means of a valuation by two experts to be named by the parties, together with an arbitrator, "who will decide without any further resource." Should the experts not arrive at a mutual agreement as regards appointment of the third party, he will be appointed by the governor of the district. The Council will then have 30 days' grace to decide whether it will take over the installation or not at the price fixed, and should it decide on taking over the installation the amount will be paid in 20 equal monthly instalments. If the Council should deem it necessary to extend the lighting it will have the right to demand the said increase of the lights, and the contractor will be compelled to make the increase, but only in lots of 60 or 120 arc lights of the same candle-power and in all other respects similar to the lamps already fixed, or of 25 or 50 incandescents, and with six months' notice to the contractor. The tariff for the additional lamps to be somewhat lower than those under the original contract, until a total of 1,040 arc lights and 300 incandescent lamps is reached, when the charge for the lights is to be fixed afresh, but not to exceed "the lowest price which may have been arrived at." The Council is at liberty to contract separately, or to itself light such portions of the city as are not lighted under this contract or its extensions. The contractor will be required to furnish current and lamps, &c., for any special lighting the Council may from time to time require. The tender must be clear as to details, and lucid in its terms and expressions, and must state the date at which the contractor undertakes to complete the installation (this not to exceed the period of one year from date of contract). The deposit of $5,000 will be returned to unsuccessful tenderers, but not to the successful firm, whose deposit will be increased to the sum of $20,000, to be lodged in the same manner as the first $5,000, this deposit to be returned to the contractor when the installation is in satisfactory operation within the specified period. Within a month of the Council's decision "it will inform the manager of the 'Compañía de Gas y Luz Eléctrica' of same in order that he may within the term of nine days advise the Council in writing whether he intends to take the right of option granted to him in the contract. If the 'Compañía de Gas y Luz Eléctrica' should not avail itself of its right of option, the bidder whose proposals may have been declared acceptable will be advised immediately, in order that steps may be taken towards entering into the contract." The person or company whose proposals are accepted will be required to attend upon the Council at the time appointed to arrange the bases of the contract, and the rights under the contract cannot be transferred without the previous approval of the Council. The expenses of drawing up the contract will be borne equally by the parties. The above particulars are translated from the original Spanish. A plan of the proposed area to be lighted can be seen at *The Electrician* office from Monday to Friday, between the hours of 10 a.m. and 5 p.m.

MORECAMBE.—The District Council have acquired a plot of land to serve as a site for a new electricity supply station, plans for which are being prepared to the Council's instructions.

WELLINGTON (SALOP).—The County of London and Brush Provincial Company have submitted proposals to the Urban District Council for the lighting of the streets by electricity. The Council view the offer with favour.

OUTINGS.—The employés of F. A. Glover and Co., of 97, Queen Victoria-street, E.C., held their annual outing on Saturday at Margate, the head of the firm presiding at the dinner at the Hotel Metropole.——A large party of employés and friends of Marryatt Lillywhite and Co., of Hatton-garden, E.C., held their annual outing on Saturday at Maidenhead.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

June 29, 1896.

14,317. J. ENRIGHT. London. Improvements in electric tramways.

14,331. A. G. ADAMSON. Glasgow. Improvements in and connected with electric tramways or railways.

14,332. A. G. ADAMSON. Glasgow. Improvements in apparatus for the use of electric light, gas, or oil for photographic, illuminating, and other purposes.

14,367. C. A. HALES. London. An improvement in electro-deposition of metals and metallic alloys.

14,376. G. B. BOWELL. London. Improvements in master clocks for operating or controlling circuits of electrical dials and similar instruments.

14,393. P. JENSEN. London. Improvements in anodes for electrolytic purposes. (H. C. F. Stormer, Norway.)

14,397. F. V. ANDERSEN. London. Improvements in electric arc lamps.

June 30, 1896.

14,442. S. VAN B. ESSICK. London. Improvements in and relating to telegraphy.*

14,462. A. J. BOULT. London. Improvements in or relating to systems of electrical distribution. (G. J. Scott and W. S. Janney, United States.)*

14,463. S. VAN B. ESSICK. London. Improvements in telegraphic alphabets.*

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14,464. S. VAN B. ESSICK. London. Improvements in telegraphy.
14,499. F. STOCK. London. Improvements in microphones.*
14,500. F. STOCK. London. An improved call-counter suitable for telephone exchanges.*

July 1, 1896.

14,551. F. HARRISON and J. PROBERT. London. Securing so-called "caps" or "collars" to the necks of incandescent electric lamp globes.
14,554. SIEMENS BROS. AND CO. (LIMITED). London. A buoy that can be sunk or raised electrically from a distance. (Siemens and Halske, Germany.)
14,555. SIEMENS BROS. AND CO. (LIMITED). London. Improvements in the process and apparatus for the preparing of iron sheets for electrical and magnetical apparatus. (Siemens and Halske, Germany.)
14,584. P. E. SECRÉTAN. Liverpool. Improvements in or connected with the arrangement and attachments of electrolytic anodes.

July 2, 1896.

14,639. H. J. DOWSING. London. Improvements in apparatus for the production of electricity from the waste heat of gas, steam, or other heat engines.
14,641. G. BYNG. London. Improvements in electro-gas lighters.
14,642. M. BYNG and F. G. BELL. London. Improvements in and connected with electric bells, gongs, and the like.

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

11,498. SAYER. Electric, &c., railways.
11,817. CAMPBELL. Measuring electric currents, &c.
11,944. RALEIGH. Electrolytic deposition of metals.
13,459. HEYL. Electric cables or conductors.
14,403. JAHNSSON. Electrical gas igniting devices.
15,134. WASHINGTON. Covering electric, &c., wires.

1896.

5,506. RIBBE. Electric accumulators.
6,981. ENTWISTLE (Smith and another). Electrical batteries.
7,833. DEVONSHIRE (Steinmetz and another). Electric railway, &c., systems.
9,530. DEVONSHIRE (Wirt). Incandescent electric lamps.
9,531. DEVONSHIRE (Steinmetz). Dynamo electric machines.
10,124. DEVONSHIRE (Steinmetz). Distributing electric currents.
10,134. BREWER. Collecting electricity from overhead conductors.

# COMPANIES' MEETINGS AND REPORTS.

## Eastern Telegraph Company (Limited).

The forty-eighth half-yearly ordinary general meeting of this Company was held yesterday (Thursday), at Winchester House, under the presidency of the Marquis of Tweeddale.

The SECRETARY (Mr. George Draper) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN stated that before dealing with the ordinary business of the meeting it was his melancholy duty to refer to the grievous loss which the Company had sustained through the death of their late Chairman. Sir John Pender's long and active life came to an end on July 7th, and with it closed a remarkable career, alike honourable to himself and beneficial to his country. They were no doubt aware that Sir John held a foremost place in that small body of distinguished men who, believing in the feasibility of establishing telegraphic communication between England and America, aided in successfully laying the first telegraph between those two countries. Having accomplished that enterprise he turned with characteristic energy and perseverance to the work of conferring a like benefit first on our Eastern possessions and later on the Continent of Europe. His efforts were crowned with signal success. Among the companies formed to carry out this great work none had a better record than the Eastern. Founded in 1872, with a capital of £3,397,000 and a mileage of 8,862 miles, it had now a capital of over £6,000,000, and its cable mileage had increased to 26,352 miles. It had paid quarterly dividends uninterruptedly from that day to this—never less than 5 per cent. and as high as 7 per cent., while its shares commanded a premium of between 60 per cent. and 70 per cent. Sir John's services received recognition not only from our Government but from many foreign Governments as well. The memory of their late Chairman would be long remembered as a foremost pioneer of submarine telegraphy, and as one entitled to their gratitude and respect. The Directors had done him (the speaker) the great honour to elect him to the vacant chair, and it would be his ambition to justify their choice. They would have noticed—with, he was sure, entire approval—that Mr. John Denison Pender would occupy the position of Deputy-Chairman and continue to perform the duties of Managing Director, which he had discharged with marked ability and advantage to the Company ever since the lamented death of Sir James Anderson. With a Board so composed, and a Managing Director so competent, they might feel assured that the affairs of the Company would be administered in the future with no less prudence and success than they had been in the past. He then referred to the results attending the working of the half-year to the 30th ult., and remarked that the gross revenue had been £466,093, or an increase of £45,567 over that of the corresponding period of 1895. The total ordinary expenses for the same period had been £99,152, or an increase of £1,092 over those of the June half of the previous year. This increase would, he believed, be considered extremely moderate having regard to the large increase in their revenue. The cable repairs had cost £33,955, or £18,775 less. In order to balance the capital and capital expenditure accounts, and to enable them more fully to invest the amount standing to the credit of reserve fund, they had issued Four per Cent. Mortgage Debenture stock, to the amount of £110,000, at the substantial premium of £31,908. This premium had been carried to the general reserve fund, and more than wiped out the discount of £28,105 on the issue of Four per Cent. stock, which was charged against the fund in 1885. The International Telegraph Conference, held this year at Buda Pesth, only came to an end on Tuesday, and it was too early, therefore, to express a definite opinion as to the effect which its decisions might have upon the future revenues of the Company. There would no doubt be some loss of revenue, but they did not anticipate that it would be important. The reserve fund now amounted to £563,295, or £43,704 less than it was six years ago. A reserve fund of £563,295 was totally inadequate for a Company like theirs. It had always been their policy to reduce rates whenever they saw a reasonable prospect of developing traffic sufficient to warrant their doing so. In fulfilling their duty to the telegraphing public it must not be overlooked that they had also the interests of their shareholders to consider, and they believed that the interests of both were best served by strengthening their reserve fund. They would endeavour to build up a substantial reserve fund, but it would take some time to carry out this object. There was no doubt that while strengthening the reserve fund they would be able to continue the dividend they had been paying hitherto, which he believed would be considered by all reasonable persons as very satisfactory. The net result was that they were able to pay a dividend and bonus equal to 6½ per cent. per annum and to carry a very substantial sum to reserve. He concluded by moving a resolution for the adoption of the report, the payment of the Preference dividend, and the declaration of the dividend and bonus recommended on the Ordinary shares.

Tht VICE-CHAIRMAN and MANAGING DIRECTOR (Mr. J. Denison Pender), in seconding the motion, thanked them for the kind way in which they had received the sympathetic remarks of the Chairman with regard to his late father, Sir John Pender.

Mr. JAMES GIBB referred in high terms to the eminent services which had been rendered to the cause of telegraphy by the late Chairman, and said he wished to move the following resolution: —

"*That this meeting of shareholders of the Eastern Telegraph Company desires to express its sense of the great loss the Company has suffered by the death of Sir John Pender, and to tender to Mr. John Denison Pender and the other members of the family its sympathy in their bereavement.*"

Mr. HENRY T. BURGESS, who said he had known Sir John for over 40 years, and who testified to the uniform courtesy and kindness of the deceased gentleman, seconded the motion.

Mr. JOHN NEWTON warmly supported the resolution, remarking that the family of their late Chairman had the great satisfaction of knowing that his life-work was accomplished. He thought that some national memorial should be taken in hand by those who had profited so greatly by Sir John Pender's work, and that of other pioneers of submarine cable work like the late Cyrus Field and Sir James Anderson.

The CHAIRMAN stated that his colleagues and himself endorsed every word that had fallen from the three gentlemen who had addressed the meeting. Mr. Newton had referred to what had suggested itself to the mind of almost everyone who was acquainted, however distantly, with Sir John Pender. The suggestion was a very proper one, and most acceptable to the Directors, who would be very glad to assist in every way possible to carry it out. He then put Mr. Gibb's resolution to the meeting, and it was carried unanimously.

The VICE-CHAIRMAN again thanked them for their sympathy, and stated that he would place the resolution himself before the family, who would appreciate it most deeply.

The resolution proposed by the Chairman was then unanimously adopted.

On the motion of Mr. NEWTON, a vote of thanks was afterwards passed to the Chairman and Directors.

The CHAIRMAN, in reply, incidentally stated that he had been for 28 years a Director of telegraph companies. He was, in fact, the first Chairman of a cable to the East—the Anglo-Mediterranean telegraph, which proceeded from Malta to Alexandria, and was afterwards absorbed by the Eastern Company.

The proceedings then terminated.

(*A full report of this meeting will appear in our next issue.*)

## Telegraph Construction and Maintenance Company (Limited).

The half-yearly general meeting of this Company was held on Tuesday, at the offices, 38, Old-Broad-street; Admiral Sir George H. Richards, K.C.B., presiding.

The MANAGING DIRECTOR (Mr. W. Shuter) read the notice calling the meeting.

The CHAIRMAN: Gentlemen, we are happy to meet you here again at this half-yearly meeting. We have no official business to transact, nor have we any figures to place before you; but I dare say you will be very anxious to know what work we have done during the first half of the year, and, so far as we are able to tell you, what are the prospects before us for the second half. Before, however, I offer a few remarks on these points, I think you will agree with me that it would be a fitting

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thing that I should refer on this occasion to the great loss that submarine telegraphy has recently sustained in the death of Sir John Pender—a loss, I think it is not too much to say, which has cast a gloom over the whole of the great companies with which he was so intimately associated, and which he so long presided over. Of course, it will be impossible here, and it would be out of place if it were not, that I should enter into any details of Sir John Pender's services to ocean telegraphy. This will more properly come from other sources. But I think we must not forget here that Sir John Pender was the first Chairman of this Company on its formation in 1864. Sir John Pender did not leave this Company until he realised that a company which made cables and laid them scarcely afforded scope for carrying out the great designs which he entertained and which he never swerved from during the whole of his life. These designs, gentlemen, were, as I dare say you all know, to encircle the globe with the electric cable. As soon as he did realise this he set himself to promote other great companies, of which he became the Chairman and the leading spirit, and it was these great English cable companies that so largely carried out his designs. He had hoped, and we had all hoped, that he would have lived to complete them—if there is such a thing as completion in marine telegraphy; but that was not to be. I think it is due to Sir John Pender that we should say from this Board that in all the great enterprises that he undertook—and they were a great many—he was never discouraged by any difficulties whatever. The greater the difficulties the more determined he was to surmount them; and he surmounted them, I believe, in a way that has resulted in great benefit to the public, and great benefit to those who were associated with him as shareholders, and in a way that redounded to the credit and advantage of this country. Well, I should just like to mention two incidents which occurred in the career of Sir John Pender. They will show his entire faith in submarine telegraphy, and also, I think, the sagacity and the bold enterprise with which he always met every obstacle that came in his way. And I mention these two incidents because we were in a great way connected with them ourselves; and, therefore, I have to but offer the least apology for doing so. The first of these was in 1865, when the "Great Eastern" dropped the Atlantic cable at the bottom of the sea in mid ocean. That was a time when men's hearts failed them, and there were very few, except the most sanguine, who did not despair of the final success of that enterprise. Well, it was Sir John Pender, then the Chairman of this Company, who was one of the ten to put down £10,000 each for carrying on the work; and it was by that act, and by their subsequent endeavours, that the lost cable was recovered, and a second line was laid across the Atlantic, thus ensuring, beyond doubt, the success of marine telegraphy, and ensuring, moreover, the possibility of Sir John Pender's great schemes. Well, the second incident I wish to bring to your notice is this—you will remember the great disaster which occurred in South Africa, when our troops were destroyed in 1879. No sooner had that intelligence come to England than Sir John Pender took the initiative and entered into negotiations with the Government; and before the end of that year Aden was connected with the Cape Colony by a cable nearly 4,000 miles in length. Perhaps I may be permitted to remind you that this work, as well as that of the Atlantic cable, was carried out by this Company. I think, perhaps, I have said enough on this melancholy subject. Other occasions will arise when fuller justice will be done to Sir John Pender's achievements by those who certainly are more entitled to pronounce on them than I am; but I am sure you will not think I have occupied your time unduly with this slight allusion to Sir John Pender. To resume, gentlemen, the remarks with which I commenced this meeting as to our work, I may tell you that although we have not carried out any large contract so far this year, yet we have received orders from various companies and Governments for several hundred miles of cable; and, although we have completed a good deal of this, we have a good deal still to complete. But, perhaps, the most important operations that we have performed this year have been the repairs which we have made in various cables, all of which have been very successfully accomplished—notably, the repairs to the French Telegraph Company's cable between Brest and New York. This cable has been lifted twice, and once repaired in deep water in the Western Atlantic. We have two of our ships at the present time employed on similar service. There is no occasion to mention the names of the cables we have repaired, but they number a great many. In regard to other work I have to mention, I am glad to say that our general trade all through is considerably better than it was during the same period of last year. I am anxious, gentlemen, not to overstate any of these works which I have mentioned. Like other things cables do not fetch the prices they used to. I do not say this by way of discouragement at all, but I do not wish to overrate the work we are doing. Now, as regards the future. It is a very difficult thing to prophesy on subjects of this kind unless they are really settled. It is also a difficult and disagreeable task to us to refuse information to you who are naturally anxious to hear it, and when we believe we have good ground for it. But experience has shown that there are always delays and postponements in these matters, especially when you are dealing with foreign countries, over which we have no control whatever. And, therefore, we think that it is the wisest and best plan in the interests of the Company not to say anything that you are not certain of. Moreover, I would remind you, gentlemen, that in work of this kind we are not the only participators, and it might not be fitting that we should publish the affairs of the other parties concerned to the world, at least, until the proper time arrives. I am glad to say we are paying the usual dividend of 12s. a share, being at the rate of 10 per cent. for the year, and I may add that the Directors are perfectly satisfied with the present position of the Company. This, gentlemen, is all that I can tell you, and, as you are aware, there is no resolution to submit to this meeting.

Mr. CROFT said the attendance at their half-yearly meetings had always been small on previous occasions; but he thought that the larger attendance on this occasion was a tribute to the memory of the great man to whom the Chairman had referred in such eloquent terms. He was sure that he should be expressing the feelings of the shareholders who were absent, and also of those present, when he said that they cordially endorsed all that the Chairman had said as to the valuable services which Sir John Pender had rendered to the cause of ocean telegraphy.

Sir H. D. GOOCH also wished to associate himself with all that the Chairman had said as to the great work which Sir John Pender had done for his age and his country.

The proceedings then terminated.

## India Rubber, Gutta Percha and Telegraph Works Company (Limited).

At a meeting of the shareholders of this Company, held on Tuesday, Mr. Matthew Gray presiding, resolutions were submitted by the Directors, and passed, making considerable modifications in the Articles of Association, in consequence of the certificate given by the auditor to the last set of accounts presented to the shareholders. The following is a report of the proceedings at Tuesday's meeting:—

Mr. COCHRANE thought the meeting must be grateful to those who had insisted upon fuller information being given before passing the resolutions submitted to them. He hoped that due attention had been given to the reverse side of the circular the shareholders had received, where they would see printed the present Articles of Association which the Directors in their wisdom were asking the shareholders to expunge and replace by the somewhat insipid and colourless resolutions now before the meeting. He was anxious that the shareholders should hear from the auditor the grounds on which he had recommended the proposed alterations in the Articles. It struck him as being very singular that for a period of at least 20 years, during which he had been connected with the Company, the Directors and the auditors had distinctly ignored the very explicit instructions contained in the Articles of Association. They had from the shareholders' side of the table again and again asked for further information, but if they had been a little sharper they might have pointed to the Articles and claimed as a legal right the information which the Directors had consistently and regularly refused to give them. He was not one of those who thought they should show their hand to the world; yet he thought the Directors had forgotten sometimes that they were not the India Rubber Company, and that really they were the representatives, and not the controllers, of the proprietors of this Company. According to the Articles the Directors were distinctly instructed to lay before the shareholders, in the capital and liabilities account, full particulars of the debts and liabilities of the Company, and how they were constituted. That, he need scarcely say, the Directors had systematically neglected to do. In their last balance sheet, which was a fair sample of the previous ones, they had not the information given them to which they were entitled by the Articles. Nearly everything was lumped together. He should like to hear from the auditor the grounds on which he proposed these alterations in the Articles.

Mr. CLARKE (auditor) explained that he had only audited the accounts of this Company personally for three years; but his partner was the previous auditor, and he had followed in his wake. He raised the question about the form of the balance sheet, but it was considered that the words, "as near thereto as circumstances admit" covered the case. He had, however, considered it carefully, and had suggested that the matter should be brought before the shareholders. He had no special reason for making the suggestion except that there was a doubt whether the words referred to rendered them free from the necessity of giving certain details. He had been told that it would be prejudicial to the interests of the Company to give the full details, and that was the whole reason why they had not been given. It was a matter, of course, between the shareholders and the Board as to what was to be done. He drew attention last time to the fact that the accounts were not quite in accordance with the Articles, and he thought there would be no objection raised to the proposals now before the shareholders.

The CHAIRMAN: I want to point out to the shareholders that we, as a trading company, are bound to give tenders for a great variety of material that we manufacture, and it is very desirable that our tenders should not be known by our competitors. Some of our competitors have bought a few shares in our Company for the purpose, I suppose, of getting to know something more about how we manage our business; and it is, therefore, I think, very desirable that the auditor, who makes a full inspection of our accounts, should be trusted by our shareholders, and also that the shareholders should have confidence in the Directors. The Directors want to manage the business in the interests of the shareholders, and we have no other object in withholding from them information than that it should not get to our competitors, and be used to our disadvantage. Other companies in the same line of business do not give nearly so much information as we do in our accounts. We think it would be desirable that the Articles of Association should be altered in the manner proposed, solely for the purpose of making it unnecessary for us to insert in the accounts details which our rivals could use to injure this Company.

## Direct United States Cable Company (Limited).

The following report of the Directors of this Company for the six months ended June 30th last will be presented at the meeting to be held at Winchester House, Old Broad-street, London, on Tuesday next, at 2:30 o'clock:—

The half-year's revenue, after deducting out-payments, amounted to £42,456. 11s. 9d., compared with £37,653. 2s. 4d. for the corresponding period of 1895. The working and other expenses for the same period, including income tax, but exclusive of cost of repairs of cables, amounted to £19,692. 4s. 2d., leaving a balance of £22,764. 7s. 7d. as the net profit of the half-year, making, with £4,148. 14s. 4d. brought forward, a total of

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£26,913. 1s. 11d. For the corresponding period of 1895 the working expenses and other payments amounted to £18,909. 0s. 10d.

Three quarterly interim dividends, amounting to £19,730. 15s., have been paid during the financial year, and a final payment of 2s. 6d. per share is now proposed, making, with the three interim dividends, 2¼ per cent. for the year, being a total distribution of £27,319. 10s. After transferring £7,500 to the reserve fund account, the balance of £4,235. 11s. 11d. is proposed to be carried forward.

The Directors record with profound regret the death of their highly-esteemed colleague and late Chairman, Sir John Pender, G.C.M.G. Sir John Pender had occupied the chair of the Company from the date of its incorporation in 1877 until early in the present year, when the precarious state of his health compelled him to retire from that position. The Directors thereupon invited Mr. E. M. Underdown, Q.C., to assume the office of Chairman, which he accep ed. The vacancy in the Board caused by the death of Mr. Charles Meara, in 1894, has been filled by the appointment of Mr. John Varley, one of the largest shareholders in the Company.

The cable repairs in progress in December last were satisfactorily completed early in January at a further cost, including new cable inserted, of £8,243. 17s. 1d., which has been debited to the reserve fund account, the balance of which, with the addition of interest, realised profit and amount transferred from revenue account, now stands at £313,969. 4s. 1d.

Mr. John Varley and Mr. E. M. Underdown, Q.C., offer themselves for re-election as Directors, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. J. and J. Sawyer and Co.

## Globe Telegraph and Trust Company (Limited).

The report of the Directors of this Company, to be presented at the meeting on Tuesday next at Winchester House, Old Broad street, E.C., at 1 o'clock, states that the net revenue for the year, after deduction of expenses, amounts to £185,222. 19s. 2d., making with the balance of £1,238. 3s. 4d. brought forward a total of £186,461. 2s. 6d. From this amount there has been distributed £125,614 0s. 9d. in interim dividends, leaving an available balance of £60,847. 1s. 9d. The Directors recommend the payment of a final dividend for the year of 3s. per share on the Preference shares and of 3s. 9d. per share on the Ordinary shares, making a total dividend for the year of 6 per cent., less income tax, upon the Preference, and 4½ per cent., net (against 4¼ per cent. for the preceding year), upon the Ordinary shares, leaving a balance of £948. 8s. 8d. to be carried forward. The Directors have deemed it advisable in future to pay the interim dividends on October 31st, January 31st, and April 30th in each year: the date of the final dividend remaining unchanged.

Since the last meeting the remainder of the money resulting from the paying off of the Direct Spanish Telegraph Company's Six per Cent. Debentures has been re-invested, and a full list of the Company's investments accompanies the report.

The Directors deeply regret to have to report the death, on the 7th inst., of their colleague Sir John Pender, who had been Chairman of the Company from the time of its inception, and to whose remarkable energy and business capacity so much of the success of this Company has been due. The Directors have appointed as Chairman the Marquis of Tweeddale, who has been a Director from the formation of the Company.

The retiring Directors, Mr. James Pender, M.P., and Lord Sackville A. Cecil, offer themselves for re-election, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co., and Mr. William Griffith, B.A., barrister-at-law.

## National Telephone Company (Limited).

The following is the report of the Directors for the half-year ended June 30th, to be presented at the meeting to be held at the Cannon-street Hotel, E.C., on Thursday next, at 1 o'clock :—

The income for the period amounted to £429,680. 14s. 9d., compared with £396,385. 7s. 4d. for the corresponding period of 1895. The working expenses amounted to £226,250. 2s. 7d., against £207,627. 12s. 3d., the net result for the half-year (after deducting the Post Office royalties amounting to £38,958. 10s. 9d.) is a profit balance of £164,472. 1s. 5d., compared with £152,321. 14s. 1d. The rentals carried forward for unexpired terms of running contracts amount to £438,321. 15s.. as against £390,978. 3s. 4d.

Out of the balance of £136,612. 4s. 3d. available for distribution, the Board recommend the payment of dividends at the rate of 6 per cent. per annum, less income tax, on the First and Second Preference shares, 5 per cent. per annum, less income tax, on the Third Preference shares, and 5 per cent. per annum, free of income tax, on the Ordinary shares. The Board also propose to transfer £35,000 to the reserve fund, and to carry forward the balance of £17,133. 6s. 9d.

The sum of £248,537. 8s. has been expended upon additional exchange and private lines erected during the half-year. A not inconsiderable proportion of this outlay is attributable to the substitution of metallic circuits for single lines, and the construction of underground work in lieu of overhead wires; both these sources of expenditure having become necessary to ensure greater efficiency in the service to subscribers in the more important and crowded centres.

The trunk lines erected by the Company were surrendered to the State on April 4th last, in consideration, amongst other things, of the payment on the same date of their value as ascertained and fixed by experts after an elaborate and prolonged inquiry. This transfer, separating, as it does, the conduct of the trunk business from the working of the local exchanges in the numerous areas assigned to the Company, has naturally involved some inconvenience in connection with the "through" telephone business of the country; but as the authorities of the Post Office and the officers of the Company are loyally co-operating with the object of securing to the public the most efficient service possible, it is hoped that the inconvenience adverted to may be speedily terminated.

The Directors finally state that they have long had under consideration the advisability and necessity of establishing a pension fund for the benefit of the officers, clerks, and others in the service of the Company, and ask for the support and sympathy of the shareholders in dealing with the matter in a generous spirit.

## City and South London Railway Company.

The report of the Directors of this Company for the half-year ended June 30th, to be submitted to the meeting to be held at Winchester House, Old Broad-street, London, on Tuesday next, at 12 o'clock, is as follows :—

The receipts from all sources for the past half-year have amounted to £24,910. 18s. 9d. and the cost of working has been £15,001. 17s. 10d., leaving a profit of £9,909. 0s. 11d. Inclusive of the balance brought forward, the net revenue account shows an aggregate total of £11,158. 5s. 2d. After making provision for the debenture and debenture stock interest, a balance remains available for dividend of £7,499. 1s. 8d., out of which the Directors recommend that the full dividend of 5 per cent. per annum be paid on the Preference shares, and that a dividend at the rate of 1⅛ per cent. per annum be paid upon the Consolidated Ordinary Stock, leaving a balance of £1,072. 5s. 6d. to be carried forward to the next account. The number of passengers, exclusive of season-ticket holders, carried during the half-year was 3,192,672, against 3,172,438 for the December, 1895, half-year, and 3,113,199 for the corresponding half-year of 1895, realising £24,021. 13s., £23,780. 3s. 7d., and £23,711. 5s. 8d. respectively.

The exceptionally mild winter, and the extremely fine weather since experienced have, there can be no doubt, militated against the traffic of the line; and it is satisfactory that, in spite of these adverse conditions, the returns for the half-year show an increase, both in the number of passengers carried, and in the amount of receipts.

The alterations at the City station have proved, as was anticipated, of considerable advantage in coping with the traffic in the busy hours of the day. The new coaches and the locomotive constructed in the Company's own shops, are now in use with satisfactory results. The generating plant, locomotives and rolling stock have been well maintained, and are in good working order and efficiency. During the half-year a further sum of £8,400 Five per Cent. Terminable Mortgage Bonds has been paid off. The erection of the condensing plant is now proceeding rapidly. This work has been somewhat delayed through the anxiety of your Directors to avail themselves of the latest improvements with the view of obtaining as perfect an apparatus as possible. Active steps are now in progress for the acquisition of the sites required for the stations at London Bridge and Finsbury Pavement, and tenders have been invited for the construction of the works.

The 20,000 Five per Cent. Perpetual Preference shares have all been placed at a considerable premium, it being stipulated that no dividend shall accrue upon those shares until after January 1, 1899, by which time it is expected the extension will be finished and open for traffic.

The Bill for the extension of time for the completion of the works authorised by the Company's Act, 1893 (Islington Extensions), have been considerably delayed owing to the opposition to the powers granted by the original Act for the acquisition of the site of St. Mary Woolnoth Church. This opposition having been overcome, it is hoped, however, that the Bill will now meet with no further opposition during its remaining stages.

## Crompton and Co. (Limited).

The report of the Directors of this Company, to be presented at the meeting of shareholders to be held at Cannon Street Hotel, London, E.C., on Monday next, at 3 o'clock p.m., states that by the fire at the Chelmsford Works the offices of the Company were, with the whole of their contents, including all the books of account there, and drawings, utterly destroyed, and as a consequence the Directors are unable to present the usual statement of profit and loss for the past year. The Directors have thought it best to have a complete re-valuation made of all the Company's property and assets as at March 31st last, and the statement so prepared they now submit to the shareholders. The loss of property by the fire has been made good by the insurance companies, and the amount has been partly re-invested in similar assets, leaving a balance of £26,585, which has been placed on deposit to be applied only in restoration.

Owing to the growth of the business and the demand of the insurance companies that the generating station for the lighting of Chelmsford should be detached from the manufactory, it has been decided, after careful consideration, that it is advisable to construct new works upon a more convenient site, and they have, accordingly, purchased nine acres of freehold ground adjoining the railway at Chelmsford, and contracts have been let for the erection of commodious works with a siding on to the railway. The Directors believe that these works, situated on the main line of railway and fitted with all modern appliances, will place the Company in a far more favourable position for manufacturing economically and rapidly than it could ever have attained at the old site.

The Chelmsford Electric Lighting Company (Limited) is making very satisfactory progress. The supply station has hitherto formed part of the manufacturing premises of this Company, and a fixed charge per unit has been made for current supplied to the Lighting Company. It is now, however, proposed that the electricity station which is being re-erected and equipped after the fire shall be sold outright to the Lighting Company, which will thenceforward carry on its own business independently.

Although the insurance companies have paid for the property actually destroyed by the fire, the consequential damage to the Company has been very great. Owing to the serious interruption to the business, and the greatly

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increased costs of manufacturing in temporary premises since the fire, a heavy loss has been incurred by the Company.

The statement of accounts now presented shows a balance of £10,051. 0s. 11d. to the debit of the revenue account, to which must be added £1,000 as a provision for doubtful debts; and, as this loss is entirely owing to the exceptional circumstance of the fire, the Directors propose to place the amount to a suspense account.

The Directors report that the order book of the Company is so full that a larger number of men are employed at Chelmsford than has ever been necessary before, and the prospects for the future are most satisfactory and encouraging.

Viscount Emlyn has retired from the position of Chairman of the Company in consequence of his having been appointed Chairman of the Great Western Railway. The Board have elected Mr. John Trotter to fill the vacancy, and a resolution will be submitted confirming this appointment.

Mr. Carlton F. Tufnell also offers himself for re-election as Director, as do the auditors, Messrs. J. H. Duncan and Co.

## Edison and Swan United Electric Light Company (Limited).

The thirteenth annual report of the Directors for the year ended June 30th, to be presented at the meeting at the Cannon-street Hotel, E.C., on Friday next, at 2 p.m., states that the profit and loss account, after writing down considerable amounts for depreciation of plant and stock, shows a credit balance of £27,526. 12s. 9d., of which £23,026. 12s. 9d. is now available for distribution. An interim dividend of 5 per cent. per annum having already been paid in respect of the half-year ended December last, a further payment of 5 per cent. per annum in respect of the second half is now recommended; the balance of £5,352. 14s. 9d. being carried forward. Notwithstanding the severe competition now existing in the trade, the volume of business during the past year (the report states) has been larger than in any former period; but the increase in the cost of material and labour, the lowering of the sale prices of many articles, and the check to the Company's manufacture consequent upon the strike at the Ponder's End Works in the early part of the year, have somewhat adversely affected the results of the year's working.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31½d. per oz. (July 23rd). Consols (2¾ per cent.) 113⅜—113½ for money, 113 7/16—113 9/16 for account; 2½ per cent. 108—108¼ (July 23rd). Stock Exchange Settling Days: Consols, Aug. 4th; Stocks and Shares Continuation Days, July 28th and Aug. 11th; Ticket Days, July 29th and Aug. 12th; Pay Days, July 30th and Aug. 13th; Mining Share Carry-over Days, July 27th and Aug. 10th.

**ALUMINIUM COMPANY (LIMITED).**—Letters of allotment in respect of the recent issue of Four and a-Quarter First Mortgage Debenture Stock of this Company have, it is stated, been posted.

**BIRMINGHAM CENTRAL TRAMWAYS COMPANY (LIMITED).**—An extraordinary general meeting of the shareholders of this Company was held at Birmingham on Monday, when the agreement for the sale of the Company's lines to the Canadian Syndicate was approved. The purchasers take over the entire undertaking of the Company in return for a cash payment to each holder of a £100 debenture of £100, to each holder of a £10 Preference share of £10, and to each holder of a £5 Ordinary share of £5, plus a bonus of £1 per share, with the option of each debenture-holder of taking a corresponding amount of Four per Cent. debentures in the new Company, to every Preference shareholder of taking Five per Cent. Preference shares, and to every Ordinary shareholder of taking debentures or Preference shares to the amount of the cash due to him. In addition, 13,000 Ordinary shares of £5 each in the new Company are to be set apart for the Ordinary shareholders only, to be exchanged at par, so that each Ordinary shareholder may still retain one-third of his present holding in the Ordinary share capital of the new Company.

**BROCKIE-PELL ARC LAMP (LIMITED).**—A Company under this title has been formed, with a capital of £80,000 in £1 shares, to acquire the inventions of Messrs. James Brockie and Bennett Pell, for the construction of electric arc lamps, with the rights of all improvements which the inventors may make or acquire in connection with such lamps, for all countries and colonies, with the exception of Canada and the United States. The Company further acquires the goodwill attaching to the patents and the business connected therewith; and as the patents under which the lamps are made chiefly centre in those of 1893 and 1894, and especially in patents of 1895 which have already received provisional protection, it will be seen the Company thus acquires a very valuable asset. It is intended early next week to invite applications for 50,000 Ordinary shares, payable 5s. per share on application, 5s. on allotment, and the balance as and when required. Of the balance of 30,000 shares, 25,000 are taken by the vendors and 5,000 are reserved for future issue. The directorate of the Company is a strong one, and includes the Chairman of the Westminster Electric Supply Corporation (Lord Suffield), the Hon. Reginald Brougham (a Director of the London Electric Supply Corporation), and Mr. Bennett Pell, who acts as Managing Director, while Mr. James Brockie serves the Company as electrician and superintendent of the works which are to be established to manufacture the lamp. The merits of the Brockie-Pell arc lamp are too well known to our readers to need recapitulation here. The lamp has been before the trade for many years, and the particulars which will appear in the prospectus about to be issued include a list of numerous Government Departments, municipalities, and leading electric light supply companies and contracting firms who are users or buyers of the lamps. This list is a formidable one, and embraces all probable trade users as well as a large number of representative business houses who have installed the electric light and have adopted the Brockie-Pell lamp, in most cases after careful tests of its suitability for the special requirements which the arc light has to fulfil. The fact that Messrs. Brockie and Pell have been intimately associated with the manufacture of the lamp stands also to the benefit of the new Company, which is launched with every prospect of a successful career. The report (dated May 18th last) of Dr. John Hopkinson, who is consulting engineer to the Company, fully confirms reports previously made as to the efficiency of the lamp. The Company is modestly capitalised, and a copy of the prospectus which we have seen gives more than usually complete particulars regarding the patents, &c.

**CHARING CROSS AND STRAND ELECTRICITY SUPPLY CORPORATION (LIMITED).**—This Company have, this week, invited subscriptions for 10,000 Four and a-Half per Cent. Preference shares of £5 each, at par, payable 10s. per share on application, and £1 10s. on allotment, one month after allotment, and two months after allotment. The object of this issue is to provide funds to meet the outlay for the erection of a new station and machinery at 85, Commercial-road, and also for the laying of mains in the Strand district, and for other purposes. The prospectus gives statistics which show a progressive revenue derived solely from the supply of electrical energy within the parish of St. Martin's-in-the-Fields. The lampage, for the half-year to June 30th, shows an increase of 647 lamps during the half-year. The list opened and closed on Wednesday last for London applications, and on Thursday, at 12 noon, for the country.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended July 19th were £857, against £831 in the corresponding week of 1895, an increase of £26. The total receipts for the half-year amount to £2,675, against £2,594 for the corresponding period of 1895, an increase of £81.

**KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY (LIMITED).**—The Directors of this Company have declared an interim dividend at the rate of 6 per cent. for the past half-year on the Ordinary shares, payable August 1st. The transfer books are closed till the 31st inst.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 19th inst. amounted to £1,267. The amount for the corresponding week last year was £1,226; increase, £41.

**LIVERPOOL UNITED TRAMWAYS AND OMNIBUS COMPANY (LIMITED).** At the meeting of the shareholders on Saturday, the Chairman, Sir David Radcliffe, referred at length to the relations of the Company with the Corporation. They had been approached by the Health Committee with a view to ascertaining whether, if some efficient means of mechanical traction were proposed by them, they would be prepared to consider the question of introducing it on their lines and on the various extensions which were asked for by the representatives of the outer districts. The Directors were ready to move with the times in the matter of mechanical haulage, provided it was perfectly clear that not only the public and the Corporation should be benefited, but also that the proprietors should reap some advantage, or at least not suffer by so doing. Yet, without any alteration in the mode of haulage, and provided the results were equal to those of the past thirteen years, they felt that they were, for upwards of eighteen years to come, reasonably safe for a dividend. They could not, therefore, agree to imperil their position. With regard to mechanical haulage, the systems they had tried up to the present had not been a commercial success. He hoped the Corporation were on the right lines in getting at something that they could recommend the Company to adopt. If they did obtain anything of the kind the shareholders and the public generally might rest assured that the Directors would soon give it a trial. Now that the Corporation are in possession of the electric light works, they could not do better than formulate a scheme for the introduction of electric traction on the entire tramway system of the city. The Leeds Council are equipping their tramways electrically; the Glasgow and Portsmouth Councils have already decided in favour of electric traction; while Swansea, Southampton and other Councils are discussing the advisability of adopting electricity.

**METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).**—Letters of allotment for the recent issue of 12,500 Ordinary shares have been posted by this Company.

**ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).**—The share transfer books of this Company are closed till the 5th prox.

**STOCK EXCHANGE NOTICE.**—Application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, the River Plate Electric Light and Traction Company (Limited) for the provisional certificates for £125,000 Five per Cent. First Debenture Stock.

**WEST AFRICAN TELEGRAPH COMPANY (LIMITED).**—The numbers are published of 123 Five per Cent. Mortgage debentures of £100 each of this Company, which were drawn on the 20th instant for payment at par, on September 1st next, at the National Bank of Scotland, Nicholas-lane, E.C., after which date interest ceases.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended 17th July, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,762.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half-month ended July 15th are £1,881, against £1,678 in the corresponding period of 1895.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, July 15. | | Price Wednesday, July 22. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending July 18. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American ..... xd | 50 | 52 | 50 | 52 | 4 16 2 | Jan., Apr., July, Oct. | 50 | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred ..... xd | 93½ | 94½ | 94½ | 95½ | 5 4 9 | " " | 94½ | 93½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred ..... | 9 | 9½ | 9 | 9½ | .. | .. .. | 9⅝ | 9 |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) ... | 100 | 104 | 100 | 104 | 3 16 11 | January and July .. | 101½ | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) ..... | 9 | 10 | 9 | 10 | .. | .. .. | 9⅜ | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine ..... | 15 | 15½ | 15½ | 15⅝ | 4 8 11 | Mar., June, Oct., Dec. | 15½ | 15⅛ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) .... | 111 | 115 | 112 | 116 | 4 6 7 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock ..... | 160 | 170 | 160 | 170 | 4 2 4 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine ..... | 12½ | 13½ | 12½ | 13½ | 5 18 6 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. ..... | 20 | 21 | 20 | 21 | 4 5 3 | " " | .. | — |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) ..... | 3½ | 4½ | 3½ | 4½ | 5 0 0 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. ..... | 10 | 10½ | 10 | 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each ..... | 106⅞ | 109⅞ | 107⅞ | 110⅞ | 4 2 0 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 ..... | 9¼ | 10¼ | 9¼ | 10¼ | 4 3 0 | Jan., Apr., July, Oct. | .. | .. |
| 400,000 | 10 | 2/6 | Eastern ..... | 17½ | 17¾ | 17⅞ | 18⅛ | 3 11 2 | " " | 17⅝ | 17½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference ..... | 18½ | 19 | 18½ | 19 | 3 3 2 | " " | .. | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock .... | 131 | 134 | 131 | 134 | 2 19 10 | May and November | 133 | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1839 ..... | 106 | 109 | 106 | 109 | 4 13 6 | February & August | 108½ | .. |
| 250,000 | 10 | 2/6 | Eastern Extension ..... xd | 17½ | 18 | 17⅞ | 18⅛ | 3 16 9 | Jan., Apr., July, Oct. | 18 | 17½ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock ..... | 132 | 136 | 132 | 135 | 3 0 2 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900 .. | 100 | 104 | 100 | 104 | 4 16 2 | January and July .. | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 .. | 100 | 104 | 100 | 104 | 4 16 2 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) .. | 106 | 109 | 106 | 109 | 3 13 11 | February & August | 112 | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) ..... | 111⅞ | 114⅞ | 111⅞ | 114⅞ | 3 10 8 | May and November | .. | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust ..... | 11 | 11½ | 11 | 11½ | 3 13 11 | Jan., Apr., July, Oct. | 11½ | 10⅛ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference ..... | 17¼ | 18 | 17⅜ | 18⅛ | 3 5 9 | " " | 17⅜ | 17⅛ |
| 150,000 | 10 | 5/0 | Great Northern ..... | 23½ | 24½ | 23½ | 24½ | 4 1 8 | Jan., April, and July | .. | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue ..... | 105 | 108 | 105 | 108 | 4 14 1 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European ..... | 53 | 53 | 53 | 56 | 4 9 3 | May and November | 54½ | 54½ |
| 37,548 | 10 | .. | London Platino-Brazilian ..... | .. | .. | .. | .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures ..... | 111 | 114 | 111 | 114 | 5 7 2 | March & September | .. | — |
| £100,000 | £100 | 4% | *Pacific European Tel.4% Guar. Debs. "Red" 1942 .. | 106 | 109 | 103 | 111 | 3 12 3 | .. .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's ..... | 7 | 8 | 7 | 8 | 5 0 0 | April and October .. | 7⅛ | 7⅛ |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. ..... | 135 | 140 | 137 | 142 | 4 4 6 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph ..... | 7 | 8 | 6 | 7 | 4 5 9 | January and July .. | 7½ | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) ..... | 103 | 106 | 104 | 107 | 4 15 3 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America ..... | 1 | 2 | 1 | 2 | .. | January and July . | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 ..... | 93 | 103 | 99 | 104 | 7 14 7 | June and December | — | — |
| 88,321 | 10 | 0/6 | West India and Panama ..... | 1⅛ | 1⅜ | 1⅛ | 1⅜ | .. | .. .. | .. | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference ..... | 11¼ | 11½ | 11½ | 12 | 5 0 0 | May and November | 11⅝ | 11⅛ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference ..... | 9½ | 10½ | 9½ | 10½ | 5 14 3 | " " | 9⅝ | — |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) .... | 107 | 110 | 108 | 111 | 4 10 6 | June and December | .. | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian ..... | 8½ | 9½ | 8½ | 9½ | 4 17 7 | May and November | 9½ | 8½ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred ..... | 6¾ | 7½ | 6¾ | 7½ | 5 3 8 | — | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary ..... | 2½ | 2¾ | 2½ | 2¾ | .. | — | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 .... | 105 | 109 | 105 | 109 | 5 12 11 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 ..... | 105 | 109 | 105 | 109 | 5 12 11 | " " | — | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds.... | 110 | 115 | 110 | 115 | 6 2 10 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) ..... | 102 | 105 | 104 | 107 | 5 14 10 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | | | |
| 44,000 | 5 | 2/6 | Chill Telephone (fully paid) ..... | 3½ | 3¾ | 3⅝ | 4 | .. | — | — | .. |
| 224,850 | 10/0 | 1¼d. | Consolidated Telephone Const. & Manufacturing xd | 1/16 | 1/8 | 1/16 | 1/8 | .. | May and November | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) .... | ⅜ | ⅝ | ⅜ | ⅝ | .. | Yearly ..... | .. | .. |
| 484,597 | 5 | 3/0 | National ..... | 7⅛ | 7⅜ | 7⅛ | 7⅜ | 5 14 3 | " " | — | — |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. ..... | 17 | 19 | 17 | 19 | 3 9 10 | June and December | 7½ | 7⅜ |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid).... | 16 | 17 | 13 | 17 | 3 3 2 | " " | .. | — |
| 119,334 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. ..... | 6⅞ | 7½ | 6⅞ | 7½ | 3 10 7 | " " | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) ..... | 105 | 108 | 107 | 110 | 3 10 2 | — | 7½ | 6⅝ |
| 53,000 | 5 | 4/0 | United River Plate ..... xd | 3¾ | 4½ | 3¾ | 4½ | 2 19 3 | January and July .. | 108 | 105½ |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) ..... | 101 | 103 | 101 | 103 | 4 11 4 | July ..... | .. | .. |
| | | | | | | | | | January and July . | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) .... | 14½ | 15½ | 14½ | 15½ | 3 4 6 | February & August | 15 | — |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid).... xd | 16½ | 17½ | 16½ | 17 | 3 10 7 | January and July .. | 17 | — |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) ..... | 133 | 137 | 133 | 137 | 2 13 0 | June and December | 13½ | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain ..... | .. | .. | .. | .. | .. | — | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. .. | 8½ | 8¾ | 8½ | 8¾ | .. | — | 8¾ | 8⅞ |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 ..... | .. | .. | .. | .. | .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8½ | 9½ | 8½ | 9½ | .. | — | 9 | — |
| £10,000 | £10 | 5 4½ | Do. Pref. (fully paid) ..... xd | 13 | 13½ | 13½ | 13⅝ | 4 7 3 | — | 13⅞ | 13⅝ |
| 8,322 | £5 | .. | House-to-House Electric ..... | .. | .. | .. | .. | .. | — | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid). | — | — | — | — | .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) ..... | — | — | — | — | .. | January and July .. | — | — |
| 45,000 | £5 | — | Liverpool Electric Supply (fully paid) ..... | .. | .. | .. | .. | .. | — | — | — |
| 111,000 | 5 | .. | London Electric Supply ..... | ⅞ | 1⅛ | ⅞ | 1⅛ | .. | — | — | — |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) ..... | 11½ | 13½ | 13½ | 14 | 2 17 2 | — | 13½ | 13⅜ |
| £1 00 0 | Stock | 4½% | * Do. 4½% Debs. ..... | 119 | 121 | 119 | 123 | 3 13 4 | June and December | .. | — |
| 6,462 | £10 | 4/0 | Notting Hill Electric ..... | 10 | 10½ | 10½ | 11½ | .. | — | — | .. |
| .. | .. | .. | Rand Electric ..... | 1⅜ | 1⅝ prem. | 1⅜ | 1⅝ prem | .. | — | — | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall ..... | 11½ | 12½ | 12 | 13 | .. | — | 12 | — |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference ..... | 9½ | 10½ | 9½ | 10½ | 3 6 8 | — | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) ..... | 10½ | 11 | 11 | 12 | 2 18 4 | — | 11½ | 10½ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 90,000 | 3 | 1/8 | Brush Electrical Engineering ..... | 1⅝ | 1⅞ | 1 | 1½ | .. | — | 1⅝ | 1⅛ |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative ..... | 1⅝ | 1⅞ | 1⅝ | 1⅞ | .. | — | 1⅝ | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures ..... | 112 | 115 | 112 | 115 | 3 19 8 | March & September | — | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref .. | 2 | 2½ | 2 | 2½ | .. | January and July . | .. | .. |
| 84,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) .. | 1⅞ | 2⅛ | 1⅞ | 2⅛ | 6 13 4 | February & August | .. | .. |
| £110,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock ..... | 103 | 105 | 103 | 106 | 4 5 1 | January and July .. | — | — |
| £10,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) .. | — | — | — | — | .. | — | — | — |
| 110,000 | 2 | .. | Electric Construction ..... | 1⅛ | 1⅜ | 1⅛ | 1⅜ | .. | — | — | — |
| 12,845 | 2 | 2 9⅛ | Do. 7 per Cent. Cumulative Pref. ..... | 2⅞ | 3 | 2⅞ | 3 | 4 13 4 | September ..... | .. | — |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing ..... | ⅝ | ¾ | ⅝ | ¾ | .. | — | — | — |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) ..... | .. | .. | .. | .. | .. | — | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works ..... xd | 21 | 23 | 21 | 23 | 4 6 11 | February & August | 22½ | 22 |
| £200,000 | 100 | .. | * Do. 4 per Cent. Debentures ..... | 105 | 108 | 105 | 108 | 5 14 1 | March & September | .. | .. |
| 15,995 | £10 | .. | International Okonite Ordinary ..... | .. | .. | .. | .. | .. | .. .. | — | — |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference ..... | — | — | — | — | .. | December and June | — | — |
| 20,000 | £5 | £5 | Manchester Edison-Swan "A" (£1 10s. paid) .... | ⅝ | ¾ | ⅝ | ¾ | .. | .. .. | .. | — |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance ..... xd | 37 | 40 | 37 | 40 | 4 7 10 | March and July..... | 40 | 38½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds ..... | 102 | 105 | 102 | 105 | 4 15 3 | January and July . | .. | — |
| 37,514 | £5 | — | Woodhouse and Rawson Ordinary (£3 15s. paid).. | .. | .. | .. | .. | .. | .. .. | .. | — |
| 41,098 | £5 | .. | Do. Preference (fully paid) ..... | .. | .. | .. | .. | .. | .. .. | .. | — |
| £100,000 | 10 | 10 0 | W. T. Henley's Telegraph Works Ordinary ..... | 17½ | 18½ | 17½ | 18½ | 4 10 1 | March & September | 18⅜ | .. |
| £30,000 | 10 | 7 0 | Do. 7 per Cent. Preference ..... | 17 | 18 | 17½ | 18½ | 3 15 8 | .. .. | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock ..... | 109 | 114 | 109 | 114 | 4 0 0 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. ..... | 44 | 46 | 45 | 47 | 2 13 2 | January and July .. | 45½ | 45 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference ..... | 14½ | 15½ | 14½ | 15½ | 3 6 5 | " " | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture ..... | 135 | 137 | 135 | 137 | 2 18 5 | May and November | .. | .. |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway ..... | 13⅜ | 14 | 13½ | 14⅛ | 2 2 6 | — | — | — |
| 10,000 | 10 | 5% | Do. 5% Preference ..... | 17⅛ | 17⅝ | 17⅛ | 17⅝ | 2 16 10 | — | — | — |
| 125,000 | Stock | 4% | Do. 4% Debentures ..... | 112½ | 114½ | 112½ | 114½ | 3 9 10 | January and July .. | — | — |

* In calculating the yield on this security, allowance has been made for accrued interest but *not* for redemption.

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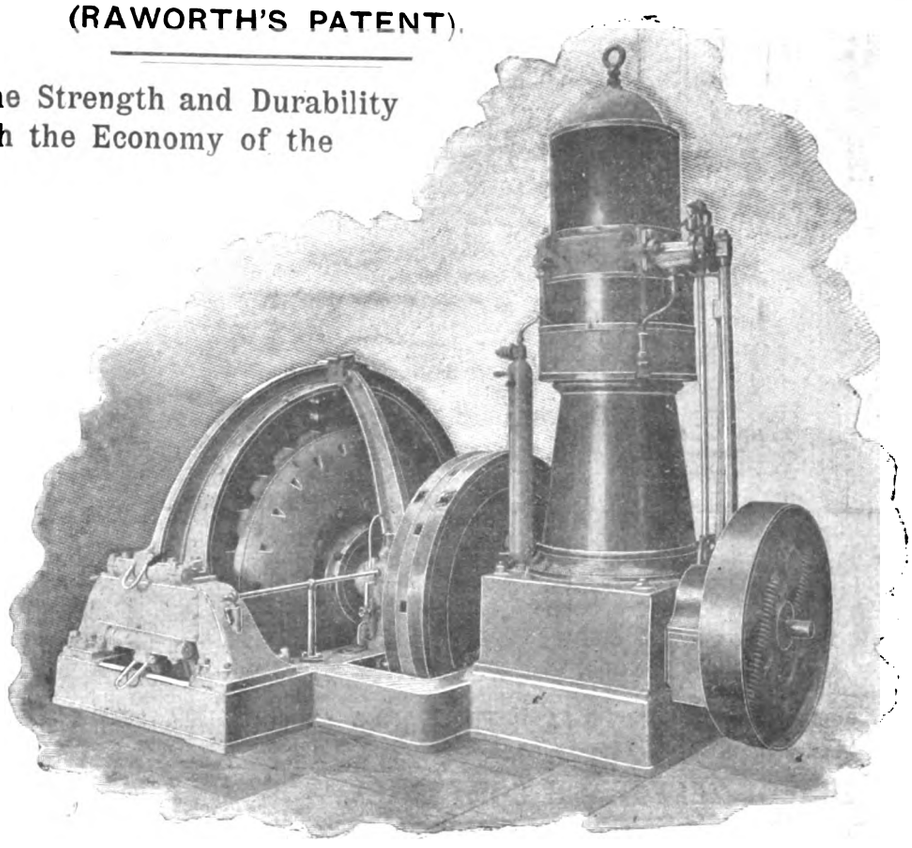
# THE UNIVERSAL ENGINE

(RAWORTH'S PATENT).

This Engine combines the Strength and Durability of the Corliss Engine with the Economy of the High Speed Engine.



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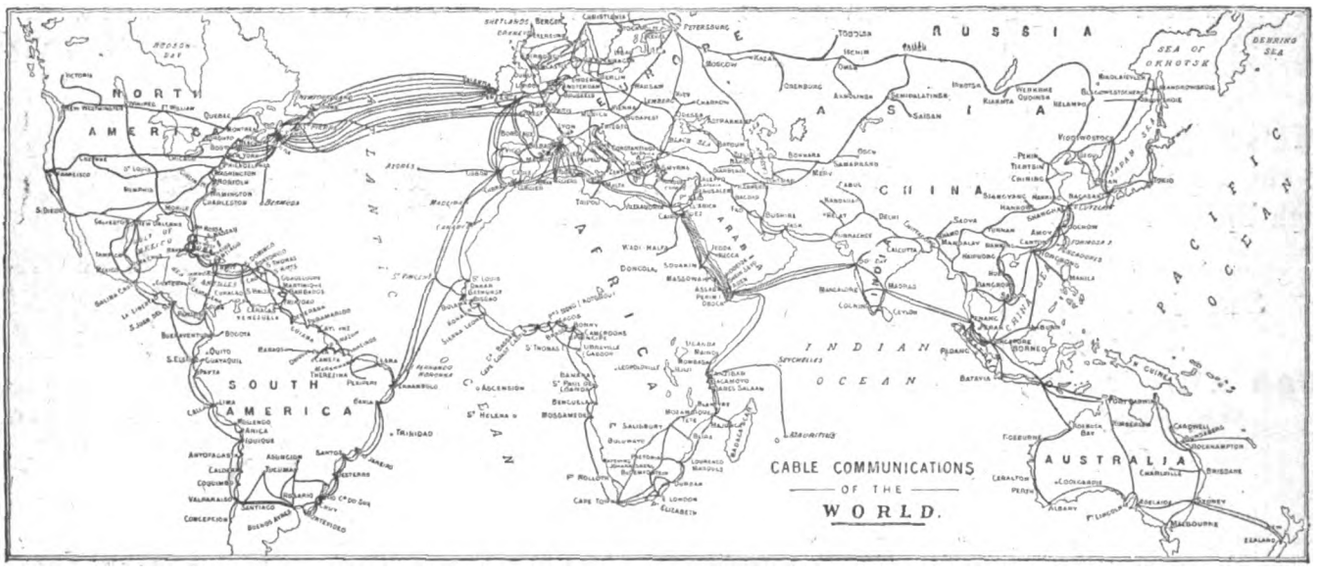


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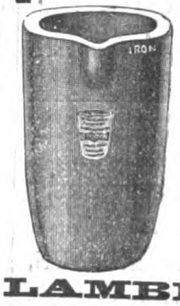


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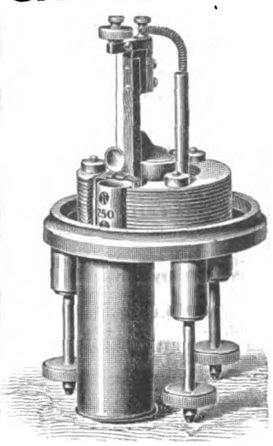

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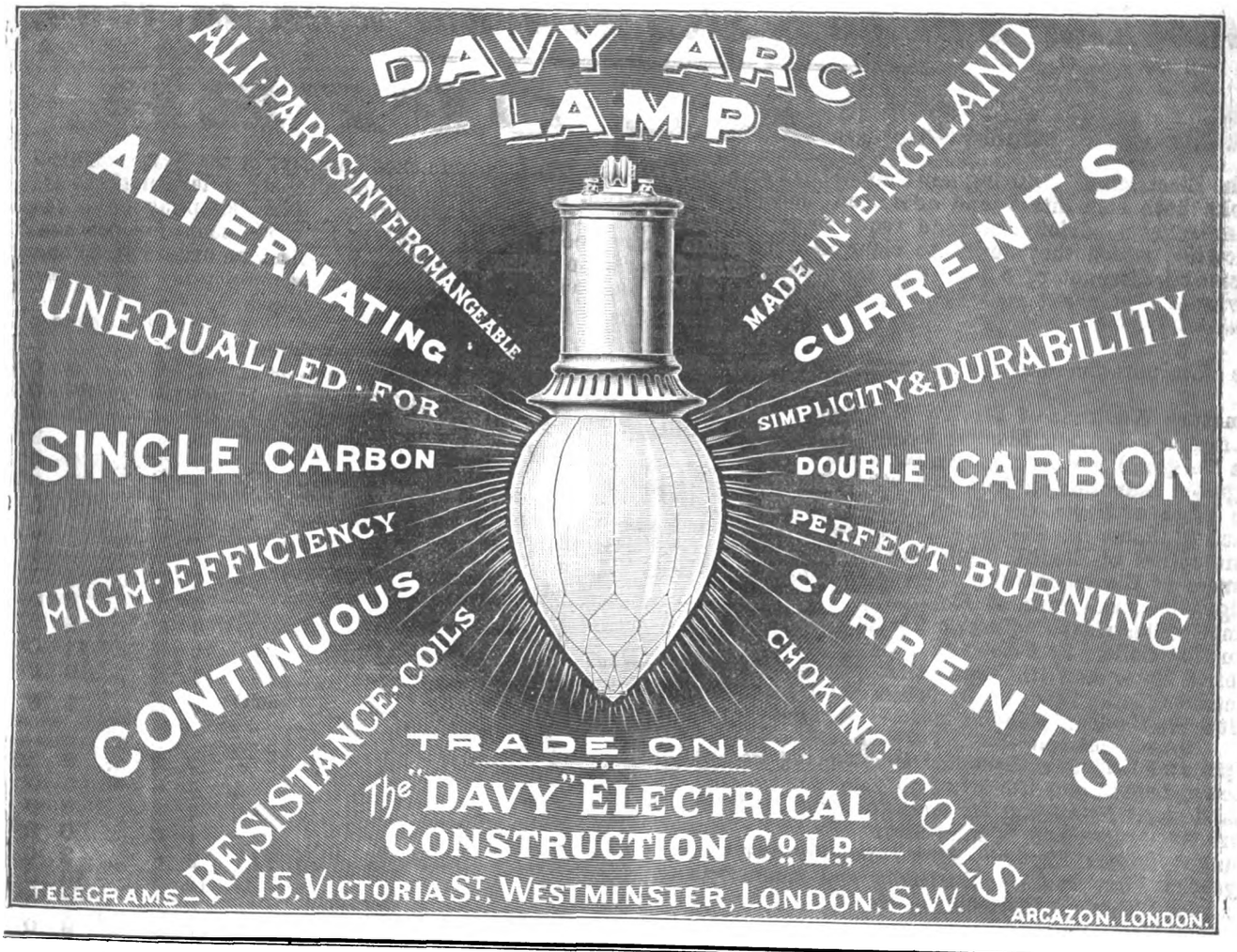


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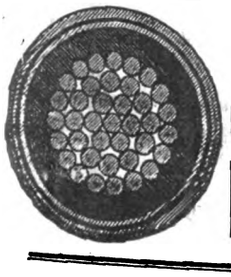

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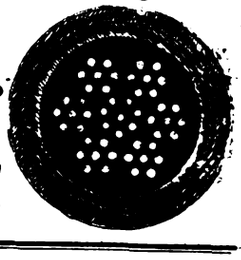

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| **Drum Armatures and Commutators.** By F. M. WEYMOUTH ... | ditto | ... | 7 | 6 | ... | **6** | **0** |
| **Bromley Holmes' Electric Light Popularly Explained** ... | **Unsoiled** | ... | 1 | 0 | ... | **0** | **8** |
| **Maycock's First Book of Electricity and Magnetism** ... ... | ditto | ... | 2 | 6 | ... | **2** | **0** |
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| **Boult's Comprehensive International Wire Tables for Electric Conductors** | | ... | 5 | 0 | ... | **3** | **9** |
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| Ditto ditto For pocket. ... ... ... ... ... | ... ... ... ... | ... | 2 | 6 | ... | **2** | **0** |
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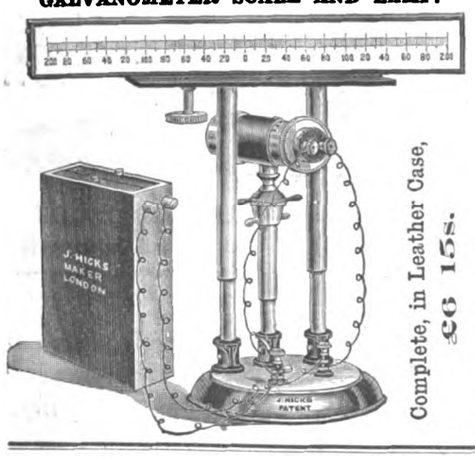

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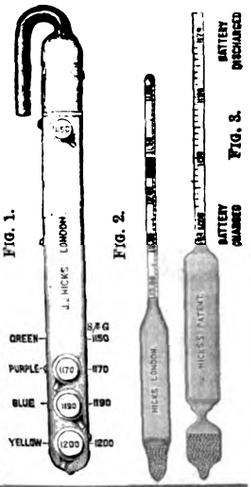

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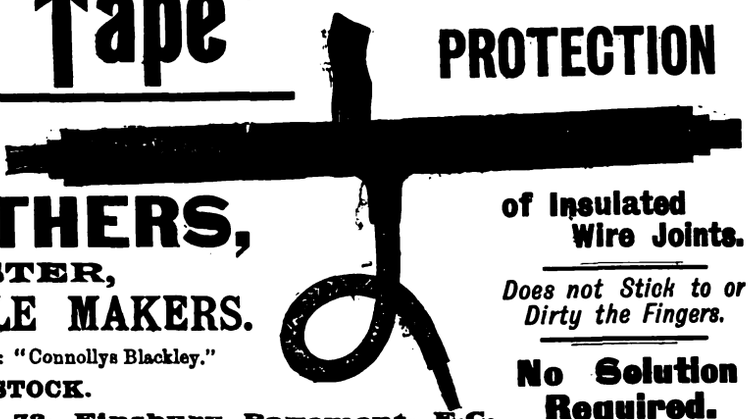

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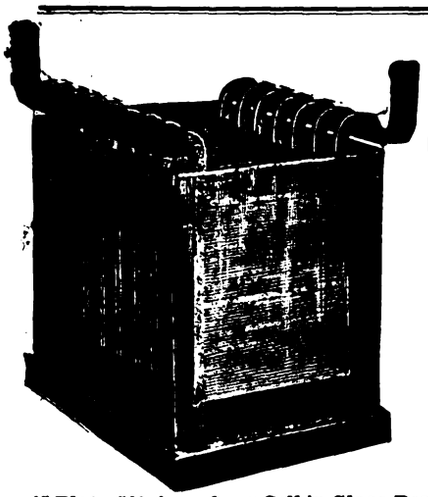

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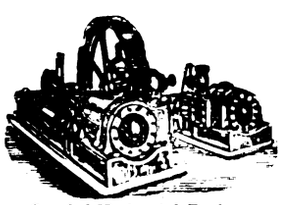

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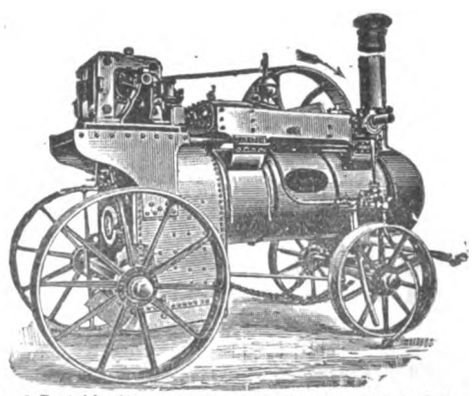

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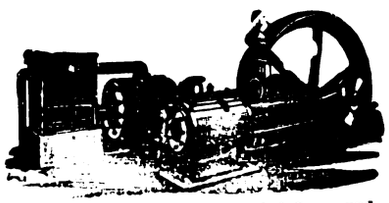

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 950. [Vol. XXXVII. No. 14.] FRIDAY, JULY 31, 1896. PRICE SIXPENCE.


## NOTES.

THE Judicial Committee of the Privy Council has refused to sanction the prolongation of the WILLANS patent, No. 4,901 of 1882, and the patent therefore expires on October 14th next. Their lordships were unable to arrive at the conclusion that this patent had produced an inadequate reward, and upon this ground alone their judgment was based. The only opposition raised against the petition for prolongation came from the CROWN, and the ATTORNEY-GENERAL, while admitting the high merits of the invention concerned, insisted that the profits made by the WILLANS AND ROBINSON COMPANY during the past thirteen or fourteen years represented a large reward, which could not be dissociated from the patentees' interest in this patent. Mr. FLETCHER MOULTON ably pressed upon the notice of their lordships the fact that, through the belated interest which the public has taken in electric lighting, many of the earlier years of the patent were passed in comparative unprofitableness. But the supreme position which the WILLANS engine has since gained for itself caused the Committee to turn their blind eye upon its early struggles.

WE are inclined to think that, after all, this judgment will do no injury to WILLANS AND ROBINSON LIMITED. The real master patent is that which controls the central valve, and this will hold the market for the engine for another three years. It makes little or no difference whether the engine is fitted with a patent air-buffer or with an air-buffer that is not under patent protection, so long as the exclusive right to manufacture the *tout ensemble* is retained, as it will be for some time to come. Meanwhile it must be somewhat satisfactory to electrical engineers to reflect that it is entirely by reason of the recent development of the electric supply industry that this engineering manufacturing concern has been able to make such an excellent showing in regard to profits, even when these are averaged over a period of fourteen years.

THE investing public is said to be at its wits' end to find suitable investments for its superfluous cash, and the electrical industry has this week made two modest attempts to ease the strain. On Monday subscriptions were asked for Brockie-Pell Arc Lamp (Limited). This concern has been formed to take over the business of manufacturing this excellent and well-known lamp from Messrs. JOHNSON AND PHILLIPS, and to acquire all the related patents. The capital of Brockie-Pell Arc Lamp (Limited) has been fixed at £80,000, of which the vendors take £60,000 (payable as to £30,000 in cash). Those responsible for the prospectus hold out hopes of "a total dividend of at least 17½ per cent. per annum." We sincerely trust that this sanguine anticipation will be realised, and that the basis of the business will be broadened as soon as possible, since a company engaged in the manufacture of a single article is peculiarly subject to vicissitudes of fortune. On Wednesday Callender's Cable and Construction Company came before the public. The objects of this enterprise are to acquire the well-known and well-established business of Callender's Bitumen, Telegraph and Waterproof Company, which it does for £100,000 in Ordinary shares, and to raise £90,000 in Four and a-Half per Cent. Debentures, of which £40,000 are to be allotted to the old Company in exchange for its debentures, only the modest balance of £50,000 being offered to the public at 103, with a view to provide for extension of premises and plant. No vaticinations are made as to the future, but ample figures are given to enable anyone at all conversant with the position and business of the old concern to make his own deductions. The thoroughly straightforward start of Callender's Cable and Construction Company is a good omen. The money asked for was, we are informed, in both cases well subscribed.

THE delightful tangle into which patentees, patent officials and judges can work themselves by a full and free use of the system of "interferences" permitted by the Patent Laws of the United States is well brought out in an article on "The Berliner Controversy," to be found elsewhere in the present issue. With us officials have little or no power to retard or hasten the granting of a patent. An interested outsider has to take the matter up himself if he wishes to prevent a patent being sealed, and it is necessary for him to have an extraordinarily strong case to succeed in his object, the maxim which would appear to govern the Comptroller and the Law Officers being, "when in doubt grant the patent." And this is a custom based on common sense. If a grant be refused, an applicant for a patent is left entirely without remedy. The validity of a patent, on the other hand, can always be contested at any time in the course of its fitful existence. In short, our disinclination to stop the issue of patents is part and parcel of our general system of allowing the value and validity of patents to be tested in fair fight in the open. We do not suggest that there are no drawbacks to

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this free and easy method of granting patents; but we have yet to learn wherein lie the overwhelming advantages of the more pedantic procedure which obtains across the Atlantic.

Our contemporary, the *Engineer*, has struck a true note in the question of smoke abatement in manufacturing cities. Practically it is this: smoky chimneys pay! It is easy enough to stop a furnace from developing smoke; no elaborate patent contrivances are necessary; it is sufficient to admit the proper quantity of air through the upper part of the fire door. Manufacturers know how to do it; they could easily do it if they chose; but they will not, because the boilers would produce less steam and work less economically, from a commercial point of view. Our contemporary admits—what indeed no engineer could intelligently deny—that there are particular instances where smoke prevention has been accompanied by enhanced economy; we could name a good many instances ourselves. But the generality of furnaces and the generality of bituminous steam coals do not admit of absolutely smokeless firing without impaired working. The high price of smokeless anthracite coals, caused by the excessive demand which their smokeless combustion encourages, bears us out in this conclusion.

The problem of smoke prevention therefore resolves itself into a revolution in the methods of obtaining power in factories. Coal-fired boilers and smokeless cities are mutually exclusive quantities. Either some alternative method of raising steam, or else some totally different source of power than steam, must be adopted. The *Engineer* suggests the former of these, and thinks that "the only way out of the difficulty lies in gas firing." No doubt furnaces for metallurgical and allied processes might advantageously be fired by gas; but we very much doubt if this is a satisfactory solution where it is a matter of obtaining power. We are more disposed to regard the abolition of steam, and the substitution of the gas engine or the electric motor, as a more probable solution.

A curious instance of the way in which the results of an investigation have to be modified when their exact meaning is understood is furnished by some recent work of Christiansen upon the contact difference of potential between mercury jets and various metals. A fine stream of mercury falls through a gas-jacket, and is caught in an iron dish below. The metals, in the form of strips, are placed within the jacket, one on each side of the stream. Christiansen supposed that an electrometer connected between the mercury reservoir and the dish, to which the plates were connected, measured the contact difference of potential between the jet and the plates, and drew up tables giving numerical values corresponding to various gases in the stream-space, and with different amalgams as the material of the stream. Wesendonck, in a short Paper in *Wied. Annalen*, 58, criticises these results, and shows that they are quite invalidated by the neglect of the electrification of the ambient air or gas by the falling drops of mercury. The investigation may not, of itself, be of much importance, and the criticism may not turn out to be justified by direct observation; the question at issue, however, affords a striking example, and one which is much wanted just now, of the care which ought to be taken in assuring ourselves of the significance of a deflected instrument, before we give to its readings a crystallised meaning. With a very slight alteration of Huxley we can say, "An electrical measuring instrument may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends upon what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result from loose data."

**Scientific Honours.**—M. Berthelot has received (not as ex-Minister for Foreign Affairs but as chemist) the Grand Cross of the Legion of Honour.

**A Curious Research.**—In the *Electrical World* of New York Mr. F. Bedell and Mr. J. E. Boyd have recently described their researches on the "Effects of Hysteresis and Foucault Currents on Polar Diagrams."

**South-West London Polytechnic Institute.**—The technical day classes in Mechanical and Electrical Engineering of this Institute commence on September 29th. Some additional particulars will be found in another column.

**University College, London.**—The 1896-7 Session commences on October 6th. Particulars of the courses (arranged to cover two and three years) in electrical, mechanical and civil engineering, &c., appear in our advertisement columns.

**Cable Interruptions and Repairs:—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique ..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Lourenco Marques—Durban..... | July 13, 1896 ... | July 25, 1896. |
| Nagasaki—Gutzlaff ..... | July 22, 1896 ... | — |
| Gibraltar—Tangier..... | July 28, 1896 ... | — |

**The Production and Utilisation of Ozone.**—On page 403 of our last issue we described and commented upon the ozone-generating apparatus of the Electric Ozone Syndicate (Limited). Mr. Andreoli, the inventor of these devices, takes exception to our remarks, and has addressed us a lengthy letter on the subject, which we have been compelled to hold over until our next issue.

**Baker-street and Waterloo Electric Railway.**—Lord Morley's Committee of the House of Lords has passed the Bill sanctioning an extension of the authorised Baker-street and Waterloo Railway, so as to place this railway in connection with the London terminus of the Manchester, Sheffield and Lincolnshire Railway Company. For this purpose additional share and loan capital is sanctioned to the extent of £100,000. This Bill has now been sanctioned by both Houses.

**Plant for Electrolytic Work.**—The Westinghouse Electric and Manufacturing Company, says the *Engineering and Mining Journal*, recently shipped eight carloads of electric apparatus to the Boston and Montana Consolidated Copper and Silver Mining Company for electrolytic purposes. The shipment comprised two 1,100 H.P. generators, each delivering 4,500 amperes at 180 volts. The Westinghouse Company has also recently furnished the Anaconda Copper Mining Company with seven 360 H.P. generators, also for electrolytic work.

**The Telegraph in the Nile Campaign.**—In a letter dated Ferkeh, June 28th, the *Times* correspondent stated that the telegraph had reached Suarda. The non-insulated wire is not suspended on posts, but is merely laid on the dry desert sand. Captain Manifold, R.E., who has with such creditable rapidity placed the base in telegraphic communication with the advanced post, states that never before has an attempt been made to telegraph with a Morse instrument along so great a length of wire laid on the bare ground.

**Priority and Coal Dust.**—We have received from Prof. Galloway a printed communication, in which he endeavours to establish against certain rivals his claim to priority in the matter of having first thought of coal-dust as a cause of explosion in collieries. It is hardly an interesting matter, such a question as this; it would be much more to the point if Prof.

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Galloway or someone else could establish a claim to priority in the matter of a successful means of preventing explosion in collieries, whether of coal-dust or other explosive.

**Money-making Push Buttons.**—An American electrician, finding it hard to make money as a wireman, has invented a bicycle track, 100ft. long and 10ft. wide, over which are distributed a number of electric push buttons. The buttons are depressed by a cycle passing over them, and actuate a row of annunciators. The public is invited, for a consideration, to ride over the track, and the rider who is successful in depressing all the buttons gets 50 cents. It is expected that this will become a popular amusement at seaside and other pleasure resorts.

**Dangerous Trades.**—The Departmental Committee appointed to inquire into certain dangerous trades have just issued an interim report, covering 33 pages. Although the Committee were directed to investigate the conditions of work in "electric generating works," it has not been found possible to include in the present publication the Committee's "observations and recommendations" under this head. The only remarks made by the Committee which are of immediate interest to the electrical industry are those (covering five pages) on india-rubber works.

**Lightning.**—A thunderstorm occurred at Kirton Lindsey, North Lincolnshire, on Thursday afternoon last week. During the progress of a local cricket match a flash of lightning knocked down three men, seriously injuring one.——According to a Reuter telegram dated Rome, July 29th, the Italian coast defence ship "Roma" was struck by lightning, and set on fire. As the flame seemed likely to reach the powder magazine, and also threatened to attack the coast defence ship "Palestro," which was filled with explosives, it was found necessary to sink the "Roma" by means of two torpedoes. Of all structures in the world, one would have thought an iron-clad at sea the least likely to suffer damage by lightning.

**Explosiveness of Oil Lamps.**—Sir Henry Roscoe, in giving evidence recently before the Committee on Petroleum, stated that he had experimented with three oils, viz., White Rose, Tea Rose, and Royal Daylight, and two kinds of lamp were used. After describing several experiments, Sir Henry Roscoe said that the general conclusions he had arrived at were, first of all, that the flash point was too low; second, that it was not possible to fix a practical flash point so high that all danger from fire could be avoided; third, that if the flash point were raised to 100deg. or 105deg., a considerable diminution in the number of accidents from explosion and fire might confidently be looked for; and, fourth, that the alteration suggested would not materially diminish the quantity of oil imported or alter the price.

**The Professorship of Mechanics at Finsbury Technical College.**—Mr. W. E. Dalby, who, as we announced in our last issue, has been appointed by the Executive Committee of the City and Guilds of London Institute to the Professorship of Mechanics and Applied Mathematics at the Institute's Technical College, Finsbury, rendered vacant by the resignation of Prof. Perry, has been since 1891 University Demonstrator of Mechanism and Applied Mechanics at Cambridge. Mr. Dalby served a seven years' apprenticeship in the locomotive works of the Great Eastern Railway and gained a Whitworth Scholarship in 1883. In 1884 he entered the service of the London and North Western Railway; graduated B.Sc. London in 1890, and in 1894 received the full degree of M.A. *honoris causâ* from the University of Cambridge.

**The Electrical Inspector to the Commissioners of Sewers.**—At the last meeting of the City Commissioners of Sewers, Mr. Voysey, Electrical Inspector, addressed a letter to the Court, giving certain reasons why he should be designated "Electrical Engineer," in addition to Electrical Inspector. He said in 1894 he was appointed to the position of Electrical Inspector, and since then he had been called upon to advise the Streets Committee upon electrical matters connected with the lighting of the minor streets, a question to which he had devoted much time and attention; while in other directions many of his increased duties were outside the office of Electrical Inspector. During the six years prior to his appointment the fees of a consulting electrical engineer had amounted to £1,200, or an average of £200 per annum, which had been saved by an extension of his duties. The question was referred to the Streets Committee.

**Electric Transmission at Soignies.**—The Soignies quarries, in Belgium, are worked with electrical power, generated in a central-power station. The generating plant comprises three Cornish boilers with Galloway tubes, a 350 H.P. compound low-speed engine, and two dynamos. One of the dynamos develops continuous current at 125 volts, and has a maximum output of 300 amperes. This machine is used for lighting purposes. The other dynamo is an Oerlikon three-phase alternator, developing about 200 H.P. for the motor circuits. From the power house there radiate three motor circuits, 650ft., 700ft. and 2,300ft. in length respectively. At present there are four motors of 24 H.P. each, one of 18 H.P., and one of 9 H.P., used for running sand-saws and diamond-saws. The Soignies quarries are said to be the first example in Belgium of the use of three-phase power.

**The Students of the Institution of Electrical Engineers.**—Mr. G. C. Allingham, hon. sec. Students' Committee, announces that a party of students and their friends will leave London on the evening of Saturday, August 29th, and arrive at Bâle on the following evening. It is proposed to spend one day at Bâle, one at Schaffhausen, three at Zurich, one at Lucerne, and three at Geneva. The party will probably leave Switzerland on Wednesday, September 9th, but arrangements can be made for any who wish to extend their visit beyond that date, as the railway tickets are available for 25 days. Arrangements can also be made to return by steamboat down the Rhine, which would take about two days, and would cost about £2. 10s. extra. Students who are already in Switzerland can join the party at Bâle. Mr. Webb is endeavouring to obtain permission for the students to inspect a number of the most important electrical works and installations in Switzerland. There are still a few vacancies in the party.

**A Combination Jointless Rail.**—A continuous rail with joints every 10ft. but without welding is something of a paradox, says the *Street Railway Review* of May 15th. The rail is made in three sections, the part embracing the web and flanges being split vertically through the web and the tread being in a separate piece. The parts are rolled in 30ft. lengths, and overlap each other one-third of their length. The tread section is held between the other two parts by a dove-tail joint, and the two lower or web and flange sections are riveted together to constitute a practically integral rail. It is claimed for the rail that the same results are secured as would be the case with an absolutely continuous rail, that all welding, bonding and the use of fish-plates and bolts are done away with, and that the cost of maintenance is greatly reduced, since a worn-out tread section can be replaced with a new one by simply shearing off the rivet heads and separating the base sections, making virtually a new rail at the cost of one section.

**The Cost of Electric Light and Power.**—For the past three months an interesting isolated plant has been in operation at Messrs. J. Snook and Co., of Nottingham. This plant includes a 60 H.P. water-tube boiler, two 25 H.P. engines, one 500 light dynamo, one dynamo capable of supplying 25 H.P. for the motors, four 6 H.P. electric motors, five electric fans, six electric irons, &c. The whole of the operations of lighting, ironing, heating, and ventilating in this establishment are carried on electrically. The cost of generating power for all these varied operations during the past three months has been very carefully noted, and after allowing ten per cent. for depreciation and all charges for wages, coal, water, oil, and sundries, the cost of generating amounts to one penny per unit. The whole of this installation was designed and laid down by Messrs. Lea and Warren, of Kettering. The working of this plant is being watched with considerable interest by manufacturers; and as showing their appreciation of the result obtained, Messrs. Snook have given a further order.

**A Three-Leaf Electroscope.**—In a recent communication to the Académie des Sciences M. L. Benoist described a simple improvement made by him in the gold-leaf electroscope, with a view to an increase of its sensitiveness. M. Benoist merely employs *three* leaves in lieu of two. When the electroscope is charged the central leaf remains rigidly vertical, whilst the

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two outer ones diverge equally on either side of it. The sensitiveness of such an instrument is markedly greater than that of an ordinary two-leaf electroscope, each of the outer leaves being repelled four times more powerfully by the central leaf than by the opposed leaf, so that the same divergence is obtained with a smaller charge, and that is so, although the charge is divided between three leaves. A simple calculation shows that for small angles the sensitiveness is something like 50 per cent. greater than that of a two-leaf instrument, and a general formula shows that the relative sensitiveness increases as the angle of divergence becomes greater. In a two-leaf electroscope the sensitiveness becomes zero at about 90deg. from the vertical. With a three-leaf apparatus the limiting angle is 120deg.

**The London County Council and Municipal Electric Lighting Loans.**—At the weekly meeting of the London County Council on Tuesday the Finance Committee reported that they had considered the application from the Hampstead Vestry for a loan of £30,000 for electric lighting works. The Vestry had submitted a statement showing that the expenditure up to March 25th last in connection with the electric light works at Finchley-road had amounted to £62,294 (including £10,214 for buildings). As the Vestry desired that the repayment of the loan might be spread over 42 years it was requisite that special conditions as to maintenance of the plant and against future borrowing in respect of the works should be imposed. They accordingly recommended that it be notified to the Vestry of Hampstead that as they have elected to spread the whole of the initial cost of the electric light installation over 42 years, the Council will decline to give its sanction to the raising of any loan to replace plant and machinery which may be necessary during the currency of the loan, and will expect the Vestry to provide for all renewals required during that period out of a sinking fund to be provided for that purpose or from maintenance account. The recommendation was agreed to.

**The Brush Company's New Engine Works.**—The new tool shop now being built by the Brush Electrical Engineering Company for the purpose of building Raworth's "Universal Engine," forms, says the *Engineer*, the fourth of the same class which have been built for the Company by Mr. Arthur Faulks, of Loughborough. In width the shop consists of three bays of 16ft., with a line shaft under each row of columns; to permit of this arrangement each column is carried on a cast-iron bridge, giving sufficient opening to allow the line shaft to pass through, and the shaft races are wide and deep enough to accommodate 30in. pulleys. For carrying the counter-shafts a 12in. by 4in. beam is run between the pillars at a height of 10ft. 6in. above the floor; this serves well for light tools, but for the heavier tools it has to be strengthened by stays attached to the crane girders. The travelling cranes are all of the hand chain class, and are very light and cheap in construction. Those in the centre bay lift five tons, and those in the side bays two tons. The principal dimensions of the building are as follows: Length, 150ft.; width, 48ft.; height under gutter, 16ft.; height of crane rail, 13ft.; cubic capacity, 136,000 cubic feet. The cost complete, exclusive of shafting and cranes, comes to about 4d. per cubic foot.

**The London Polytechnics.**—During the last few weeks, says the *London Technical Education Gazette*, the recreative side of the Northampton Institute has been opened to members of the City Polytechnic, and it is intended that the educational classes shall be commenced in October next. The Birkbeck Institution has made a new departure in the appointment of an educational Principal, who will give nearly the whole of his time to the development of the day and evening classes. The choice of the governors fell on Prof. G. Armitage Smith, and the Board has approved his appointment in accordance with its published regulations. The South-West London Polytechnic has made arrangements for the establishment of day classes in engineering and other technical subjects, on the same lines as the classes at the Finsbury Technical College of the City and Guilds of London Institute. The classes, like those of the Finsbury College, will be preparatory to the course of study provided at the Central Technical College in Exhibition-road, and the proposals have met with the cordial approval of the London Polytechnic Council, the representatives of the City and Guilds of London Institute on the Technical Education Board, and of the Principal of the Finsbury College. At the Northern Polytechnic arrangements have been made to proceed immediately with the erection of the great hall, and the heads of the departments of engineering, physics, and chemistry have been appointed. The educational work is expected to be commenced in October next.

**Corrosion of Iron by Raw Tar.**—In a Paper recently read before the Nottingham section of the Society of Chemical Industry, Mr. F. J. R. Carulla gives some instances of the corrosive action of raw tar on iron. As tar is sometimes used for lining and covering iron pipes, which are employed as conduits for cables and for other engineering purposes, the subject is of interest to engineers. The following is an abstract of Mr. Carulla's Paper:—Coal or gas tar is very extensively used for protecting from rust iron surfaces exposed to the weather. This is the reason for bringing before you a remarkable example of the danger that the careless or ignorant use of raw tar as a substitute for paint may entail. Two bolts (exhibited) originally 12in. by 1⅛in. thick were so thoroughly corroded as to present the appearance of having been soaked in some dilute acid for a considerable time. The bolts had been in the valve boxes of a pump through which only water from a well had been passed. The only explanation is that tar residues known to exist on the surface soil have communicated this undesirable property to the water in the well. A chemical examination confirms this. The water was found to be basic, which might be expected from its strong smell of naphthalene or gas liquor. That this corrosive action was due to something communicated by the tar would appear to be indicated by the fact that similar bolts in a pump at the same works used for raising tar, and that only, also show corrosion of a similar character, although not quite so pronounced. The bolts in another pump, lifting river water in the same place show no signs of corrosion.

**Contemporary Electrical Science.**—A new theory of electrical vacuum discharges is developed by M. P. DE HEEN in a Paper recently read before the Belgian Academy and published in the *Bulletin*. The fundamental phenomenon upon which the theory is based is that of pith balls dancing up and down between two electrified glass plates. Let the pith balls decrease in size, their velocity will increase; let them be diminished to the size of molecules of air, and their velocity will be some 200,000m. per second, which means a molecular temperature of 46 million degrees! Molecules impinging upon glass with this velocity will produce waves of excessive shortness, and these are the extremely ultra-violet X-rays—*voilà tout*. The author reduces atmospheric electricity to a similar source in the solar protuberances. It is just as well that he has already made his reputation as a careful experimenter. His colleague, M. DWELSHAUVERS DERY, sheds further light on the question of the reflection of Röntgen rays. He comes to the conclusion that there is no such thing, properly speaking. It is true that if X-rays are sent through a sensitive plate on to a plate of tin in contact with it, a photographic impression is obtained. But this is intercepted by a piece of ruby paper, whereas X-rays are not. Hence the reflected waves have different properties, and probably a much greater wave length. The case is analogous to that of a black surface, which reflects luminous waves in the form of long heat waves. The author also found that a layer of collodion interposed in the path of the rays increases their photographic effect. To diminish exposure, he places a sheet of collodion over the object, and a sheet of tin under the plate. The polish of the tin or other metal is quite without influence, which shows that there is only diffuse reflection. In the *Nuovo Cimento*, Prof. CARDANI continues his researches on the thermal phenomena of derived circuits. His results confirm Lord KELVIN'S theory. BATTELLI and GARBASSO speculate upon the connection between cathode and X-rays. They incline to the belief that they both consist of projected particles, the latter having a far higher velocity than the former. MALAGOLI and BONACINI also found reflection of X-rays by metallic surfaces, but believe that the state of polish made a difference. Their experiments are not conclusive on this point.

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## THE CAPILLARY ELECTROMETER IN THEORY AND PRACTICE.*

BY GEORGE J. BURCH, M.A.

(*Continued from page 403.*)

*Production of Photographic Records.*

The capillary electrometer is essentially the poor man's instrument, costing, even including the price of a microscope, less than any other form of electrical measuring instrument of equal delicacy. It is also by far the easiest to make. But it has certain disadvantages. It is fragile and easily spoilt by careless usage, and unless employed for zero methods, requires careful calibration against a standard instrument. It has, however, one property which outweighs all these disadvantages, and in virtue of which it stands alone among the implements of research. The rapidity with which it responds to all changes of potential is so great that nothing but photography can render all its movements visible. It is accordingly this branch of the subject to which I have devoted a great deal of my time. The form of the instrument is such as to render the production of photographic records of its excursions extremely easy. The magnified image of the mercury column is projected on to a narrow vertical slit, behind which a sensitive plate travels with a uniform horizontal motion. It thus forms a continuous band of shadow, varying in height according as the position of the meniscus changes. But however sharply the top of the mercury column may be focussed on the screen, a sudden to-and-fro excursion of the meniscus will produce a blur instead of a sharp-edged shadow, unless the plate moves through a

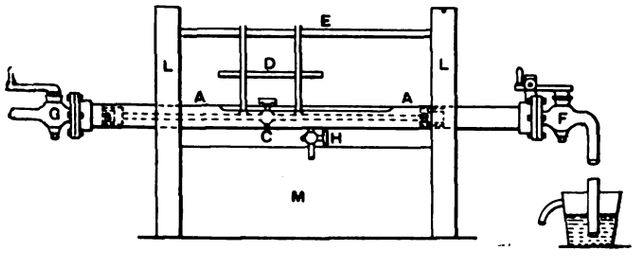


FIG. 5.—Hydraulic Motor.

space greater than the width of the slit during its occurrence. And if the slit is made very narrow, not only is the illumination feeble, but diffraction comes into play and spoils the definition. My first improvement consisted in the use of a cylindrical lens of 25mm. focus placed about 25cm. behind the slit. This had two advantages. It concentrated the light from a much wider slit into a mere line, and it increased the working distance between the sensitive plate and the apparatus. But it necessitated the adoption of a more perfect machine for propelling the plate. Driving clocks were found to be useless, and I therefore designed the hydraulic motor illustrated in Fig. 5.

A is a brass tube 3cm. in diameter and 110cm. long. It has a slot about 1cm. wide and 45cm. long cut in the middle portion. It is flanged at each end, and provided with taps, F and G. The piston B is tubular, and has a cup leather packing at each end, and a tap C in the middle. To this piston B is attached the plate holder D, which is guided at its upper part by the brass rod E held parallel to the tube A by the wooden framework of the apparatus L, L, M. The tap G is connected with the water supply, and a waste-pipe is led from F to the nearest sink. The lower end of the waste-pipe must be kept constantly under water to prevent the entrance of air. For the same reason the supply pipe must be fitted with an air trap if the water is taken direct from the main. The tap H serves to empty the central portion of the tube A of any water that may leak past the piston heads and of the surplus oil used for lubricating it.

To use the instrument, close the taps F and G and open the middle tap C. The plate-holder D can then be drawn as far as it will go to the left hand, the water passing from one end of the tube to the other through the hollow piston rod. C having been closed the apparatus is ready for action. The tap F on the waste pipe is opened more or less according to the speed at which the plate is require to travel. When all is ready, the tap G is suddenly turned full on. The pressure of the water upon one end of the piston is resisted by the friction of the flow through the tap F, and the result is a very steady motion of the plate-carrier from left to right. The power of the instrument is considerable, and the rate is constant after the first 2cms. The speed may be varied from 0·3cm. to 5cm. per second, by adjusting the tap F, the long handle of which comes up against a set screw.

This machine answered admirably. Electrical phenomena lasting from 4sec. to 2min. were recorded by its means, and the resulting photographs were perfectly sharp and even. But we had not realised with what great rapidity the capillary electrometer can respond to changes of potential.

While examining with a lens one of the physiological photographs which will be described later on, I noticed a well-marked notch in the commencement of the curve, showing that two impulses had been given to the mercury in rapid succession, and that it had responded first to one and then to the other. It was known that two changes of potential difference had actually taken place in the circuit; but the interval between them could not possibly be greater than 0·01sec. This indicated that the instrument was capable of acting much more rapidly than we supposed. I accordingly designed a simple experimental arrangement for trying higher velocities. It was in the form of a balanced pendulum, and carried the plate in a circular arc instead of a straight line. This was at first considered a disadvantage; but shortly afterwards I discovered that, owing to a peculiar property of polar curves, it was in reality far better for our purpose, as will be seen from the description of the mode of measuring the photographs. The principle was, therefore, retained, and subsequent alterations have been simply improvements of the details of the apparatus.

*The Pendulum Apparatus.*

The present arrangement of the photographic apparatus is shown diagrammatically in plan in Fig. 6 and in elevation in Fig. 7. A is an ordinary 5-inch condenser, in the focus of which is placed an arc lamp on an adjustable stand. A tank, *b*, filled with water or alum solution, serves to intercept some of the heat rays. Sometimes a second tank containing ammonio-sulphate of copper is also used. This effectually stops the heat, and does not appreciably diminish the actinic power of the light, but makes focussing rather difficult. Next comes the microscope, *m*, with its condenser, and the electrometer. This part of the apparatus is situated in a window in the wall of the dark room. The microscope, which is fixed to the solid stone, occupies half the window, and the other half is closed by a door made perfectly light-tight. The electrometer is supported on a stand provided with vertical and horizontal rack work motion and two tilting adjustments for setting the capillary vertical and at right angles to the optic axis. The tube of the microscope is fitted with a light-tight joint where it passes through the partition W, which it does not touch.

Inside the dark room the apparatus is attached to the floor, and is only connected with the window by a creased paper band, which keeps out the light without transmitting mechanical vibrations. The rays pass first into a narrow box 50cm. long, with a sliding lid, *f*, and a pane of ruby glass, *g*, at the farther end. By opening the lid, and placing a piece of paper in the path of the light, the movements of the mercury can be observed, and the ruby glass allows the operator to watch the meniscus up to the very moment of the exposure. At the end of the box *c* are the two false slits *d*, and between them is the shutter *e*. This shutter works on a pivot underneath the apparatus, and is connected with the same handle that releases the pendulum *l*. Immediately beyond the false slits are the tuning fork and the signal, which will be separately described, and close behind them is the true slit *h*. This is contained in a separate frame, so that it can be removed entirely during

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focussing and replaced exactly in the centre of the image of the mercury column. The width of the slit can be adjusted to suit different velocities of the plate. Behind the slit comes the cylindrical lens *j*. This is of 25mm. focus and is placed about 25cm. from the slit. It is provided with an adjustment for focussing, and is fixed to a slide so that it can be drawn up quite out of the path of the light. The plate carrier, and focussing screen *k*, are fixed to the top of the pendulum *l*.

Fig. 8 is a diagram of the apparatus for propelling the plate, seen from behind. It consists of two parts, viz., the pendulum and the automatic key for determining the instant at which an experiment shall commence. The pendulum A is a wooden bar 125cm. long by 12cm. wide, which swings by an axis at its centre on bearings fixed to the table. To avoid friction the shaft is very small, but it is supported on each side of both bearings by a solid bracket bolted to A. The bearing nearest the pendulum has no cap. The shaft rests upon it, and the weight is so arranged that the other end of the shaft, in which a V-shaped groove is turned, presses upwards into a semi-circular notch in the edge of a brass plate. Thus the pendulum can be easily unshipped, and at the same time the plane of its movement is always at a fixed distance from the cylindrical lens. C is the plate carrier. It is made to hold an ordinary dark slide. S is a ground-glass focussing-screen. At the lower end of the pendulum is a movable weight, B. This has to be fixed so that when the dark slide is in place with a plate

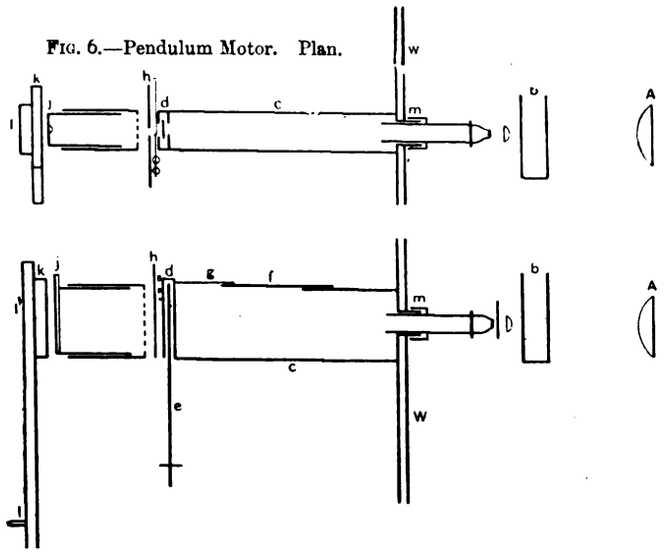


FIG. 6.—Pendulum Motor. Plan.

FIG. 7.—Pendulum Motor. Side Elevation.

in it and the shutter drawn up, the pendulum will rest indifferently in any position. The arm D carries a weight, E, attached to it by a cord. In the actual instrument the weight is replaced by a board, hinged to the table at one end and loaded more or less heavily according as a slow or high speed is required.

The action is as follows: the pendulum is held in the position shown in the figure by the latch G. When this is raised the weight E causes the pendulum to swing over with increasing velocity until it rests on the table, just before the sensitive plate comes into the line of light. The acceleration now ceases, and the pendulum being in neutral equilibrium continues to move with a constant angular velocity until caught and held by the catch H. To counteract the slight retardation due to friction, a small weight, fixed to the bar D, is adjusted until the vibrations of a tuning fork, recorded on a long negative, measure the same at each end of it. For fast rates, up to 150cm. per second, a weight of 2 kilos. is employed. For slow speeds the bar A is loaded with equal weights at both ends, and the weight E is reduced until it is only just sufficient to act with certainty.

The apparatus is capable of two classes of work, viz., it can record a short portion of a series of repeated movements of the image, as in investigating dynamo currents, or the vibrations of a spring; or it can register the effect of a single excitation of a muscle, or of an induced current. For the latter class of work it is necessary to have means of determining with great accuracy the exact instant at which the experiment commences. This is done by the arrangement shown to the left hand in Fig. 8. M is a bar attached to the pendulum A. It carries a pin on which rests the light arm J of the automatic key. This is furnished with a contact screw, K, dipping into a cup of mercury, L. Terminals are provided, by which this key is connected with a battery, and with the signal key shown on a larger scale in Fig. 9. It is essential that the screw K should be connected with the terminal by a flexible wire, and not through any rubbing contact. By adjusting K, and then

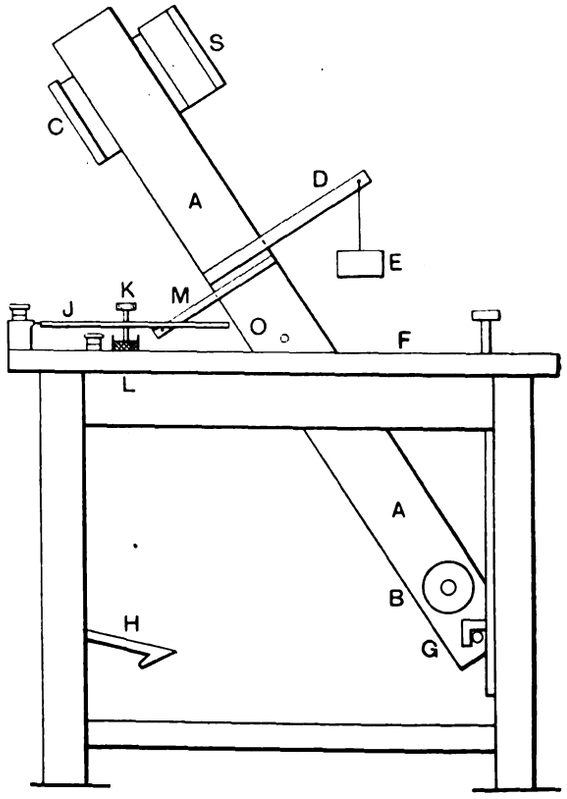


FIG. 8.—Pendulum Motor. End Elevation.

moving the pendulum slowly across by hand, this key may be made to break contact when the plate reaches any desired position, with an error of not more than 1mm. It only serves, however, to actuate the signal key, which records the exact instant of the stimulus in the act of giving it. In Fig. 9, A and B are the coils of a small electromaguet, the terminals of which, $M_1$, $M_2$, are in circuit with the automatic key. The armature C is connected by a piece of watch spring with a brass pillar on which is the terminal $P_2$. It rests upon the

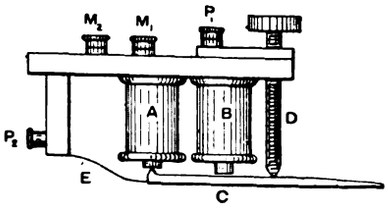


FIG. 9.—Signal Key.

pole of A by a knife edge, and is just kept from touching B by the point of the set-screw D, connected with the terminal $P_1$. The end of C, which is very light, but stiff, projects somewhat beyond the rest of the instrument. A stop, not shown in the figure, prevents the spring from moving the armature more than a couple of millimetres away from the pole. The signal key is fixed in the position indicated in Figs. 6 and 7, between *h*, and *d*, so that the end of the armature crosses the slit near the upper part. As long as the automatic key is closed, the

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magnets A and B of the signal key hold the armature C against the screw D, but directly the plate comes into the requisite position, the circuit $M_1$ $M_2$ is broken and the armature springs back, breaking the circuit $P_1$ $P_2$ and recording the exact instant of so doing by the sudden drop of its shadow upon the sensitive plate.

It will be noticed that in this key also there are no rubbing contacts, and only one place at which the circuit can be broken. I sometimes use a modification in which a spring key is struck open by a small hammer connected with an electromagnet. But the principle is the same—the shadow of the key itself is recorded on the plate.

It remains to describe the time-marker. This is simply a standard fork making 500 double vibrations per second. It is fixed horizontally so that the lower prong projects across the slit at its upper part, leaving a mere line of light 1mm. long above it. The prongs are forced apart by a cam so as to allow a block attached to one end of a pivotted lever to be placed between them. On pulling the lever the fork is released, and vibrates with sufficient amplitude for 15 or 20 seconds.

To illustrate the working of the machine I will describe the process of photographing a "normal excursion," *i.e.*, the excursion produced by placing the uncharged electrometer suddenly in connection with a constant source of E.M.F. of known intensity, *e.g.*, 0·01 volts.

The derived circuit of a potentiometer is put in series with the electrometer terminals, and a short-circuit across them is connected with the terminals $P_1$ and $P_2$ of the signal key. The arc lamp having been switched on, the lid *f* (Fig. 7) is slid back and a piece of paper placed in the path of the light. The pressure-bulb is then raised until the meniscus appears in the capillary in the proper position. The light-tight door in the window of the dark room is kept open while the electrometer stand is adjusted so that the image of the mercury column appears on the shutter in the middle of the false slit. The shutter *e* is then opened, the true slit *h* removed, the cylindrical lens *j* drawn up out of the way, and the pendulum placed so that the magnified image falls on the focussing screen S (Fig. 8). The top of the meniscus is then focussed as sharply as possible, with the aid of a lens. A long rod, not shown in the figure, passes through the partition W to the fine adjustment of the microscope. Two pins on the end of this rod engage in two *large* holes in the head of the screw, which can thus be adjusted with great nicety. When the focussing is finished the rod is drawn back clear of the screw. The next step is to replace the slit *h* exactly in the centre line of the mercury column. Then the cylindrical lens is pushed down into its place, and focussed until the image of the slit appears upon the screen as a mere line of light.

It remains to test the circuit. The rider of the potentiometer is first lifted off the wire so as to break the electrometer circuit. Placing his finger and thumb on the terminals of the electrometer, the operator rubs first one and then the other. The meniscus ought to move up and down freely, remaining up or down if the fingers are removed, and returning to zero sharply when the key is closed. But when the rider is on the potentiometer, it ought not to be possible to cause the mercury to move by rubbing the terminals, because the circuit is no longer open.

A dark slide containing a plate is now put into the plate-holder and the pendulum pushed back into the position shown in Fig. 8. This action closes the automatic key, so that on raising the armature C of the signal key (Fig 9) it will be held by the magnet. The short-circuit of the potentiometer being now closed, no charge should enter the electrometer, and accordingly there should be no movement of the meniscus on opening the electrometer key. It remains to set the tuning fork by placing the block between its prongs. The light-tight door is closed, the sliding lid shut to, and the shutter of the dark slide drawn up. The tuning fork is made to sound, and a second later the handle of the latch G (Fig. 8) is raised. This opens the exposing shutter and at the same time releases the pendulum, which swings over. The automatic key releases the signal key, and this in its turn breaks the short circuit of the potentiometer, the current from which flows into the electrometer and charges it, the shadow of the moving meniscus forming a curved band upon the sensitive plate.

As soon as the operator hears the clash of the pendulum against the catch H, he lowers the handle, thus closing the exposing shutter, and removes the sensitive plate.

After the first adjusment, very little attention is needed, save an occasional glance at the focussing screen, and plates can be exposed almost as quickly as in an ordinary camera.

It should be pointed out that the actual form of the apparatus was determined by the position in which it had to be erected. I do not confine myself to the pendulum motion. I have also made a portable camera in which the sensitive plate is attached to a disc which for very high speeds is made to revolve continuously. It is provided with an arrangement for giving the exposure as soon as the requisite velocity is attained. Details of this machine will be communicated hereafter.

*(To be continued.)*

## AN ELECTRIC FREQUENCY TELLER.

BY ALBERT CAMPBELL, B.A.

Few persons who carry out tests with alternating currents taken from the mains of supply companies realise the extent to which the frequency of such currents may vary; and it may surprise many to hear that variations of five or ten per cent. within a few hours (or even minutes) are common even in the case of steady running companies. In many tests such variations, if not taken account of, would seriously affect the results. To get over this difficulty I have devised a simple and portable instrument for the direct measurement of frequency.

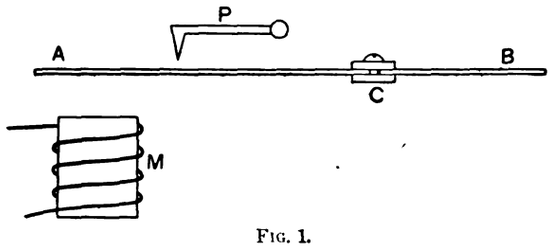


FIG. 1.

The principle I employ depends on *resonance*, and is illustrated in Fig. 1. In this, A B is a steel strip or reed which, by means of suitable driving gear, can be moved back and forwards through the clamp, C, while a rack and pinion connected with the end, B, show on the scale of the instrument the variation in the length of A, which is the end free to vibrate.

Near the vibrator, A, is fixed an electromagnet, M, with well laminated core, excited by a small current from the supply circuit to be tested.* The length of A is continuously varied, until it is thrown into strong vibration by the alternating field due to M. This takes place when the vibrator is of such a length that it naturally vibrates with a frequency double that of the current in M, and the resonance is indicated by a loud note given out. The exact point of maximum resonance is more easily observed by using an adjustable part, P, which can be set so that it jars against the vibrator only when the latter reaches its greatest amplitude.

Fig. 2 gives an outside view of one of the instruments in which the range extends from 40 to 150 ∿ per second. The milled head at the top has to be turned until a loud note is obtained, and the frequency is then read off directly on the dial. As the adjustment can be made in a second or two, the instrument can follow quick changes in the frequency. By its help I have often watched the variations in speed while the alternators at the central station are being synchronised. By means of the milled head at the side of the instrument, the jarring piece, P, can be adjusted so as to get

* Since writing the above I find that Profs. Ayrton and Perry some years ago suggested the use of an adjustable magnetic tongue, but the idea was never embodied in an actual instrument.

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sharply defined readings. It is easy to obtain readings definite to less than a half per cent.

The range of the type shown in Fig. 2 is suitable for all the ordinary frequencies used in practice, but, by varying the magnifying gear, scales either much more open or of much longer range may be obtained. Figs. 3 and 4 show the scales of two actual instruments. It will be noticed that in Fig. 3 the scale goes more than twice round the dial.

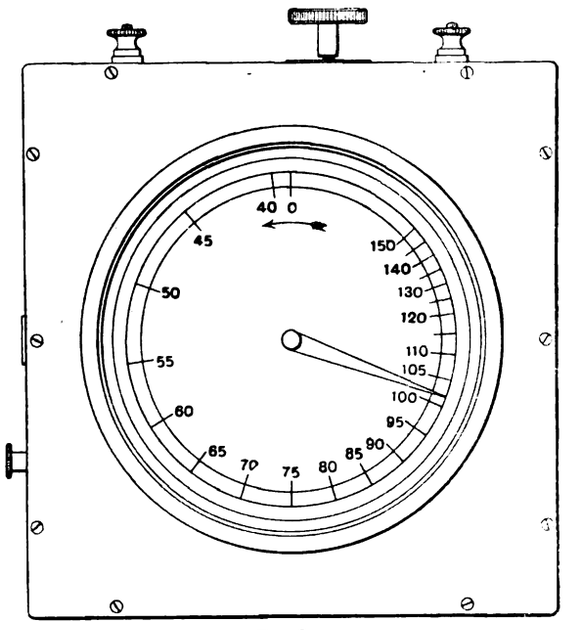



Fig. 2.

In the instrument as described above it will be seen that the vibrator is *not polarised*. The note obtained is thus an octave higher than if a polarised strip were used, and this is of great advantage at the lower frequencies, for their own notes are not so distinct; besides, in this way we dispense with permanent magnets or auxiliary direct current circuits.

It will be found that some of the instruments respond faintly when the pointer is set to read a frequency twice that

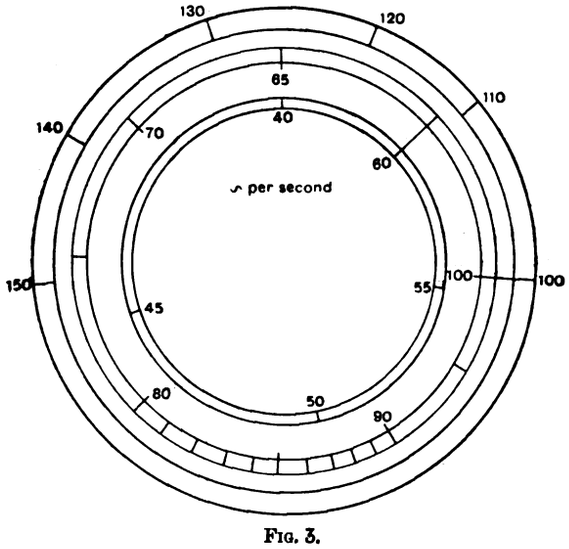



Fig. 3.

of the actual frequency; other multiples may even be observed. Now quite recently* Stumpf has shown by experiment that a tuning-fork cannot be set into sympathetic vibration by multiples or sub-multiples of its pitch. It is clear that the overtones which sometimes show themselves in the instrument even when the alternator gives a pure sine curve electromotive force are due to the iron core of the electro-magnet which modifies the wave form. By putting in circuit with the electro-magnet enough non-inductive resistance to swamp the inductance, we can, if desired, get rid of those harmonics which do not occur in the wave form of the alternator.

The instrument works with unidirectional pulsating currents as well as with alternating ones. It can, therefore, be used as an accurate speed indicator. For this purpose a commutator is mounted on the shaft whose speed is required, and a direct current made and broken by this commutator is led to the instrument, which may be at any distance.

* *Wied. Ann.*, LVII., pp. 660-681, 1896.

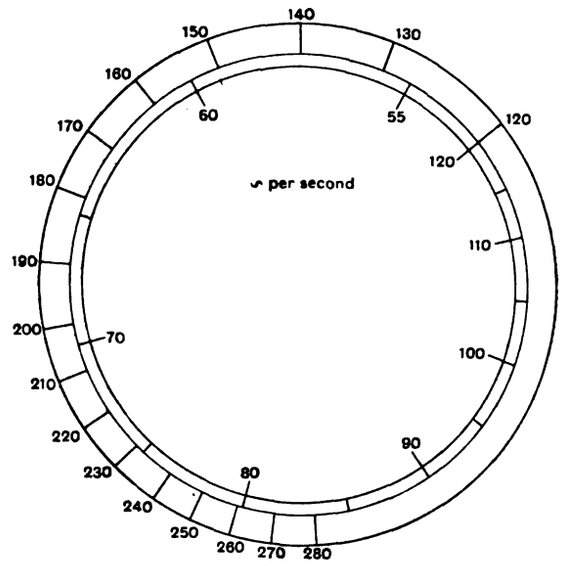
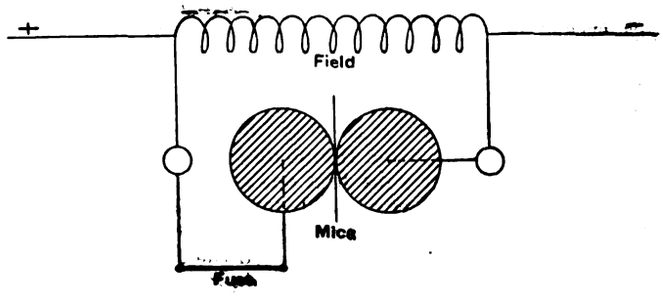



Fig. 4.

## JOHNSON AND STEELE AUTOMATIC "POTENTIAL" ARRESTER.

This instrument is the invention of Messrs. W. Claude Johnson and L. J. Steele, and is manufactured by Messrs. Johnson and Phillips. It is employed for automatically arresting the rise of potential such as is induced on breaking the field-magnet circuit of a dynamo or other circuit of high self-induction, the electromotive force in such a case being, as is well known, sometimes sufficiently high to break down the insulation of the coils or of conductors and instruments connected to the circuit. The device is, as shown, connected as a shunt to the inductive circuit, and consists of two carbon discs mounted side by side on a slate base. These discs are pressed towards each other by springs; but between them is interposed a strip of mica of suitably adjusted thickness, which, not being so wide as the faces of the discs, leaves a small air space between them. A safety fuse is provided, which, in case of a permanent circuit being established between the discs, will give way, and thus prevent short-circuiting the field. The discs can be turned on their axes, so as to present towards each other fresh portions of their peripheries, which are cleaned by metal scrapers that bear against them. If the field circuit of a dynamo is broken accidentally, or otherwise, the difference of




Connections for Potential Arrester.

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potential at its terminals will rise to an amount sufficient to produce a spark between the two discs, and this spark will last until the field has gradually died down. In some cases, especially when breaking the field circuit of large multipolar machines or alternators, the spark is seen to last as long as 20 to 30 seconds.

Messrs. Johnson and Phillips have supplied a large number of these instruments, which have been found to work satisfactorily.

## THE BERLINER CONTROVERSY.*

BY W. CLYDE JONES.

There is perhaps no question which at the present time is of more importance to the telephone industry than the Berliner controversy now pending before the Supreme Court of the United States on appeal from the Circuit Court of Appeals of the First Circuit.

It is important to the company which owns the patent, as a decision favourable to the patent may ensure an exclusive monopoly of the microphone or constant contact transmitter until the year 1908; it is of importance to competing telephone companies, as such a decision would necessitate the employment during that period of the magneto-transmitter; while the annulment of the patent would leave the microphone transmitter open to the world.

On June 4, 1877, Emile Berliner filed an application for a patent on an improved form of telephone; and after a pendency of over 14 years, the patent was issued November 17, 1891, No. 463,569. The first and second claims of the patent cover broadly the variable pressure transmitter, and read as follows:—

"1. The method of producing in a circuit electrical undulations similar in form to sound waves by causing the sound waves to vary the pressure between electrodes in constant contact, so as to strengthen and weaken the contact, and thereby increase and diminish the resistance of the circuit, substantially as described.

"2. An electric speaking telephone transmitter operated by sound waves, and consisting of a plate sensitive to sound waves, electrodes in constant contact with each other, and forming part of a circuit which includes a battery or other source of electric energy, and adapted to increase and decrease the resistance of the electric circuit by the variations in pressure between them, caused by the vibrational movement of said sensative plate."

On February 13, 1893, a Bill was filed by the Attorney-General against the American Bell Telephone Company and Emile Berliner to annul the patent on the ground that the Commissioner of Patents had exceeded his powers in the issuance of the patent, and that the defendants had been guilty of fraud or misconduct in delaying the issuance of the patent. By the sifting process to which the case has been subjected by the Courts, all charges of fraud have been dismissed from the case, and the controversy has settled down to two main subjects of inquiry: first, as to whether the patent is void for illegal delay in its issuance, whether caused by an unauthorised act of the Commissioner of Patents, or misconduct on the part of the assignee of the patent in not prosecuting the application with due diligence; and, second, whether the patent is void because a prior patent was granted upon the same application to the same applicant for the same invention.

The Berliner application was placed in interference with the applications of Bell, Gray, Edison and Voelker, the Bell and Gray applications claiming broadly the method of transmitting speech by the production of undulatory currents, while Edison claimed the carbon microphone and Voelker the microphone broadly. Berliner's claims related to the variable pressure microphone. At that time there was a rule of procedure of the Patent Office providing that when two or more applications *show* the same invention they should be placed in interference, though they may not claim the same subject-matter. The Berliner microphone embodied the broad idea of speech transmission by undulatory currents, and was therefore adjudged to conflict with the Bell and Gray applications, which broadly claimed this invention. The Voelker application claimed the microphone transmitter, and was therefore placed in interference; and the Edison application, though limited to the carbon transmitter, showed the microphone broadly, and was therefore placed in interference. The determination of these interferences occupied considerable time, and it was not until March 3, 1885, that a final decision was reached awarding the broad claims upon the microphone to Berliner as against Voelker, who was claiming the same structure. It had been previously adjudged that Bell was entitled to the broad claims on the art of telephony as against Gray, who alone of those in interference was contesting this broad claim. Bell and Gray were thus eliminated from the controversy over the microphone. Edison was adjudged to be the inventor of the carbon microphone, thus leaving Berliner and Voelker the only contestants for the microphone transmitter broadly considered; and by this decision of March 3, 1885, priority was awarded to Berliner, so that had there been no other obstacle to the issuance of the Berliner patent, it would have issued at this time.

On July 26, 1880, however, Daniel Drawbaugh filed an application in which he claimed not only the broad art of telephony as claimed by Bell and Gray, but also the magneto-telephone of Bell, the microphone of Berliner and the carbon microphone of Edison. Drawbaugh claimed to have made his invention as early as 1867, and offered to submit proofs of the fact. The application was filed too late to be involved in interference with Bell, Gray, Berliner, Edison and Voelker; but, in addition, there was an objection to the Drawbaugh application which prevented its immediate consideration.

The statute which provides for the grant of letters patent states that a patent shall not be granted upon an invention which has been in public use for two years prior to the date of the application. The Courts had held that the prior two years' use, either with or without the consent of the applicant, was sufficient to prevent the grant of the patent. Edison's carbon microphone was introduced into public use in the spring of 1878, and before July was in use to a considerable extent, so that at the date of filing of the Drawbaugh application the microphone had been in public use for more than two years, and such use was thus a bar to the grant of a patent to Drawbaugh. The examiner rejected the Drawbaugh application on the ground of two years' public use, and this decision Drawbaugh contested.

According to the rules of procedure of the Patent Office, an application must be in such condition as to be considered allowable before it will be placed in interference with a conflicting application, so that the Drawbaugh application could not be placed in interference with any other application until the objection to two years' public use had been overcome.

At about the time that the Drawbaugh application was filed, it was assigned to the People's Telephone Company, of New York; and on October 20, 1880, the American Bell Telephone Company brought suit against this company for the infringement of the Bell patents. The People's Telephone Company set up as a defence to this suit the prior invention of the telephone by Drawbaugh, and as the vigour and earnestness with which both parties prepared and presented their cases in this suit promised to definitely settle the question as to whether Bell or Drawbaugh was the inventor of the art of telephony, and as to whether Berliner or Drawbaugh was the inventor of the microphone, the Commissioner of Patents decided that the quickest and surest way of determining the rights of Berliner and Drawbaugh in reference to the microphone was to await the decision of the Court.

On December 5, 1884, Judge Wallace rendered a decision in this suit in favour of Bell as the prior inventor. On December 4, 1885, upon further argument and additional proofs Judge Wallace rendered a second decision in favour of Bell. An appeal was taken from this decision to the Supreme Court of the United States, and on March 19, 1888, a decision was rendered in favour of Bell. The question as to whether Berliner or Drawbaugh was the inventor of the microphone was at the same time determined, as Drawbaugh's claims rested upon the truth or falsity of his story, which was held by the Supreme Court to be a fabrication.

In May, 1888, the Berliner application was rejected on Berliner's intermediate patents and on the ground that his original application was insufficient. This objection was overcome February 25, 1889, and the Berliner application was ready for issuance, but for the fact that the Drawbaugh application was still pending, though rejected because of two years' prior use, which rejection Drawbaugh was still contesting. Public use proceedings had been instituted by the Patent Office, and on October 28, 1891, the Commissioner of Patents affirmed the final rejection of the Drawbaugh application on two years' public use. On the following day, October 29, 1891, the Berliner patent issued.

It is claimed on behalf of the Government that the suspension of the Berliner application, pending the decision in the Supreme Court in the suit against the People's Telephone Company, was an unauthorised act of the Commissioner, and that the Bell Company was guilty of misconduct in submitting to such suspension, the effect of which unauthorised act of the Commissioner and misconduct on the part of the owner of the patent is to render the Berliner patent void *ab initio*. Likewise it is claimed that the delay after the decision of the Supreme Court, excepting the period during which the Berliner application was rejected, was an unauthorised act of the Commissioner and misconduct on the part of the owner of the patent. The application was suspended during this period because the Drawbaugh application had not been technically rejected finally and in accordance with the Patent Office procedure on the ground of two years' public use, and it is alleged that since it was evident that the public use preceding would result in the final rejection of the Drawbaugh application, there was no

* From *Electrical Engineering* of Chicago.

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necessity of withholding the Berliner patent, and that this act of withholding the patent by the Commissioner and the acquiescence in such delay by the Bell Company render the patent void.

Judge Carpenter, of the Circuit Court of the First Circuit, before whom the case was initially heard, stated the case as follows :

The proposition is that the Bell Company intentionally delayed the prosecution of the Berliner application, and the issue of the Berliner patent, for the purpose and with the result of prolonging their control of the art of telephony, which would cease with the expiration of the Bell patent in 1893 ; and that they did this by submitting to delays on the part of the officers of the Patent Office, which delays they, the Bell Company, had it in their power to prevent, and refrained from preventing, for an unlawful purpose. This conduct is alleged to constitute a fraud practised upon the public through the Commissioner of Patents and his assistants. And it is claimed that the patent so obtained by such fraud may be and should be annulled by the decree of the Court on the authority of United States *v.* American Bell Telephone Company, 128 U.S. 315, because there is no substantial difference between a fraud practised upon the Commissioner as an agent, and a fraud practised upon the public with the Commissioner's connivance or acquiescence.

The Circuit Court of Appeals remarked that this view of the case practically reduced the inquiry to that of whether the American Bell Telephone Company submitted to delays which it was in its power to prevent, and refrained from preventing for an unlawful purpose, the unlawful purpose being the expectancy of a prolonged monopoly by the delays in the Patent Office. The Court then criticised this position, saying that to lay down the proposition that acquiescence in the delay of a public official who is bound to perform a certain act, involves an unlawful purpose because it may result to the advantage of the applicant, omits an important element ; that if the applicant is under no obligation touching the delay, there is no rule of law by which it can be said that, because he may receive an incidental benefit therefrom, his purpose in relation thereto is unlawful, since a man's motive will not make wrongful an act which in itself is not wrongful. (Heald *v.* Carey, 11 C. B. 977, 993.)

The Court also discussed the question in view of the principle of legal ethics that every man is bound to enjoy his own in such a manner as not to interfere with a like enjoyment of their own by others. On this principle it was contended that the acquiescence of the Bell Company in the delays in the Patent Office was liable to work injury to the rights of the public by prolonging the monopoly of the microphone, thus withholding from the public the right to use the microphone ; that the Bell Company was, therefore, under obligation to use the highest degree of diligence in prosecuting the application and avoiding delays, and that the Bell Company should, therefore, have taken every possible means known to the law for hastening the issue of the patent, failing in which the patent was for this reason void. The Court held that an applicant is not responsible for the highest degree of diligence in the prosecution of an application, nor is it necessary to invoke every means known to the law to speed the issuance of the patent.

The Circuit Court held that the patent was also void because of the issuance of a prior patent to Berliner for the same invention. The Circuit Court of Appeals dismissed this point of inquiry on the ground that the Commissioner of Patents in issuing the later patent knew of the earlier patent, and therefore adjudged that the later patent would be valid notwithstanding the earlier patent. As the error complained of was thus alleged to be a mistake of judgment as distinguished from an unathorised act, which latter alone could render a patent or grant void *ab initio*, the inquiry was not properly before the Court. If the officer acted beyond his power and outside the scope of his office, the patent or grant would be void from the beginning ; but if he acted within his powers and within the scope of his office and made a mistake in judgment or opinion, decreeing the later patent to be properly issued, the patent could not be declared void in a proceeding founded upon the unauthorised acts of the officer, although it might be declared invalid upon proceedings instituted to determine the correctness or error of the officer in making his decision. In the case of patents, where one patent is alleged to be invalid because of prior issuance of a patent for the same invention, the question may be tested in an infringement suit.

Should the Supreme Court, therefore, affirm the decision of the Circuit Court of Appeals, the effect will be to say that the Berliner patent is not void because of any unauthorised acts of the Commissioner of Patents or because of any acts of omission or misconduct of the Bell Company, and will leave undecided the question whether or not the Berliner patent of 1891 is void because of the issue of the Berliner patent of 1880. Should the Bell Company then bring suit against an infringer upon the Berliner patent the prior patent would be set up as a defence and the effect of the earlier patent would be determined. It is therefore possible that the decision of the Supreme Court, which is being awaited with so much anxiety, may not settle the question. Though the Supreme Court should declare that the patent was regularly granted it may leave the question of the invalidity of the patent on the ground of the issuance of the 1880 patent to be determined by a protracted infringement suit which may carry the first decision directly affecting the competing telephone industry into the next century.

On September 3, 1880, Berliner filed an application as a division of his first application, and a patent was granted on this application November 2, 1880, numbered 233,969. Subsequent to the invention of the microphone transmitter, Berliner found that if an undulatory current be passed through two electrodes in constant contact the electrodes will become charged as the current rises, and the charges, being of like sign, the electrodes will repel each other ; as the current decreases, the charges decrease and the electrodes move together, due to the resiliency of the diaphragm. A to-and-fro motion is thus imparted to the diaphragm conforming to the current undulations, and the device acts as a telephone receiver. The construction of the receiver is identical with that of the transmitter, undulatory currents being sent through the electrodes in one case to cause the vibration of the diaphragm, while a vibratory motion is imparted to the diaphragm in the latter case to cause a variation in the pressure of the electrodes and the consequent production of an undulatory current. Claims 1, 2 and 3 of the patent claim the apparatus when used as a receiver. Claim 4, however, is the claim about which the battle is fought ; this claim reads as follows :

"4. A system of two or more telephone instruments in electrical connection with each other, each consisting of two or more poles of an electrical circuit in contact one with another, either or both poles of each instrument being connected with a vibratory plate, so that any vibration which is made at one contact is reproduced at the other, substantially as set forth."

This claim is not drawn to the receiver alone, as are claims 1, 2 and 3, nor to the transmitter alone, as are the claims of the 1891 patent, but are to the combination or system comprising two similar instruments, one at each end of the line, so that when one party is talking he uses the instrument as a transmitter while the opposite instrument is a receiver, and when the opposite party is talking the instruments are reversed and the first now becomes a receiver and the second a transmitter.

It is pointed out by the Bell Company that Berliner made the invention of the microphone transmitter in January, and did not discover the adaptability of the device as a receiver until April, and they argue that he is entitled to one patent for what he did in January, and to a second patent for what he did in April, and that the 1880 patent covers the invention of April ; that is, the receiver, while the 1891 patent covers the invention of January, that is, the transmitter. But the Government points out that the claims of the 1880 patent are not confined to the receiver, but that claim 4 contemplates the use of the device as a transmitter. To this the Bell Company replies that claim 4 is for a combination of a transmitter and a receiver ; that after the invention of the transmitter, and after the invention of the receiver, the idea was conceived of employing two instruments, each of which could be indiscriminately used either as a transmitter or as a receiver ; and that the applicant is entitled to three patents or claims, one to the device as a transmitter, one to the device as a receiver and a third to the combination of the two devices. The Government argues that claim 4 is not drawn to cover the combination of a transmitter and a receiver as two separate instruments, but that it is drawn to cover the combination of two electrode instruments, each of which has two functions or modes of operation ; first as a transmitter, and second, as a receiver ; that having thus claimed a structure having two functions, the applicant cannot afterwards take a patent on the same structure to be used for one function only ; that the 1880 patent claims a structure comprising two electrodes in constant contact capable of use as a transmitter and also as a receiver, while the 1891 patent claims the same structure, but limits its use to that of transmitting speech.

The Supreme Court has held (Miller *v.* Eagle Manufacturing Company, 151, U.S., 186) that where a patent has been granted upon a certain structure having two functions, a subsequent patent upon the same structure, but claiming but one of the functions, is invalid. The invention related to a spring of peculiar shape, which acted upon a plough beam when at a certain height, to press the same into the ground, while, when the beam was at a greater elevation, the spring served to support the beam in an elevated position. The earlier patent claimed the spring of the peculiar shape, having the function of lifting the plough beam and also the function of depressing the plough beam, while the later patent claimed a spring of the same peculiar shape and having the lifting function, no mention being made of the depressing function, which in accordance with the later patent could be performed by the same or by a different spring. The later patent was thus the broader in scope, being limited by the one function, while the earlier patent contained a limitation to both functions. It is claimed that the Berliner patents are wholly analogous to the

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spring patents, the 1880 patent claiming a structure to be used in its function of transmitting speech, and also in its function of receiving current undulations and reproducing speech, while the 1891 patent claims the same mechanical structure, but limits its use to the transmission of speech only.

If the Supreme Court follows the Circuit Court of Appeals, and refuses to discuss this proposition as to the relation of the two patents, the question must wait for a decision until the American Bell Telephone Company sues an infringer, should the patent be not declared invalid because of unlawful issue. Should the patent be declared invalid because of unlawful issue, the controversy will be at an end.

## EFFECT OF TEMPERATURE ON INSULATING MATERIALS.*

BY F. SEVER, A. MONELL AND C. L. PERRY.

In designing electrical apparatus it is often of the greatest importance to know the effect of different temperatures on the insulation to be used in its construction. Of the many kinds of insulation a few of the most common were chosen—*i.e.*, paper, cloth, oiled paper and oiled cloth—and the following conclusions have been drawn from the result of 102 tests on samples of materials which were kindly furnished by several of the most prominent manufacturers of electrical machinery.

*The Apparatus.*—The heating apparatus consisted of a glass cylinder 8in. in diameter and 10in. high, covered at the top and bottom with asbestos plates. The lower part of this cylinder was occupied by 12 enamel resistance tubes 5in. long and 24 ohms each. The terminals of these were brought out through the asbestos plate. The current in these tubes being controlled by a rheostat, the temperature in the cylinder could be varied at pleasure. An inch above the heating tubes, and supported by an asbestos collar, was a metal plate having holes punched in it to allow the free circulation of air in the cylinder. This plate was connected to one side of a galvanometer.

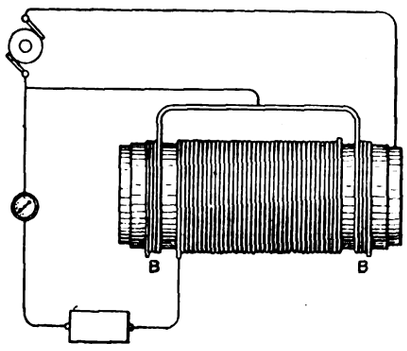


Fig. 1.—Apparatus for Testing Effect of Temperature on Insulating Materials.

The insulating material to be tested was wrapped on brass cylinders ¾in. in diameter and 3in. long, the insulation not reaching quite to the end of the tube. The insulation was then wound with No. 26 Brown and Sharpe bare copper wire for a space of 2½in. Five tubes so wound were then placed on the metal plate in the cylinder and their terminals brought up through the asbestos cover, and then to a switchboard, in order that any tube might be thrown into the galvanometer circuit. This arrangement made it possible to heat five specimens at one time.

With the above apparatus was used a Thomson high-resistance galvanometer, a megohm box and a difference of potential of 500 volts. The thermometer used was of the nitrogen-filled mercurial type, and capable of measuring from 0 to 400°C. When troubled with surface leakage, it was eliminated in the following simple manner. The diagram shows the connections while testing a tube, and also the leakage shunt. It will be seen from the diagram (Fig. 1) that all of the current going through the galvanometer must pass from the dynamo to the brass cylinder, and thence through the insulation to coil A and on through the galvanometer. Any current tending to leak over the surface of the insulation from the brass cylinder to coil A will be intercepted and shunted past the galvanometer by coils B B.

During the investigation many different specimens of paper, oiled cloth, &c., varying greatly in thickness and composition, were tested, and it was found that each class has its characteristic properties strongly marked. We will now proceed to the discussion of each particular class.

* Paper read before the American Institute of Electrical Engineers.

*Plain Paper.*—In this class 40 specimens were tested. After the resistance at the temperature of the air (22°C.) was carefully noted, the temperature was gradually increased (100deg. in one-half hour) and readings taken every 10deg. up to 80deg., and from there on every 20deg. Fig. 2 shows a curve which is characteristic of practically all kinds of plain paper. It should be noticed, however, that in general the resistance of papers that are not protected from moisture falls between 22deg. and 50deg., and then rises rapidly, until at 75deg. it has attained a maximum resistance. It should also be noted that this temperature of 75deg. is very constant for all kinds of paper. From 75deg. upward the resistance falls rapidly, and at 150deg. is but a small fraction of its initial resistance.

The initial resistance of paper protected from moisture by japan (Fig. 3) is very high, but falls rapidly with the increase of temperature, as is the case with all material protected from moisture (*see* oiled paper and oiled cloth). Hence we see that all paper having a porous structure, and therefore containing more moisture, has a lower initial resistance than the protected paper, but is affected by heat much less than the latter. This would lead to the conclusion that there are two phenomena taking place. First the

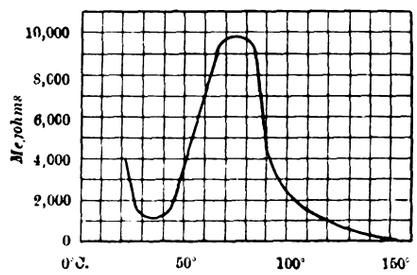


Fig. 2.—Plain Red Paper 0·009in.

driving off of the moisture, which tends to increase the resistance, and secondly, some change (not a mechanical deterioration) in the material, dependent on the temperature, and which may be called the temperature coefficient. This temperature coefficient tends to lower the resistance with increase of temperature.

Examining the several curves shown, we see that the initial resistance of unprotected papers is low on account of the presence of moisture. Now, on gradually increasing the temperature, the resistance falls during the first 20 or 30 degrees, because the effect of the temperature coefficient predominates during this period and before the material is warm enough to start the evaporation of the moisture it contains. This, however, lasts but a short time, as the result of the evaporation is to increase the resistance very rapidly, until, at 75 degrees, the temperature coefficient again asserts itself, and the resistance rapidly falls.

In the case of japanned papers (Fig. 3), the initial resistance is very high, due to the absence of moisture; but on being heated the resistance drops rapidly as the small quantity of water con-

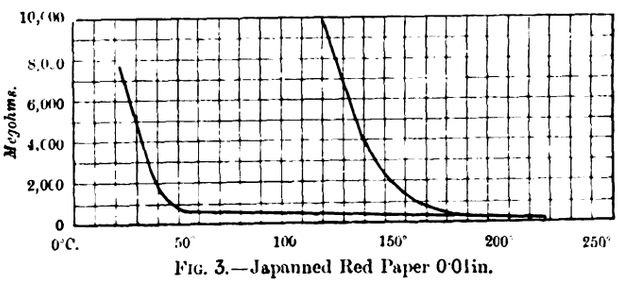


Fig. 3.—Japanned Red Paper 0·01in.

tained is evaporated off so slowly that it has very little counteracting effect on the temperature coefficient. Paper does not seem to deteriorate mechanically at less than 180deg.; above this point the material begins to carbonise. At 230deg. a peculiar phenomenon takes place. The material, after possessing a very low resistance from 175deg. upward, would at about 230deg. suddenly increase greatly in resistance and immediately after break down. This may be caused by some molecular rearrangement taking place at that temperature, which changes the resistance of the material. Other cases wherein the resistance of a body changes at a certain temperature are well known. In the phenomenon of "recalescence" a piece of iron or steel, after having been heated to a bright redness and allowed to cool slowly, will, at a certain stage of the cooling process, receive a sudden check. Heat being generated in the metal as a result of the change which the molecular construction suffers at the critical point, the cooling is arrested and the temperature and resistance rise, though the loss by radiation is still going on. The experiments of F. Kohlrausch and Hopkinson have also shown

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that the critical temperature is marked by a sudden change in the coefficient which expresses the effect of temperature on the electrical resistance of iron. This is also true of nickel. It would seem that paper insulation has a critical temperature somewhat analogous to that of iron, steel and nickel, but, of course, the characteristics of the materials are too different for any close similarity.

*Plain Cloth.*—Under this head 20 specimens were tested, including canvas, linen, and muslin of different thicknesses. The action of this material (Fig. 4) is much the same as that of paper, Fig. 2. The initial resistance is lower, as it contains more moisture than is the case with paper. For the same reason, when the moisture evaporates off, the increase over the initial resistance is greater than with paper. By reference to the curves of paper and cloth it will be noticed that their resistance varies in the same manner. For cloth, as for paper, the maximum resistance is at 75°C. The material does not begin to carbonise until at a temperature of

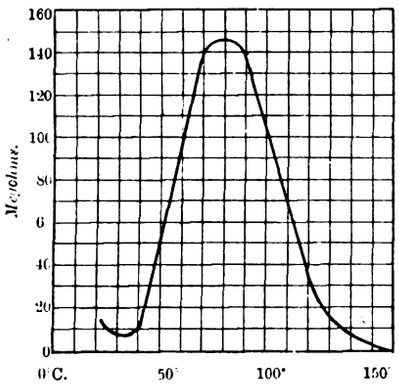


Fig. 4.—Plain Cotton Duck 0·015in.

180 C., and even beyond that point it loses its mechanical strength very slowly until past 220deg. The explanation for the resistance of cloth varying as it does, is exactly similar to that for paper.

*Oiled Paper.*—In this class 14 tests were made on papers of different thicknesses. With the single exception of one specimen, the resistance of which was very high, the initial resistance was ower than in the case of paper. (Compare Figs. 2 and 5.) On increasing the temperature the resistance fell rapidly, the curve being much the same as that for japanned paper. The reason for the sudden decrease in resistance is the same as that for japanned paper. Oiled paper deteriorates mechanically at a lower temperature than paper or cloth, commencing to blacken at so low a temperature as 120°C.

*Oiled Cloth.*—In this class 28 specimens of oiled silk, muslin, and linen of various thicknesses were tested. The initial resistance of this material is much lower than that of paper, and on increasing the temperature the resistance falls rapidly, the shape of the curve,

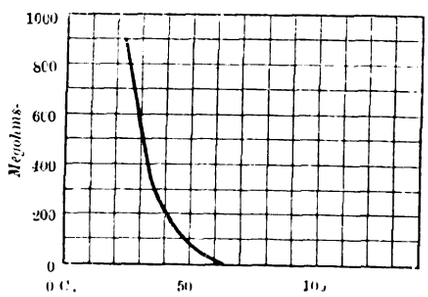


Fig. 5.—Oiled Paper 0·0045in.

Fig. 6, corresponding to those of japanned and oiled paper, the reason for the sudden decrease in resistance undoubtedly being the same as for the japanned and oiled paper. The insulation begins to char at about 120 C.

*General Conclusions.*—In the foregoing discussion there are some main points to which it is necessary to draw attention. These are:—

(*a*) That paper is a better insulation, and withstands increase in temperature much better than cloth (shellac and varnish were not used in any of the experiments), oiled paper, or oiled cloth.

(*b*) That paper and cloth have a maximum resistance when first heated at about 75°C., and are not injured mechanically under 180 C.

(*c*) That the point of maximum resistance for paper and cloth (in this case 75 C.) depends on the rapidity with which the temperature is increased. Here the authors would like to suggest that if the material were kept at a constant temperature until all the moisture had been evaporated, the resistance of the material would then be its true resistance at that temperature.

(*d*) That all give a high resistance after cooling, but have little mechanical strength. Oiled paper and oiled cloth, however, after having been heated to 220°C. and allowed to cool, not only have a high resistance, but become so firmly fixed to the brass cylinders that it was found necessary to remove them with a file.

(*e*) That it would be well to bake paper and cloth insulation to 140°C. before applying varnish or shellac.

(*f*) Referring to Fig. 3, it will be seen that on decreasing the temperature the resistance increased, but the second curve does not by any means coincide with the first. On further experimenting in this direction it was found that there is no temperature at which the curve with falling temperature coincides with the first. This may be due to more moisture being driven out at higher temperatures, which is not absorbed by cooling.

Here it may be well to mention an interesting phenomenon that occurred in connection with this investigation. When the tempera-

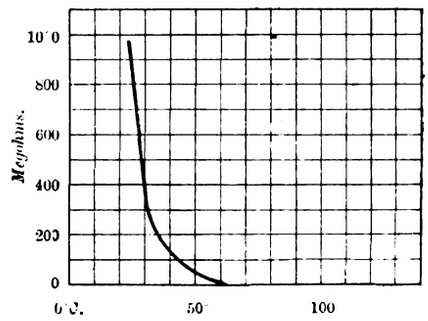


Fig. 6.—Oiled Silk 0·007in.

ture has risen above 100°C. the zinc in the brass cylinder begins to leave its surface and combine with the copper wire wrapped about the insulation, so that the wire has a brass surface and the brass cylinder a copper surface. Owing to the limited time at the authors' disposal they were unable to further pursue this investigation, but much remains, and any research along this line will be found full of theoretical as well as practical interest.

## ON THE ORGANISATION OF AN ELECTRICITY WORKS STAFF.*

BY E. T. RUTHVEN-MURRAY (WORCESTER).

As the success of an electricity works depends in no small degree upon the staff directly engaged in running the plant, the organisation of this staff requires considerable judgment on the part of those responsible for their engagement.

No hard and fast rules can be laid down as to the number of men necessary on the staff, as this will depend upon the individual characteristics of the electricity works. Among other matters to be considered, which have a direct bearing upon this, are the size of the works, their design, the system employed, whether a direct-current battery station or an alternating-current supply, and, of course, whether the supply is constant or intermittent. Unless there be a large demand throughout the night for public lighting, or an intermittent demand both by day and by night for motors, the small battery station may be able to give a constant supply with only one watch of men, whereas the alternating-current station will require three eight-hour watches. How many men are required for a watch will depend upon the size of the works; but probably it will be necessary to have at least one engineer in charge, one driver, and one fireman. The number of men necessary will be lessened by careful design of the works; the number and sizes of engines and their arrangement, the use of mechanical stokers, coal conveyers, and the situation of the coal-bunkers. All these details will influence the economical and easy working in addition to the size of the staff necessary. One has seen stations in which it is only possible for a driver to look after one engine, while in others it is safe and easy for one man to take charge of four or six engines running at one time if they are properly arranged. The high speed enclosed engine with continuous lubrication requires less attendance than any other, and there is little doubt that where a large battery of boilers is fitted with mechanical stokers the result is to reduce labour and the number of firemen required.

* Paper read before the Municipal Electrical Association, June 11th.

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A variety of opinions exists among different engineers as to the precise duties one man can perform, and also what men are necessary—some considering electricians or engineers in charge and switchboard attendants superfluous; while others hold the same opinion with regard to greasers, cleaners, and coal-trimmers. It is certain that by a proper understanding at the time of engagement, especially if one does not take them from over-manned stations, men can be obtained who will combine the duties in a perfectly satisfactory manner for which in other works two men will be employed. It behoves the engineer to be particularly careful and far-seeing in engaging a staff to keep the wages item of the standing charges as low as is consistent with safety; since when the output is small this item is a heavy burden on the young station. If a good fitter-driver is engaged and kept on light load watches, it will be possible to dispense with a regular fitter until the works can afford to keep one, and it should not be necessary in the early existence of the works to employ both cleaners and greasers—indeed, in some stations these men do not exist. Either locomotive or marine engine-drivers and firemen are found particularly well suited for service in electricity works, as their previous employment seems to give them steady nerves, and this will prove invaluable in emergency. They have also more economical ideas of working.

Regarding assistant engineers, it seems only right and proper to employ them, as one can hardly expect either the engine-drivers or switchboard attendants to have the necessary technical training to enable them to take entire charge of the works during the absence of the chief engineer; moreover, it is obviously necessary to give some one man the general responsibility of the proper working of the station during each watch. Undoubtedly the best men for the post are those who, in addition to having received a thorough technical training, have served an apprenticeship in a good mechanical workshop. It is admitted that the mechanically trained man proves more useful and reliable than the purely theoretical electrician. It is unfortunate that the remuneration of assistants is not higher than it is, since, if it were, they would be inclined to remain longer in the same works than they now feel they can with justice to themselves. But this is a matter which time will cure; for, when electricity works are firmly established, they will be in an even better financial position than gas works, and it is to be hoped their staffs will be remunerated accordingly.

In works having a large area of supply, a distribution engineer will be required to superintend the outside work, such as the laying of mains, the testing and connecting of consumers' installations, and to take the more direct charge of the outside staff of meter-readers, jointers, wiremen, and the labourers necessary for opening up the streets. It is almost essential, at any rate advantageous, that the distribution engineer should have had some station experience. The number of outside men required will vary at different periods of the year, and in many municipal electricity departments arrangements can be made with the surveyor to lend labourers whose bare time is charged against the department. Notwithstanding that the greater part of the outside expenses go to the capital account, such an arrangement is of great assistance in reducing wages under this head.

In organising the staff, it is most important that the engineer be allowed to choose or recommend men for appointment, and that the men know to whom they are responsible. It is the greatest mistake for the committee who have charge of the department, not to allow their chief engineer a free hand in this respect, and internal troubles in electricity works have often been due to this cause.

## DISCUSSION.

Mr. ALBERT GAY (Islington) thought the subject of the Paper a very difficult one to deal with. The local conditions made all the difference as to the number of staff employed. It was only advisable to reduce the staff consistently with safety. Moreover, a station which was not properly manned would cost more for repairs through not being looked after properly. It did not necessarily mean that a reduction in the staff meant a reduction in the wages, because if they were going to work a man 12 hours instead of 8 (and 8 hours was quite enough for any man in an electric lighting station) he could not work as well as if he had been working the shorter number of hours. There was another point in connection with the reduction of the staff that he called attention to. It was quite possible, perhaps, to run a station in its early stages or in the early hours of the morning with say three men, one stoking, one driving the engine and another regulating and generally superintending. But it was not an impossible thing for a man to be taken ill, and in the event of that taking place it was rather a serious matter if they did not have a spare man on the premises, and it was only a wise precaution to have an extra man and utilise him as a cleaner during the small hours of the morning. He did not believe in fitter-drivers, because a man that could do everything, or said he could, generally could do nothing at all properly, and if they wanted to keep their machinery in proper order they must have proper men.

Mr. R. A. DAWBARN thought a place should be built next to the central station for the men to reside in, after the principle of the fire stations, so that in case of an emergency the men could be called upon.

Mr. CROSSLAND said there was a general impression among mill-owners that any man would do for a fireman. This was a very wrong impression. The fireman had a very large influence upon the economy upon the station. He (Mr. Crossland) had to make trials of the economy of boilers, and he found that the air admission to the boiler was a very important question, and the air admission was largely dependent upon the care of the fireman. If he was a bit careless and left an open space through which they had an air admission, they got a very serious loss. The careful control of engines such as were in electric lighting stations certainly required great care and skilful men.

Mr. W. ARNOT (Glasgow) wanted to speak more especially upon the engaging of the staff. One of the most difficult positions an engineer could be placed in was to have a man recommended to him and have to refuse him, when he came with a good recommendation from a Councillor or from men who knew him. He thought all engineers should be strong enough to use their own judgment in the matter, and that they should be left alone; they should not be compelled to engage men who came with recommendations from outside people.

Mr. A. B. MOUNTAIN (Huddersfield) could not help thinking that if they were going to cut down their staff they were doing a very dangerous thing. They might have their chief assistant leave at a moment's notice, and have to find someone to fill his place. He believed in having pupils on the premises, who understood the station, so that one of them could take a spare place at a moment's notice. He did not think that an engine-driver could be of any use as a fitter in a big station.

Alderman HIGGINBOTTOM (Manchester) thought that all Committees should place implicit confidence and power in their engineer as to the engagement of the staff, and they could then hold him responsible. They had had considerable trouble over this question in Manchester. Matters got to such a pass in Manchester that Dr. John Hopkinson (their consulting engineer) said that unless they placed the whole matter in his hands and made him responsible for six months, he would withdraw from the station and let them get on as best they could. The Committee did so. Dr. Hopkinson got rid of the chief man, lent them their present engineer on trial for six months, and things had gone on satisfactorily since. They gave their resident engineer full power over all the workmen. He thought it was a mistake for Councillors to recommend their own friends; the engineer found a difficulty in saying that he could not find work for them, or that they were not suitable. If he took a man on outside, and he did not suit, he could at once tell him so, and that he would have to go. If Committees would only leave the matter in the hands of the resident engineer, they would do a very wise thing.

Alderman NORMAN (Cheltenham) thought that any other course than that recommended by the last speaker would be an absurdity. His Committee would never think of interfering with the staff. They held their engineer responsible for everything, and it was much better that a Committee should look at in this way and keep the man up to his responsibilities.

Councillor PEARSON (Bristol) considered the Electric Lighting Committee was responsible to the Town Council for the management of the station, and the engineer-in-chief was responsible to the Electric Lighting Committee; but he should no more think of transferring the direct responsibility of the management of the Bristol station to his own shoulders from those of the engineer, than he should think of flying. In his opinion the Chairman at the head of an Electric Lighting Committee was responsible for the whole thing. They had a good engineer managing their station, who was free from the difficulties with Committees which had been pointed out by other speakers. He always told him to please himself about a man, whether a Councillor recommended him or not.

Mr. E. T. RUTHVEN MURRAY, in reply, thought he had been misunderstood. He did not advise the reduction of a staff, but only the greatest care in organising it, so that too many men should not be employed. With regard to the last paragraph of his paper to which so many speakers had referred, he had had a little trouble in this respect himself, and that was the reason he had mentioned it. With regard to fitter-drivers, he only suggested that they *might* be employed during light loads when the station commenced to run, and certainly not afterwards. It must not be understood, when he suggested only three men as being capable of running a station, that he was referring to a large station. He was thinking of the organisation of the staff when the station commenced work.

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## THE INSTITUTION BUILDING FUND.

Not the least valuable of the many results which have already followed, or may be expected to follow, from the recent stirring of the waters at the Institution of Electrical Engineers is the resolution which was come to at the meeting of July 6th, "That the Building Fund, which is now but a sub-division of the funds of the Institution, shall be made a permanent Building Fund, and that the interest accruing from such fund or the investments thereof be added to the fund from time to time." Every reputable citizen, when he arrives at a certain age, bethinks himself of setting up house; and it is no less incumbent upon a 25-year-old Society, claiming to represent, or wishful to represent, an important and ever-growing branch of the engineering industry, that it should give up living in lodgings and "settle down." Precedent has a pernicious power in this realm of England, but when it tells in our favour it is as well to make full use of it. Have not our generous hosts at No. 25, Great George-street lately spent no less a sum than £25,000 to render their local habitation more worthy of their name? and has not that comparatively youthful but admirably vigorous body, the Institution of Mechanical Engineers, also devoted some £28,000 to a similar object? Everywhere in this overgrown city of mean buildings and depressing streets we see to-day unmistakable signs that the reign of the superstition that "houses are built to live in and not to look on" is over, and it no longer passes for wit to assert that fine buildings should be left to the poets, who can build them out of their imaginations at no cost to their pockets. Even the London County Council is in labour with quite a grandiose scheme for housing itself in a fitting manner; and the strictly business-like £ s. d. suggestion that it should turn an honest penny and mar the whole idea by letting out the ground floor to shop-

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keepers was mooted only to be scouted. The psychological moment has, therefore, it would appear, arrived for placing the Building Fund of the Institution on a firm footing, and for actively pushing towards the goal in view, a building which shall be in style, size and site worthy of electrical engineers.

Large buildings, good architecture, and suitable sites are, however, costly desiderata, and none the less so in these days when the idea of the Manchester school that architecture "means only sound construction and sanitation, and is all based upon the drain pipe," has nearly passed away, and when land in the neighbourhood of Great George-street is scarcely less valuable than in the heart of the City. The electrical profession, it will be urged, is by no means a wealthy one, and it must consequently content itself with a modest house in a back street. We cannot admit the premiss without considerable qualification. Modern electrical engineering, if we take as criteria the dividends of manufacturing concerns, the incomes of the majority of consultants, or the salaries of central-station engineers, has without doubt an impoverished aspect. But it must not be forgotten that the Institution of Electrical Engineers has on its register many representatives of the earlier and more profitable industries of telegraphy and telephony, not to mention here and there a successful inventor, and here and there a wealthy manufacturer. There was money to be made and money was made before the rush came; and to what better object could some of it be devoted than to raising in the capital of the Empire a prominent and permanent memorial of nineteenth-century electrical invention and enterprise? A large London hospital has recently represented to the Public that it is in need of half-a-million sterling as an endowment to make good the decrease in income due to agricultural depression. The money did not flow in freely; and an ingenious individual, who possessed a greater sense of irony than of expediency, was moved to compile and to publish a list of potential donors, appending to the name of each a donation suitable to his means. It is needless to say that the potential donors were not converted by this ruse into actual donors; and the general Public, of course, took the joke quite seriously, and seeing the movement so well supported stopped sending in its mites. We do not for a moment suggest a similar piece of unbecoming—and ineffectual—levity on the part of anyone anxious to hasten the natural growth of the Institution Building Fund; but we do suggest that the length of such a list would be longer than many imagine, and the sum total of the appropriate donations large enough to enable the Building Fund Committee, if any such body exist, to get to work immediately. Why, even a "benevolence" of a guinea a head levied on the 2,000 odd members and associates now on the register would place the Building Fund Committee in a position to immediately purchase any suitable site in the market, and enable them to quietly await the great day when the fund shall have received increments from "munificent donors" and sundry sources sufficient to warrant the commencement of building operations. A good site once secured, all the rest will follow in due course, and we sincerely hope that those who have this matter in hand will not allow their views to be bounded by what *seems* immediately possible, but only by what *is* desirable. Englishmen, it has been scornfully said, "have built like frogs and mice since the thirteenth century;" and now that this reproach is likely to become more remarkable for its vigour than for its veracity, it will be a thousand pities if fresh point is given to it by the erection of a public building lacking in all dignity, though possessing the single merit, if merit it be, of low prime cost.

Many electrical engineers, no doubt, will ask:—Why do we want a building of our own? Have we not the free use of the Institution of Civil Engineers? Are not many of us members of that Society? What is the *quid pro quo*? The electrical engineer has done more even than the civil or the mechanical or the chemical engineer to revolutionise the social world; he is day labourer in a field the limits of which recede like the horizon as he advances; he is in daily contact with phenomena of the profoundest physical interest; no sooner does telegraphy, on land or under the ocean, lose its first freshness and cease to excite wonder than telephony revives public and technical interest; no sooner does the electric light tend to realise the ideal and become the poor man's light, than electric traction and electro-chemistry open up long vistas of new work. And on the scientific side the perennial youth of electricity is even more marked. But, strange to say, the electrical engineer is somewhat ashamed to confess himself as such. It is quite right that he should be a mechanical engineer first and an electrical engineer afterwards; it is quite right, that is, if the formula means that no electrical engineer is complete without a sound mechanical training; but it is quite another thing if the phrase be used, as undoubtedly it often is, to convey the idea that the speaker is at heart a mechanical engineer, and that it is merely due to the sad exigencies of existence that he takes up with electrical engineering as an adjuvant means of livelihood. There is, in short, among electrical engineers a marked lack of proper pride in their profession, though individually they are, of course, by no means inclined to undervalue themselves. In our opinion no one thing would tend to generate a greater feeling of "solidarity" and a higher sense of the dignity of the calling of the electrical engineer than the possession of an independent home in a fine building. If the Institution of Electrical Engineers had its own lecture theatre, its own library and reading-room, its own laboratory, and its own museum filled with mementos of the past, many who to-day seek to save their respectability by disguising themselves as members of the older branches of the engineering profession might be brought to see that there was nothing inherently disreputable in applied electricity.

## REVIEWS.

**Electric Lighting: Vol. I.—The Generating Plant.** By F. B. Crocker, Ph.D. (New York: D. Van Nostrand Company. London: E. and F. N. Spon. 1896.)

The purpose of the treatise of which the present is the first volume seems to be to present a complete summary of the mechanical, electrical and commercial considerations involved in public and private electric lighting. We use the word "summary" advisedly, as, although the author has evidently schemed out his work with careful thought and arranged it in logical order, he does but touch briefly on each of the branches with which he deals. This defect, if we may call that a defect which was probably part of the author's design, is the most prominent feature; and it is generally in those places where one naturally looks for detailed information that the author exhibits his vaguest and most summary phraseology. Some compensation is certainly afforded by the numerous references, by footnote, to works where more detailed information is to be found. In this, however, we are not altogether at peace with the author; for instead of acknowledging the various researches and inventions to their English or other originators, he merely refers to some one or other's article on the subject, in an American periodical. For instance, the ingenious idea of using flywheel boosters on electric railways is not credited to the engineer whose fertile brain originated it, but is credited to a Mr. John Galt, who read a Paper on the subject, in America, in 1894. This

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custom may enhance the value of the book for American readers; but it lessens it to an equal extent for readers who have not ready access to American periodical literature.

The plan adopted by Mr. Crocker in framing his treatise is the simple one of following the natural sequence of the plant, from the source of energy to the lamps. It will be convenient if we divide the matter of this first volume, which treats of generating plant, into three parts. In the first part we may place the introductory matter, which occupies six chapters; in the second part, eleven chapters on the sources of energy and mechanical plant for utilising energy; and in the third part, the remaining eight chapters on dynamos and electrical equipment of generating stations.

Passing briefly in review the introductory chapters, we notice that Mr. Crocker treats at some length of such questions as the advantages and disadvantages of the electric light; the history of electric lighting (from the time of Otto von Guericke); various systems of units, metrical and otherwise; the classification of electric lighting systems; and the location and erection of station buildings. In the historical chapter we are told that "arc lighting in Europe has never been particularly popular or extensively used, even up to the present day." Nor must we forget to say that in the chapter on units Mr. Crocker raises an outcry against the multiplication of units. He thinks that "it may be the duty of future electrical congresses to abolish units and terms which are found useless."

Various remote parts of the universe are searched for "possible sources of electrical energy," the internal heat of the earth being regarded as not impossible. Mr. Crocker has doubts about the efficacy of primary batteries, but he holds very hopeful views in regard to the thermopile. "Though it might not compete with the present method for large central stations," he writes, "it is certainly admirably adapted to small isolated plants." We are not so hopeful, but confess to having once seen a small isolated glow lamp run by a thermopile. It was quite a large thermopile.

A number of chapters are devoted to mechanical subjects, and deal successively with the steam engine, gas engine, water turbine and windmill. As regards the relative merits of direct-coupled and belt or rope-driven dynamos, the author leans towards the use of gearing. His arguments in favour of this, however, are not very convincing. Firstly, he does not believe the dynamo can be designed satisfactorily to run at a low speed:—

"It is a common thing to hear persons attempt to get around this fact, and confuse or deceive themselves by assuming some form of winding or other arrangement which will give the same output at a lower speed; but we know that a dynamo running at 250 revolutions per minute will give almost exactly twice the output if the speed be increased to 500 revolutions per minute."

The fallacy is obvious. A dynamo run at twice the speed may possibly give twice the output; but there is no inference that a dynamo *designed* to run at twice the speed of *another* dynamo would give twice the output. Nor are Mr. Crocker's arguments against running steam engines at high speeds any more convincing:—

"The running of an engine above a certain speed is decidedly objectionable; since it reduces its efficiency, requires more attention, increases the wear and repairs, and consumes more oil. Anyone who has ever had experience in running engines at 80 revolutions per minute, and also at 350 revolutions per minute, realises the enormous difference between the two cases in what might be called the *comfortable*, as well as the economical, working of the plant. In fact, any increase in the speed of an engine, even if it is only 10 or 20 per cent. above that at which it runs normally, will begin to make very perceptible differences in its working."

Here is another example of the fallacious logic and loose phraseology which pervade the book. The author is utterly unable to discriminate between an engine that is being run too fast and an engine that is designed to run at the higher speed. And even where he is fallacious he fails to be explicit. He vaguely tells us that to run an engine too fast "will begin to make very perceptible differences in its working." What sort of very perceptible differences? Yet, upon such an unsound basis as this does the author place his conclusion that "the ordinary steam engine and dynamo do not naturally agree in speed." *Ergo*, they must be connected by gearing. Was ever so specious and so erroneous an argument raised before?

## LOAD LOSSES IN DYNAMOES.

BY W. M. MORDEY.

Before acceding to your request that I should state from my own experience how I regarded Mr. Blathy's recent announcement of the discovery of a loss in dynamoes* increasing with the load, and often of very serious dimensions, I should have preferred to have waited for fuller particulars of the tests on which he bases his conclusions. His article, unfortunately, is confined to a general statement containing no details of tests, methods of measurement, or other particulars on which one can form an opinion.

However, knowing what I do of Mr. Blathy, of his work, and of the facilities at his disposal, I do not doubt that when full details are received we shall find that he actually has made an interesting discovery. And it is with a view to inducing him to give such particulars as will enable us to see how this load-loss effect is caused, and how it may be prevented, that I now write. For I have no information whatever to give from my own experience. I have never come across this loss either in tests with which I have been connected nor in any published tests of others; nor do I call to mind any references to the subject either in papers or other publications on dynamoes. Possibly my reading has not been close enough, and I am prepared to find that the matter has escaped my observation; but until I have my attention drawn to the published anticipations, I shall consider Mr. Blathy entitled to the full credit of the discovery. I may confess I was a good deal surprised at his article, as, for my own part, I had considered that I was placing the losses high enough when I added the $C^2R$ losses to the no-load losses, easily ascertainable by experiment. In fact, I have gone further than this, and have been under the impression that the full-load losses are often somewhat less than the sum of the no-load parasitic losses and the $C^2R$ loss. That this may be and is the case under some circumstances will be readily acknowledged by those who can recall instances not only of there being no increase of power required to drive certain dynamoes when the external load was increased, but even of cases where the power absorbed actually decreased as the external load was increased. I have on previous occasions called attention to such instances as illustrating the reaction of the working current on the eddy currents, and need only mention them now to make it clear that there is no necessity in the nature of things for the stray losses to increase with the load.

In matters of this kind one always turns to the classical 1886 Paper of the Hopkinsons', and in this case with the usual result. That Paper gives, in very full detail, tests of two Edison-Hopkinson drum-dynamoes, and of two "Manchester" Gramme dynamoes. These tests were made by the well-known Hopkinson method then first announced, the power being circulated, the losses only having to be supplied and measured. In the case of the Edison-Hopkinson machines the generator was worked at various loads up to about 46,000 watts. The stray losses are given as follows (see *Phil. Trans.*, 1886, p. 350, *et seq.*)

| Output of generator in watts. | Stray loss in watts. | Output of generator in watts. | Stray loss in watts. |
|---|---|---|---|
| 4,720 | 676 | 41,567 | 822 |
| 10,678 | 825 | 42,086 | 831 |
| 21,014 | 935 | 42,451 | 856 |
| 25,256 | 691 | 40,304 | 653 |
| 26,592 | 657 | 46,242 | 459 |

And in the "Manchester" machines—

| | Load. | Loss. |
|---|---|---|
| About | 16,000 | 289 |
| „ | 5,000 | 294 |

These stray losses, the authors explained, "were calculated by deducting the power absorbed in the armatures and magnets and extraneous resistances from the total power given to the combination, as measured by the dynamometer. They must

*[This peculiar style of spelling has been permitted in this particular article at the special request of the author. Ed. *E.*]

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therefore include all the energy dissipated in the core of the armature, whether in local currents or in the reversal of its magnetisation; also the energy dissipated in local currents in the pole-pieces, if such exist; also the energy spent in reversing the direction of the current in each convolution of the armature as they are successively short-circuited by the brushes. Further, it will include the waste in all the connections of the machine from the commutator to the terminals and the friction of the brushes against the commutator. . . . . Probably 100 watts is the limit of error in any of the measurements."

The loss was not determined separately for generator or motor. Indeed, it would be difficult to make such a separation. It is half the sum of the total stray loss. It may be added that the hysteresis loss alone, estimated from separate tests on the iron, is given as 292 watts in the Edison-Hopkinson, and 159 watts in the "Manchester" dynamoes.

It will be observed that in a range of load from 4,720 to 46,212 watts there is no evidence of any gradually increasing load-loss. The *smallest* loss was when the *largest* load was on; and looking to the character of the readings one would be inclined to think that the average of the ten readings, which gives 740 watts, would probably very closely approximate to the actual loss at all loads throughout the range of readings. As to my own tests I have already said that I have not come across this effect. In testing an alternator by a modification of Dr. Hopkinson's method, using one half the armature as a motor and the other half as a generator, measuring all the quantities electrically, I found no indication of an increasing load loss. The figures may be found in the *Journal* of the Institution of Electrical Engineers for 1893.

I have said enough to show that this load-loss of Mr. Blathy's is not general. It is no doubt capable of explanation when it does occur, and I trust the matter may now be so ventilated that it will not be difficult to avoid it.

It will, of course, be recognised that if there can be a decreasing load-loss, an increasing load-loss is equally possible. A decreasing load-loss may occur in dynamoes where the eddy loss at no load is great. An increasing load-loss may occur where eddy currents are set up by the armature current acting on masses of metal beyond the reach of the field.

## ELECTRICALLY OPERATED FACTORIES.*

BY R. E. B. CROMPTON.

Of all the modern applications of electricity probably none is of greater importance than its employment for transmitting power in factories; in other words, to take the place of the long lines of shafting, pulleys and belts, which distribute the power from the steam or water engine or other prime mover to the various machines which are to be driven.

The advantages of electric transmission became evident from the first moment when it was noticed that with a current passing through a Gramme dynamo, the latter revolved and acted as a motor. Within few years of this, almost every electrical engineer had developed this convenient arrangement wherever detached machinery had to be supplied with power at a distance from the main shafting. As early as 1881 the author supplied to M. Emil Bürgin, of Basle, a pair of dynamos to act as generator and motor for transmitting power at Schaffhausen, in Germany, and this early example of electric transmission, from which a combined efficiency of 66 per cent. was obtained, remained at work until the year 1890—in fact, until it was superseded by a larger scheme.

In this article it is not proposed to enter on the very extensive ground of electric transmission of power to great distances, but to consider the simpler problem of using electricity to take the place of shafting and belting for distributing power to machines in factories of moderate size, and in which the distances over which the power has to be transmitted do not exceed a few hundred yards.

The size and arrangement of factories designed to manufacture goods in the most economical manner is governed very largely by this distribution of power question. Whenever the old arrangement of shafting and belting has to be used it matters not what is the source of power, whether steam, gas or water, the factories must be so laid out that the lines of shafting can be readily driven either simultaneously or independently. This has hitherto been carried out in the most perfect manner by laying out all main lines of shafting, parallel to one another, by the very limited use of toothed gearing, and by the large use of belting or rope driving, as it is found that any arrangement of driving secondary shafting, at right angles to a large main line of shafting, through toothed bevel gear (although it appears at first sight to be a convenient one) is, in the end, noisy, wasteful in power, and costly to maintain. Even with factories so laid out, it is quite usual to find that on account of special processes, which, by the rules of the insurance companies, must be carried out in detached buildings, transmission plant, in the shape of wire or cotton ropes, has to be used, and such transmissions are, in many respects, unsatisfactory.

It was to meet the obvious inconvenience of transmitting power to detached tools which could not be readily placed in a convenient position to be driven from the main lines of shafting, or which required, from the above reasons, to be placed in detached buildings, that small plants of electric transmission were first used, and there is no doubt that to the increasing employment of such detached transmission plants, originally put in solely for convenience, we owe the very wide development of electric transmission in factories which has taken place during the last few years.

In fact, electric transmission, on account of the higher cost of the dynamos, conductors and motors, has not come into actual competition with the ordinary lines of shafting until a very recent period. This has been due to two causes:—First, that the great economy attending the use of electric transmission was not at first noticed; and second, that the extended use of electric motors in cities where electric supply systems have been, for some years, at work, has so greatly increased the demand for them that special plant has been in many cases put down to turn them out in very large quantities, and consequently at low prices, so that high cost of motors no longer is a deterring cause, preventing their wide introduction.

It is very evident that there are cases where a manufacture, such as that of explosives, must, for purposes of safety, be carried out in a number of detached buildings, and in such cases the employment of electric transmission is so evidently the most convenient and most economical system of supplying power, that its use has been almost universally adopted; but it is here proposed to show that, quite apart from these special cases, there are a very large number of factories in which the machinery can be operated electrically far more economically and conveniently than by the older methods hitherto in use.

The cases in which electric driving tells to great advantage are those in which the machines require to be driven intermittently. In these instances great economy follows, from the fact that no long lines of shafting are required to run idle during the time that the machines driven by them are kept waiting for the work to be fixed or for other causes. On the other hand, in textile or similar factories, where a steady amount of power has to be supplied to the machinery throughout the working day, and where the time that each machine is thrown out of use forms an insignificant fraction of the whole, the above advantage which electricity offers in reducing the idle hours of the shafting are but small, but even in these extreme cases there are economies to be obtained from electrical driving which make it appear probable that electricity may compete favourably with other sources of power.

Let us first take the case of a large engineering works, such as is commonly met with in all countries where iron and steel is not only produced from the ore, but is also made into castings, forgings and finished engineering goods, steam engines, machine tools and the like. In such works, previous to electric transmission, we find the power required for the various processes which deal with the manufacture of the raw material scattered over a large area. In the great majority of cases steam power is used; groups of boilers are put down at various points, each of which require the services of one or more stokers. Again, each group of boilers supplies a number of steam engines, some of them of large size, some of them small. The steam is conveyed to these engines by extended lines of steam pipes in which the condensation is very great, and each of these detached engines requires the services of an attendant.

It is needless to remind the technical reader that, worked under such conditions, the efficiency of an ordinary steam plant is excessively low. No one who has thoughtfully examined the power plant of the best arranged ironworks, either in England or on the Continent of Europe, can have failed to observe the extremely low duty that is obtained from the fuel in the form of horse-power actually applied to the work; for not only is the boiler efficiency low, but the condensation loss in the steam pipes is excessive, and the engines are worked so intermittently that there is no advantage obtained in compounding them; and, further, the difficulties of collecting the steam from the scattered exhaust pipes entails such complication that, as a rule, the advantages of condensing cannot be obtained. In other parts of the same works, where the raw material is worked up and where the boilers and engines can be brought nearer to their work, the case is not quite so bad, but even there the power plant generally works at a low rate of efficiency.

* Abstract from *Cassier's Magazine*.

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To deal with such a case electrically is an easy task for the engineer. He has simply to provide a power house which need not be placed very centrally, but the site for which may be chosen for the purposes of the easiest and cheapest supply of fuel and condensing water, and for the most convenient attendance. From this power house he transmits energy exactly in the form in which it is required to every class of machinery that is to be driven in the works.

The author does not propose to select any special type of generating plant as pre-eminently suited for the power house of such a works. In every country we find direct-driving generating plant of high efficiency, and in all probability it is only necessary for such a power house to select such plant as that which is ordinarily used in a well-designed electric light station for the supply of light and power to a large town. It is abundantly evident that in these very large works, where many steam engines have to be used, electric transmission offers advantages almost as great as in the case of the explosives factories first mentioned.

We now come to the most common case—a factory of moderate size—where the buildings are of such dimensions that the shafting can be driven by not more than two or three steam engines conveniently placed, and where the work is such as that of building steam engines or general mechanical construction.

It is necessary here to digress a little to point out the various methods of employing electric motors for driving machinery. In order that we may obtain the fullest economical advantages from electric transmission to machine tools, we must, as far as possible, do away with shafting and belting by supplying an electric motor to each machine, so that whenever the tool is not doing useful work the motor is completely at rest and no electrical energy is used. This, the most perfect system, has hitherto not been adopted to its fullest extent on account of the high cost of small motors, so that in the majority of cases it has been found cheaper to forego some of this advantage and to group several small machines, connecting them by a short line of shafting which is driven by a motor.

This arrangement, which at first sight appears to be far from perfect, is not so imperfect as it appears, for the reason that with the modern system of manufactures such small tools are driven, doing useful work, for a very large share of their total time. This is due to the extended use of jigs and like apparatus for the drilling machines, which enable the driller to keep his machine almost constantly running, or to the use of special stops, combined with capstan rests and similar appliances in the smaller sizes of lathes, which are usually employed for turning or shaping small articles.

At the same time, the reduction in the cost of small motors is going on at such a rapid rate as to make it probable that, at no distant time, it will be an advantage to supply each of these small tools with its own motor: but even at the present time, in electrically operated factories, separate motors are, in actual practice, supplied to all the large tools and to a very considerable number of the medium size tools, especially to drilling machinery which can be made portable and so be carried to its work, instead of making it necessary to carry the work to the tool. The work, it must be remembered, is, in some cases, very massive and costly to move.

Factories in which the whole of the plant is operated electrically to the above extent are now becoming common, and from some of them it has been possible to obtain data which enable us to show with great confidence the very considerable economy which such electrical transmission offers.

Although Prof. Kennedy, the President of the Institution of Mechanical Engineers, in his address to that Institution in April, 1894, considered that in a factory, with the useful work taken at 100, the total indicated horse-power of the steam engines may be taken at 145, the author finds that this proportion is far too favourable and is true only in the case of a limited number of establishments where the load is steady throughout the working day. In most cases the following figures more closely represent the actual state of affairs:—

| | |
|---|---|
| Average useful work | 100 |
| Average wasted in belts and shafting | 75 |
| Average wasted in engine friction | 60 |
| Total average indicated horse-power | 235 |

If the author's assumption is approximately correct, and he believes it to be so in the majority of cases in works such as we are now considering, and if we apply it to a factory which requires an average of 500 H.P. net, delivered at the tools, we find the average indicated horse-power, which probably would be spread over three steam engines, would be 1,175. We find, however, that in order to work this plant for 2,950 hours per annum, taking coal at 12s. a ton, the coal bill will work out at £2,260, the probable wages bill £1,480, the stores £600, and the repairs and depreciation of plant together £1,600, making a total cost per annum of £6,000 for 500 net horse-power delivered at the tools, or at the rate of £12 per annum per horse-power.

Now, what can we promise by substituting for this arrangement a modern electrical equipment? In the first place, although we should still divide our total power between three engines, we do so only in order to avoid the risks of a breakdown affecting the whole establishment. We should make these three engines identical in form and size, and we should place them together, so that they could be worked by one attendant.

We can claim for modern generating plant that it can be made with certainty to specification to produce the electrical horse-power, delivered at the terminals of the various motors, distributed all over the works within a radius of 500 yards, with a consumption of 2½lb. of coal per hour, and it is easy to show from the actual records of Messrs. Siemens, Messrs. Crompton, and others, that the proportion of useful work done at the tools may bear to the average indicated horse-power of the engines the high proportion of 500 : 680, so that the total coal bill in this case would be only £1,080; wages, £375; stores, £260; repairs and depreciation, £1,300, making a total per annum of £3,000, or £6 per annum per net horse-power, which is exactly half the cost of the older system.

It will be seen that a very large share of the above saving is on the labour bill, and that consequently, in the cases where fuel is exceptionally cheap, the saving would be diminished; but even if we take fuel at the extremely low price of 6s. per ton, the correction in the above figures would be only such as to reduce the cost of the older system to £10 per annum per net horse-power, and in the case of electric transmission, to £5. In this case, too, it is here shown, the saving effected may be £2,500 per annum.

This large margin, which can be well established from the very careful data obtained by Messrs. Siemens in a long series of trials at their works, and by Messrs. Crompton in a similar series of trials at their works, could be probably obtained, though, of course, to a small extent, in cases where the machinery is much more regularly driven, as, for example, in making textile fabrics. The author believes that it is not at all a difficult matter to take the cases of a large number of textile factories, which have been fitted up recently to be operated by rope driving with the least possible transmission loss and at the least possible annual cost of upkeep, in which electric transmission could be substituted and a saving shown, but these cases, although interesting, are those which the electrical engineer is least likely to be called upon to deal with.

Apart from the economy in cost of power which can, in most cases, be shown to follow on the adoption of electric transmission, it is necessary to point out its great convenience. However ingeniously the belt-driven gear of machine tools is contrived, it is always difficult to keep the shafting and belts clear so as to avoid interfering with the lifting appliances in these factories. No such difficulty occurs in the case of electric transmission. In all larger tools the electric motor should form an integral part of the tool itself, and the conductor can be carried to it in such a manner as to be completely out of risk of interference with the gangways or the floor or with the lifting appliances overhead.

In modern factories, where large masses of material have to be dealt with, there are many cases where the moving about of a heavy casting or forging is, if possible, to be avoided; it is far more economical to bring the machine tool up to the work than to move the work up to the tool, and this is readily carried out with electric transmission. Drilling, shaping and milling machinery can be made portable, and can be brought up and fixed to the work by the ordinary shop-lifting appliances. As soon as such a tool is in position, power can be applied to it from distribution boxes, arranged at convenient intervals along the floors or walls of the workshop.

In this way the floor of a large erecting shop can be kept entirely free from obstacles or hindrances of any kind, so that large pieces of machinery of any class may be erected in the positions most convenient for them, and any machining to be done on them can be carried on by the tools being brought up to them and operated electrically. It can be easily shown that in most cases such an arrangement will lead to the reduction of the total number of tools required, as well as in the cost of doing the work.

Further than this, the introduction of electric power all over a mechanical workshop is attended with many advantages which are now only commencing to be appreciated. Not only can welding, brazing, soldering and many similar operations requiring high temperatures be effected by electrical means in a most certain and economical manner without oxidation of the surfaces, but annealing, case-hardening and other operations can be effected locally to parts of a structure, and results can thus be produced which were quite impossible before the introduction of electricity.

The author does not propose to enter into any lengthy comparison of the various systems of electric transmission that are in use. In many cases the electric transmission plant has been developed from the electric lighting plant originally put down for lighting the works, and in such cases direct-current electric motors, worked at from 100 to 200 volts, have been found highly satisfactory. The only improvements which could be made in the use of these motors has been in diminishing, as far as possible, the slight attendance required at the commutators and brushes, and the necessity for occasionally oiling the bearings. This has prevented direct-

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current motors from being placed in inaccessible positions, but of late the use of multiphase commutatorless motors has enabled them to be placed in comparatively inaccessible places; and now that the use of self-oiling bearings, containing oiling rings, has become so universal, such motors can be run for many days without attendance or even inspection.

The author noticed quite recently, in several of the large Swiss engineering works in which electric transmission is used, that a favourite position for these commutatorless motors was inside the built-up wrought-iron supports which carry the roof and travellers. This is a very neat and convenient arrangement, placing the motor, as it does, out of all possible reach of injury. These commutatorless motors are also frequently used for driving tools of the planing machine class, and are then placed out of reach under the level of the workshop floor. Some very well arranged examples of this, in which multiphase motors are employed to drive planing machines by worm gearing, may be seen in the Oerlikon Works in Switzerland.

Although multiphase motors have this considerable advantage of requiring so little attention, yet against this must be set the necessity of carrying three conductors everywhere, with corresponding complications in the switching arrangements. Moreover, the direct-current system has the advantage that the same generating plant can be used for the supply of light and power and also for welding, annealing and similar purposes which cannot be nearly so readily carried on when alternating currents are used.

Although the author has said little about the best form of generating machinery to be adopted wherever the energy is supplied from a central situation, *i.e*, a power house, this article would be incomplete if it did not indicate to some extent what the author believes to be the best practice as regards generating plant. In England the experience of the last ten years has been to show that the highest results in economical efficiency, combined with low first cost of plant, has been obtained by the use of high-speed, direct-acting engines of the Willans or similar type, coupled directly on to two or four-pole dynamos.

Such plant has been largely used for central station electric lighting purposes, for generating electricity for metallurgical purposes, and also for the power houses of works. There are many cases on record where such generating plant is run continuously all the year round; that is to say, it is started up on New Year's day and is run night and day without stopping the engines or dynamos until the following Christmas Day, the Christmas week being occupied in cleaning up and preparing for the following year's run. In such cases, where the power is supplied for 24 hours, the electric horse-power has been produced with this class of machinery at 9·225d., and it is believed that this cost can be still further reduced.

It will be seen that at this price the production of energy for distribution throughout the works compares very favourably with the lowest cost at which energy has been distributed where water power is the prime mover. This results from the fact that the interest and depreciation on the capital invested is so much lower in the case of the steam plant than in the case of the water-power plant, and this difference is sufficient to compensate for the whole cost of the fuel used by the steam plant.

In the ordinary cases, where the plant is not driven night and day, but only during the working year of about 2,950 hours, such low figures cannot be obtained; but it is quite possible to approximate to them very closely, and to those who wish to operate their factories electrically in the best possible manner from an economical point of view, the author can only recommend them to use in their power houses plant of this description, which has stood the test of several years' running, and yielded such extraordinary results.

When such generating plant is used, and under the ordinary distribution conditions, where the most distant machines to be driven are situated not more than 500 yards from the power house, there appears to be ample evidence to show that there are a very large number of cases in which the highly favourable results given above can be reproduced with certainty, and that consequently the field for this employment of electrical energy is very large indeed, and will doubtless soon be generally appreciated at its full value.

## A SAFETY MINING CABLE.

Messrs. Felten and Guilleaume, of Mülheim-on-the-Rhine, have recently brought out a new type of safety mining cable. The cable devised by Mr. Ll. B. Atkinson, it will be remembered, consists of two conductors in parallel, insulated from each other, except at the main terminal of the circuit to be protected. The outer, which is to carry the larger part of the current, is of ordinary make, but the inner is constructed of fine wire in the form of a continuous cylindrical coil. The idea is, that when a fall occurs the outer conductor will be cut through, whilst the loosely coiled conductor will be simply drawn, so that the entire current will then pass through the latter, blowing the magnetic cut-out in circuit with it, and transferring the spark from the mine to the engine-room.

In the Felten and Guilleaume cable, on the other hand, as described in *L'Electricien*, the principal conductor *a* (Fig. 1) is separated by insulating material *b* from the safety conductor *c*, the whole being covered with an insulating layer *d*, and enclosed in a protecting sheath, *e*. The main conductor *a* consists of copper or

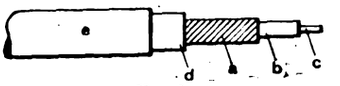


Fig. 1.

some other similarly soft and ductile metal. The safety conductor *c*, on the contrary, is of steel or bronze or some equally stiff metal. When by any chance the cable has to submit to excessive tension, the safety wire breaks first, and the rupture of this circuit causes the armature of an electromagnet to fall, breaking the main circuit. How this result is obtained is shown in Fig. 2. The principal

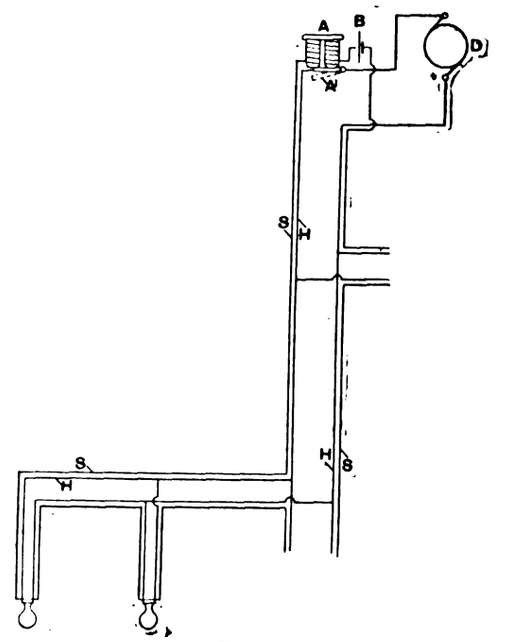


Fig. 2.

circuit H derives its current as usual from a dynamo D, whilst the safety circuit S is connected with a battery B, which furnishes sufficient current to enable the electromagnet A to sustain its armature $A^1$. When the circuit S is broken, the armature $A^1$ falls away and the principal circuit is broken.

When it is expected that a cable will be submitted to crushing, it is arranged as in Fig. 3, where the safety wire consists of a

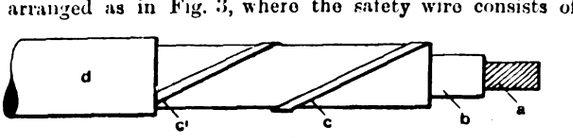


Fig. 3.

double ribbon of steel *cc'* rolled in a spiral round the principal conductor *a*, and separated from it by a layer of insulating material *b*. If the cable is only likely to be exposed to this single form of accident, both conductors are of the same metal, but if it is desired to avoid the effects of drag, a less ductile metal is employed for the safety conductor *cc'* than for the main conductor *a*.

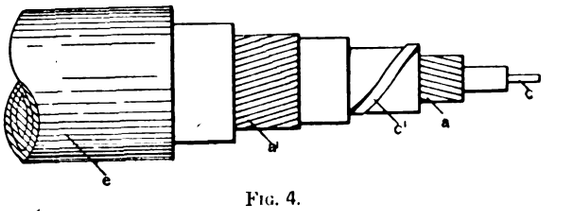


Fig. 4.

By a slight modification, this system can be applied to concentric cables, as shown in Fig. 4, where one of the safety conductors runs along the axis of the cable, whilst the other, *c'*, is wound round in a spiral between the two concentric main conductors *a*,*a'*, being separated from them by a layer of insulating material, the whole being covered by a protecting envelope.



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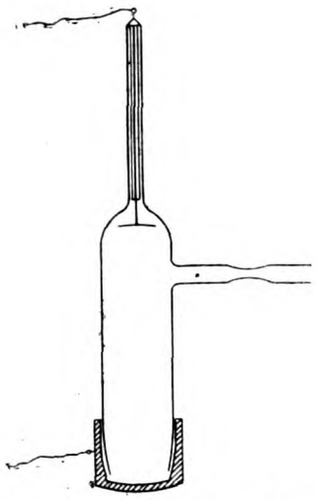
## PROF. A. ROÏTI'S RÖNTGEN TUBE.

This tube is provided with an aluminium window, and is at the same time free from all impurities due to cementing. It consists of a cylinder of rather thick glass. One end is drawn out into a narrow neck, into which is fused a platinum wire carrying the concave aluminium cathode. The other end is open and tapers slightly. An aluminium cap serving as the anode is placed over it, the glass being ground very carefully so as to fit the cap exactly



over a zone of about 1·5cm. The connection is kept free from any lubricants, the cap being pressed and turned into place. The outer edge of the cap may then be cemented with a little white wax and olive oil. This tube was a great success. Exhaustion could be carried so far that the whole interior of the tube was covered with green phosphorescent light. The cap was only slightly heated. With sparks of 20cm. in air, the author obtained good photographs of the bones of his hand in 30 seconds. With the aid of a fluorescent backing, the exposure could, no doubt, be still further reduced.

## ON A WINDING FOR MOTOR GENERATORS.*

BY P. M. HELDT.

When it is desired to transform a continuous current into an alternating current an ordinary continuous-current motor is provided with a pair of collecting rings connected to diametrically opposite points of the armature winding, in case the machine is bipolar, or to corresponding points where the machine is multipolar.

When such a machine is attached to a continuous-current circuit of E volts, the maximum of the alternating E.M.F. between the two rings is E, and if the pole-pieces be so shaped as to give a sine form of E.M.F. curve, the virtual E.M.F. between the rings will be $\frac{E}{\sqrt{2}}$, or about seven-tenths of the continuous E.M.F. The output of such a machine is about the same as if it were driven mechanically and at the same speed.

When the alternating E.M.F. must have some particular value different from $\frac{E}{\sqrt{2}}$ it is usual to provide the armature with two different windings, one for the continuous and one for the alternating current. Where this scheme of winding is employed any E.M.F. may be obtained by suitably proportioning the turns to each winding. It has, however, the disadvantage of reducing the permissible output by one-half, and the efficiency from $n$ to (2 $n$—100) per cent. In what follows, a winding combining the advantages of these two will be described. Although it is probably known to engineers experienced in the design of motor generators, it has never been published, as far as I am aware.

Consider a simple ring armature for a two-pole machine and provided with two collecting rings, Fig. 1. The armature is wound with two similar windings, which for convenience will be referred to as the primary and secondary. In winding the primary leads are brought out as usual for every commutator segment, while in winding the secondary only two leads are brought out, at diametrically opposite points of the armature. One of these two leads is connected to the lead of the primary winding nearest to it, while the other secondary lead and the primary lead nearest to it are connected to the collecting rings. The E. M. F.'s induced in the two windings will be in opposition. The reason for connecting the windings in opposition is that in a motor armature the current flows in opposition to the induced E. M. F., while the induced E. M. F. of the secondary, in order to raise the voltage of the current, must be in unison with it, or nearly so. In Fig. 2 the directions of the induced E. M. F.'s at some particular instant are indicated.

The number of turns to the primary winding is determined by the speed of the machine or the frequency desired. The rise in voltage required fixes the number of secondary turns. Let E be the voltage of the direct current, $E_a$ the effective alternating voltage, and $N_p$ and $N_s$ the number of turns to the primary and secondary respectively. Then

$$N_s = N_p\left(\frac{\sqrt{2}\,E_a - E}{E}\right).$$

It is, however, not necessary to have the two halves of the secondary in parallel like the primary. In a small machine for

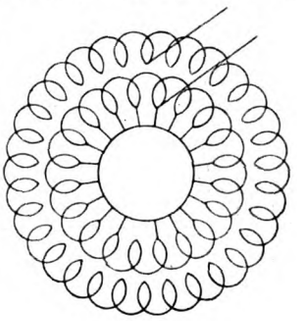


Fig. 1.

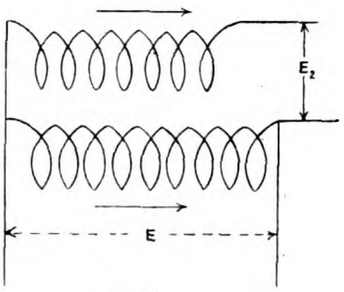



Fig 2

high voltage it would be advantageous to have the two halves in series, because with double the size and half the number of turns of wire the work of winding and the space taken up by the insulation would be reduced. The formula for the secondary turns now becomes

$$N_s = N_p\left(\frac{\sqrt{2}\,E_a - E}{2E}\right).$$

Fig. 3 illustrates this method of connecting the windings.

This method of winding may be equally well applied where it is desired to obtain multiphase currents from a continuous current. Fig. 4 shows a diagram of the winding for three-phase currents.

Here the secondary consists of three coils, each connected with one terminal to a point of the primary winding and with the other to one of the contact rings. Let $E_a$ represent here the effective difference of potential between two of the secondary terminals, $N_s$ the number of turns of one secondary coil and $N_p$ the total primary turns. The alternating E.M.F. developed in one branch

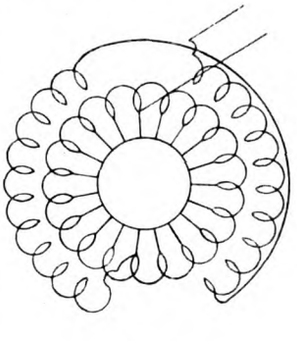


Fig. 3.

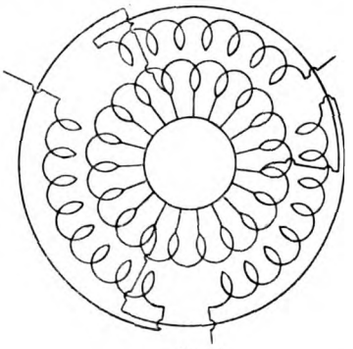


Fig. 4.

of the primary winding is $\sqrt{\frac{3}{8}}\,E$. The E.M.F. added by the secondary winding is therefore $(E_a - \sqrt{\frac{3}{8}}\,E)$. This is the resultant of two E.M.F.'s induced in adjacent coils. They differ in phase by 120deg. The components have the same value as the resultant. The maximum E.M.F. induced in one of the secondary coils is $(\sqrt{2}\,E_a - \sqrt{\frac{3}{4}}\,E)$. Remembering that the primary has its two halves in parallel we find

$$N_s = N_p\left(\frac{\sqrt{2}\,E_a - \sqrt{\frac{3}{4}}\,E}{2E}\right)$$

For a two-phase machine the winding is essentially the same as for a three-phase machine. The number of turns to each of the four secondary coils is

$$N_s = N_p\left(\frac{\sqrt{2}\,E_a - E}{4E}\right).$$

Whenever the value of $N_s$ is negative the secondary coils must be connected in the opposite way from that shown in the diagrams.

This winding is also applied to alternating continuous converters.

* From the *Electrical World* of New York.

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## THE RIETH RAIL BOND.

The *Street Railway Review*, of Chicago, describes and gives the accompanying illustrations of the Rieth rail bond for electric tramways and railways. The method of constructing this bond employs

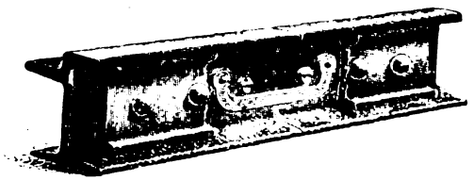

FIG. 1.—Rieth Bond.

the expanded tube principle for securing good contact in the rail web, while the bond being at the same time short and thick, it can be put inside the angle bars of a joint. The accompanying illus-

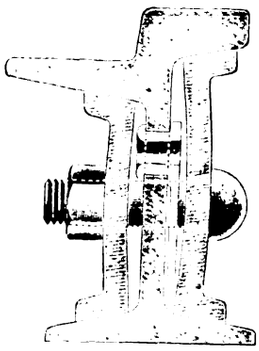

FIG. 2.—Rieth Bond. Transverse section.

trations show the bond and its manner of fastening. It is made of nearly pure cast copper. In fastening it in the rail web it is first expanded to fit the hole by driving in the expander D. Then

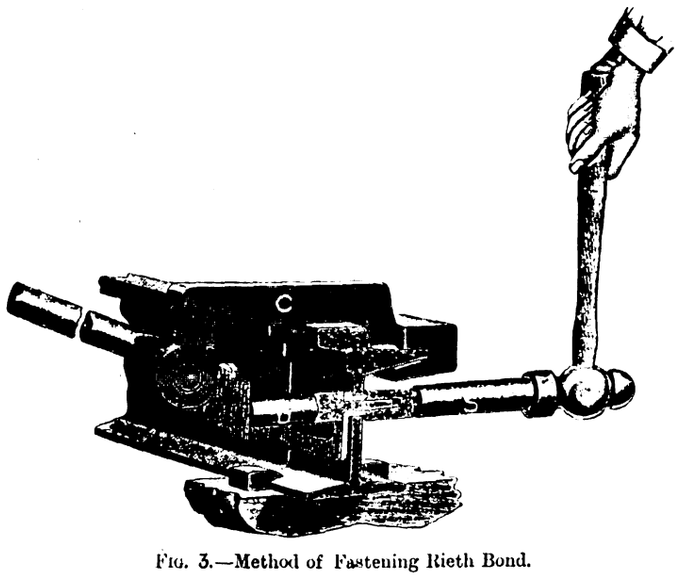


FIG. 3.—Method of Fastening Rieth Bond.

the clamp C is put in position as shown, and by driving the tool S the bond is both upset and expanded to a perfect electrical and mechanical fit.

## BOOKS RECEIVED.

Memorandum and Articles of Association of the Institution of Electrical Engineers. (London: E. and F. N. Spon, 1896).

List of Officers and Members of the Institution of Electrical Engineers, corrected to June 30, 1896.

*Journal* of the Institution of Electrical Engineers, Vol. XXV., No. 124. (London: E. and F. N. Spon, 1896. Price 3s. 6d.)

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July 17, 1896.*

**The New York Telephone Company.**—The incorporation of this Company, which was noted in a recent letter, and the object of which was kept a profound mystery to all except those in the innermost circles, has shown its hand. The Metropolitan Telephone and Telegraph Company, which operated the telephone system in New York city, announced recently that the New York Telephone Company had taken over the entire property, franchises, contracts, &c., of the Metropolitan Company, and would henceforth conduct the business as it had been previously conducted under the old management. The transfer to the New York Telephone Company included the Westchester Telephone Company, whose territory extended outside of New York city within a radius of 33 miles northward from New York City Hall, excepting Long Island and Staten Island. The object of the consolidation is stated to be to acquire increased capital for future extensions and for improvements in existing service.

**Overcrowding Trolley Cars.**—On June 7th last a heavily-crowded car on the Nassau Electric Railway, Brooklyn, while ascending a steep grade in that city, became unmanageable by reason of the trolley jumping from the wire and the failure of the brakes to work. The result was the return of the car down the hill with unchecked speed, with disastrous consequences. The car was wrecked, and one boy instantly killed and several other persons injured. One of them died a few days afterwards from injuries received. This accident aroused so much indignation that the Railroad Commissioners took the matter up and made an investigation into the cause. The Commission has just made its report, and in the decision the Commissioners say that while the immediate cause of the accident was the trolley wheel leaving the wire, they are of opinion that the primary cause was the overcrowded condition of the car. At the examination, the officers of the railway company, had sought to lay the blame upon the motorman, claiming that he did not first apply the hand brake. The Commission, however, states that the evidence shows that the motorman did apply the hand brake as soon as the trolley wheel jumped the wire. In their recommendations the Board lays out some suggestions to be followed by electric and cable railway companies. They recommend that cars should not be allowed to proceed as long as persons are standing upon the side steps and refuse to get off the car or stand in the aisles. They also recommend that all cars operated on a grade of five per cent. or more should be equipped with an auxiliary brake, or with some appliance which may be used by the conductor or motorman for stopping the car. They refer to a simple device used by the Albany Railway Company, Albany, N.Y., which consists of a so-called dog attached to a chain running up through the rear platform of the car, by which it is held up when not in use. The dog is always dropped by the conductor before ascending a hill, and materially aids in holding the car when a stop is made on a hill.

**220-Volt Lamps.**—The use of high-voltage lamps in this country is evidently growing in favour, and thus far experience has shown them to be giving very satisfactory results, as far as efficiency, durability and light-giving power are concerned. In Minnesota, Wisconsin, Michigan and Iowa there are plants operated on the 220-volt system and using these lamps. The plants are giving satisfactory service, and some plants have been extended by the purchase of additional machinery. Many of them are operated in connection with the town water works system, and most of them are owned by municipalities. In the east there is only one 220-volt plant, and that is in the New York Custom House. This plant was installed in the spring of this year, and is working with perfect satisfaction. The Custom House building was originally wired for the three-wire system, and when the new plant was put in the wiring was overhauled to adapt it to the new conditions. The building is wired for 1,600 lights, although not more than 600 are used on an average. A storage battery plant is being installed here, and will be charged during the daytime. The battery will supply



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current necessary for the limited amount of light needed in the building at night time. The battery plant will consist of 130 cells of type E 15 chloride accumulators, having a total capacity of 72 kilowatt hours. A motor-driven booster of 4 kilowatt capacity will be installed for the purpose of raising the potential sufficiently to charge the battery when the power is available during the day time. The generating plant consists of three units of equal size and capacity, and as the two Sprague elevators in the building are operated at 220 volts, the elevator system and the lighting system are practically interchangeable on the switchboard with reference to the generating units, that is, any one of the three units can be used on a light or power circuit. This plant is attracting a great deal of attention on account of its extreme flexibility, and was designed originally to operate both power and lighting from one machine, but this plan was not carried out.

**Electricity at the Christian Endeavour Convention.**—The Christian Endeavour Society, which held its Convention in Washington, D.C., last week, and at which 20,000 members were in attendance, held its meeting in three immense tents erected for the purpose on the large open space at the back of the White House and near the great Washington monument. The lighting of these tents presented a difficult problem, which was, however, solved by the aid of electricity. Each tent contained 28 arc lights, for which 10,000ft. of wire was required. Besides the electric light equipment there was a complete telephone system, which required 18,000ft. of telephone wire, and a complete bell alarm signal wire system with 20,000ft. of wire. Each of the tents was, by means of the telephone and bell signal systems, placed in instant communication with each other, so that it was possible for the manager to control the proceedings, and know what was going on in all, from any given point. On the centre pole of each tent a large electric bell was used to call the meetings to order, and a loud electric buzzer notified excessively long speakers that their time was up, each speech being limited to a certain time. The electrical features of the convention were unique and very complete.

**Compressed Air Cars.**—The use of compressed air cars on some of the surface street railways in this city, which has been looked for for some time, has not as yet materialised. There was considerable talk at the time the innovation was first announced, but the matter seems to have dropped from the public mind, at least for the time being. President H. H. Vreeland, of the Metropolitan Traction Company of New York, in a statement made a few days ago, said that it is proposed to change the motive power on the Broadway line from cable to compressed air, and that the motors are now nearing completion, and in a few weeks several of them will be in operation. It is also proposed to use the same system on the Madison Avenue line, which has just been added to the Metropolitan Company's system.

## CORRESPONDENCE.

### NEGATIVE RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am asked my opinion about negative resistance. This I take to mean simply that if a body formally obeyed Ohm's law $E = RC$, and Joule's law $H = RC^2t$, but with R a negative instead of a positive quantity, it would possess negative resistance. The effects produced by the negativity of R (and other quantities) have occupied my attention in certain papers, and are interesting and instructive. But I have no faith whatever in the permanent existence of a body with negative resistance, on account of the general instability. At the same time I am not prepared to deny that a substance might temporarily, and under suitable circumstances, behave as a negative resistance approximately, especially if it is in a state of continuous material change. Whether the arc may be conveniently regarded in this light, is not for me to say. I do not know enough about the arc. I prefer gas for personal use.—Yours, &c.,

OLIVER HEAVISIDE.

July 28, 1896.

### NEGATIVE RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In what follows I am not to be understood as offering any remarks on the merits of Messrs. Frith and Rodgers' Paper, as for obvious reasons their Paper should be in the hands of those interested in the subject before its methods or results are discussed. I therefore reserve anything of this sort I might wish to say.

As I understand the matter it has been stated that in certain cases the electric arc yields electric energy at a rate $a A^2$ ($a$ positive) to the circuit, when at the same time there is a greater rate of contribution $E A$ to the arc by the circuit, in consequence of the existence of a back electromotive force E having its seat at the arc. The total rate at which energy is given to the arc is, therefore, $E A - a A^2$; and this result Prof. Ayrton, with the authors of the Paper, proceeding on the analogy of a conductor which contains a back electromotive force E and a resistance R, and so absorbs energy at the rate $E A + R A^2$, prefers to describe by calling the $-a$ the "true resistance" of the arc, so that the "true resistance" is in such cases negative. And Prof. Ayrton urges with considerable force that if the result had been throughout what it is in another class of cases, an evolution of energy $E A + a A^2$ ($a$ positive), there would have been no difficulty, and $a$ would have been regarded as the resistance of the arc without question.

But ought we to call by the name "resistance" a quantity which in certain cases is positive, corresponding to an evolution of energy in the arc, and in other cases is negative, corresponding to a yield of energy from the arc to the circuit? It would seem to me preferable, if such is the case, to adopt if possible some mode of speaking of the phenomenon which cannot confuse the ideas of those who think about and study electrical matters; and all risk of this would be avoided if the physical facts which the experiments seem to prove (and these, after all, are the only things of importance) were described without the use of the term "resistance" at all.

There can be no question that the term "resistance" has been associated in electrical science (and also in dynamics to a considerable extent) with dissipation of energy. The possession of resistance R has been attributed to any conductor in which energy has been evolved in heat at a rate $R A^2$. The further question whether R is or is not independent of the current flowing, that is whether or not Ohm's law is fulfilled, is irrelevant. Thus to many the phrase "negative resistance" and still more a "negative true resistance," will appear as objectionable as "negative dissipation of energy," a mode of speaking which is unnecessary and undesirable.

As to the question of directed quantities, it seems to me that what is to be compared with, or distinguished from, an adjuvant electromotive force is not the $-a$ of the expression $E A - a A^2$, which Messrs. Frith and Rodgers identify with their $d V / d A$, but the product of this by the current A. The multiplier $-a$ is a scalar which, according to Messrs. Frith and Rodgers, is negative in one set of physical circumstances and positive in others. What is essential to its scalar quality is that a reversal of the current in the circuit should not alter its sign. The product $-a A$, however, has direction and changes sign with the current, so that $-a A^2$, or $A^2 d V / d A$, has, in the same physical circumstances of the arc, still the same sign.

With regard to the nature of resistance, I have long believed, what Prof. FitzGerald seems to indicate is his opinion also, that we have in an ordinary metallic conductor a back electromotive force due to molecular dynamos, so to speak, which are driven by the current and oppose an electromotive force to the driving current, which is proportional to that current. The work spent in driving these molecular dynamos is dissipated on the spot in overcoming frictional resistance. If a metallic conductor, absolutely free from inductance, could be detached from a battery and tested with sufficient quickness, it might very possibly show polarisation, as does a gas cell or an ordinary secondary battery.

When, however, this electromotive force is not *back* but *adjuvant*, there might seem to be a difficulty. But imagine a motor, on the axle of which, or geared with its axle, is an

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armature mounted in a field produced by the current driving the motor, and all so arranged that when driven by the motor this armature runs so as to give an adjuvant electromotive force. If the motor run at a constant speed, and the field of the connected armature be proportional to the current A, we should have a system in which, in consequence of the back electromotive force E of the motor and the resistance R of the whole arrangement, energy is spent at the rate $E A + R A^2$, and, by the action of the armature and field, given back at a rate $a A^2$. Further, we should have, for a sufficiently small resistance R of this system, the difference of potential V between its terminals nearly enough equal to $E - A a$; and therefore a diminution of V would correspond to an increase of current applied without change of speed of the motor.

May there not, if the experiments are correct and correctly interpreted, be something in the arc molecularly corresponding to this? At any rate, it shows that, as I stated in the discussion at the Physical Society when the Paper was read, there is no paradox in having a forward electromotive force proportional to the current associated with a greater back electromotive force which is either constant or varying according to another law.

I would urge again the desirability, in view of the discussion which has taken place, and the opinions which have been expressed, of not applying the term "true resistance" (even if it be, as I understand it is, quoted from previous experimenters) to any quantity measured for the arc, until the physics of the subject have been more fully investigated. There is no compulsion upon us to apply the terms associated with dissipation of energy in a case (as Prof. Ayrton has more than once described it) in which what goes on is shut up from us. We have till then to suspend judgment as to the phenomena, and our descriptive terms in the meantime ought, therefore, not to appear, even, to carry with them hypotheses as to what takes place; for that appearance, however unintentional, is almost certain to mislead. We are all too much led by the nose by mere words.—Yours, &c.,

ANDREW GRAY.

Bangor, July 26, 1896.

## LEGAL INTELLIGENCE.

### The Willans' and Robinson's Letters Patent.

The application for the prolongation of Patent No 4,901, granted to the late Mr. P. W. Willans and Mr. M. H. Robinson on October 14, 1882, came before the Privy Council on Wednesday last. The Committee consisted of Lords Watson, Macnaghten, Davey and Shand, and Sir Richard Couch. Mr. Moulton, Q.C., Mr. R. W. Wallace, Q.C., and Mr. J. C. Graham appeared for the petitioners; and the Attorney-General (Sir R. Webster, Q.C., M.P.) and Mr. Sutton appeared for the Treasury.

When the case was called the Attorney-General said that the merits of the patent seemed to be quite sufficient to justify an extension, if there were no other objections arising out of the accounts and upon the amount of remuneration.

Mr. MOULTON said the petitioners, Willans and Robinson (Limited), were a Company formed to take up the business of the inventors. The invention related to a development which had been taking place in the last few years in steam engines, whereby, instead of having very large engines with very massive parts, small engines with small parts were employed, which produced power by means of the extreme rapidity with which they moved. It was evident that anything which saved the jars and vibration very greatly tended to preserve the life of the engine. The prejudice against high-speed engines, that they would rack themselves to pieces, was well-founded in the earlier forms; but the invention of the air-buffer—the patent for which was the one before the Committee—prevented all the knocking and the jars which came from the rapid motion of the engine. The invention was particularly applicable to single-acting engines, but at the date of the Letters Patent their use was almost in its infancy; and for several years later they were very little used, and no good types of such engines comparable with ordinary engines as to economy of steam were known. The inventors, after devoting a large amount of time and trouble to it, ultimately produced the single-acting engine known as the Willans central-valve engine. That engine, fitted with the air-buffer, was now extensively used for electric lighting purposes, and had greatly advanced the development of the electrical industries. Owing, however, to the absence of demand for engines of this class for several years after the granting of the Letters Patent—notwithstanding the continued efforts of the petitioners to bring the invention into public use—the invention did not come into any extensive commercial use until recently; and, therefore, neither the petitioners nor the inventors had derived any adequate benefit from it. The petitioners were prepared to show that they had received very little over ordinary manufacturing profits during the past 14 years.

Lord WATSON: Allowing 5 per cent. on capital, what is the excess which you attribute to the inventions?

Mr. MOULTON replied that allowing 5 per cent. on the capital employed, the excess in the 14 years due to the development of the air-buffer and the central valve would come to about £24,000.

Lord DAVEY: Meantime they have created a very valuable business, and have created and have still got a very valuable goodwill.

Mr. MOULTON said the Act giving their lordships jurisdiction laid stress on the fact that the profits were to be profits made by the patentee "as such." In this case it was impossible for his clients to attribute to the air-buffer the whole of the profits, which were the result of the two inventions combined. The patents differed in date, and that for the central valve went on for two years longer.

Lord SHAND: It is a very valuable one, and in any case you would continue to get profits from that?

Mr. MOULTON said that was so. He contended that the inventors here had not been adequately remunerated, considering that it had only been profitable to them during half the life of the Letters Patent. The profits which had been made must not be considered to be all due to one patent, because it was the union of the two which made the success. As he had said, the whole profits from the two during the 14 years only amounted to £24,000, although the engines were pushed and advertised as much as possible.

Lord WATSON: You have first to ascertain what profit is applicable to these two inventions; and, secondly, what proportion of that profit is applicable to each.

Mr. MOULTON: The central-valve engine was the main patent, although its utility and use was very largely due to the removal of the objections to its use by means of the air-buffer. Where there is a patent for a particular feature it is very difficult to bring forward anything which is reliable as a fair partition of the profits; but I should suggest that you should take one-third as attributable to the air-buffer, and two-thirds as attributable to the central valve.

Lord MACNAGHTEN: You say, then, about £8,000?

Mr. MOULTON: I suggest that. It was the invention of the central valve which prevented our bringing an overwhelming case, because I think it was that which enabled us to make any profit at all.

The ATTORNEY-GENERAL: Then at the commencement of the proceedings, I made an admission I ought not to have made, if that is so.

Mr. MOULTON: The central valve is that which led, sooner than it would otherwise have come about, to the adoption of the high-speed engines.

Mr. MARK HEATON ROBINSON was then called and sworn. In reply to Mr. Moulton he said he was Chairman of the petitioning Company. Single-acting high-speed stationary engines were now a success, and were largely used. The effect of the air-buffer was to enable them to be worked without injurious shocking. The great credit of the central-valve engine was that it was very economical. Down to 1885-6 the chief business of the firm was general engineering; but recently the chief business of the Company had been the making of the central-valve engine, and substantially the profits shown in the accounts came out of the central-valve engine. The air-buffer was applied to practically all these engines, but it was not the cause of their being economical. They could be used without the air-buffer, but not so successfully at high speeds. In his opinion more than 5 per cent. should be deducted from the gross profits as interest on capital; 7 or 8 per cent. was mentioned in the Company's prospectus. So far as the accounts were concerned, it was absolutely impossible to separate the air-buffer from the central valve. It was practically essential that high-speed engines should be single-acting engines, and the air-buffer was specially suitable for those.

Cross-examined by the ATTORNEY-GENERAL: He was very sorry that the papers in the case omitted to state that the bulk of the profits shown in the accounts was earned by the central-valve patent. A considerable portion of the commercial value of the engine depended upon the air-buffer. There were two patents for the central valve, one granted in 1884 and the other in 1885, and they held the market for that class of engine. When the first Company was formed to take over the business, Mr. Willans and himself received about £12,000 for the goodwill and for their interest as patentees; and upon the reconstitution of the Company a sum of £8,000 was paid under an award by an arbitrator to the Directors of the old Company, of which he got about £4,500. People did not come to them to ask for a Willans' valve or a Willans' air-buffer; the command of the patents enabled them to command the orders for the entire engines.

The ATTORNEY-GENERAL said his admission on the merits was made on the assumption that the accounts related only to the air-buffer patent. As that was disclaimed, and it was stated that the accounts related also to the central valve, he should ask their lordships to deal with the case as a whole.

Mr. MOULTON said he did not propose to call any further evidence. A large portion of the profits shown up to 1887 arose from the application of the capital to the general engineering business, and no large fraction was attributable to the inventions until 1887. The sum paid by the Company to the old firm included the purchase of a large number of patents for electric governors, and other matters, and of the goodwill of the business. The total amount of the profits from January, 1888, after deducting £15,000 for loss by fire, amounted to £35,000; deducting £53,000 as the equivalent of 5 per cent. interest on the capital, that left £31,000 profit, which was equivalent merely to about 3 per cent. on the capital. So far as that £31,000 was not ordinary business profits, it had been made by reason of the two patents both being used. The importance of the air-buffer was enormously great, but probably, fairly considered, the greater importance attached to the other inventions. He said that not for the purpose of diminishing the merit of this invention, but to point out its proper station in regard to the whole success. In conclusion, he urged that the profits

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disclosed by the accounts did not afford the adequate remuneration to which the inventors were entitled.

The ATTORNEY-GENERAL said the position of an Attorney-General in these cases was an invidious one. Mr. Robinson, who had given his evidence with perfect candour and frankness, and most fairly, stated that since 1887 the business of the Company had been the manufacture of high-speed engines under these patents; therefore this was not a case in which the patentees' profits were merely engrafted on to the manufacturers' profits; but it was a case in which, to some extent, the manufacturers' profits flowed from the possession of the patents. Mr. Robinson had also told them that these patents had enabled them to command the markets for these engines, only it was suggested that during the residue of the life of the central-valve patent other persons might possibly be able to apply the air-cushion patent to other engines. The total profits of the patentees had been £12,634 before they formed the Company, and the total profits of the Company had been £85,216. It would not be unfair to allow 5 per cent. upon the capital, and deducting that from these two amounts, that left, roughly speaking, a sum of about £45,000. What part of that was to be allocated to the air-cushion? This was a patent which was connected with the central-valve patent, and there was not the slightest ground for supposing that the monopoly of the central-valve engine would be interfered with during the next two or three years that that patent had to run. If he pursued his calculation he believed he could show that something like £17,000 or £18,000 might be attributable to the air-cushion patent; but he did not care whether the sum taken was £10,000 or £13,000 or £15,000. In any case the patentees had been adequately remunerated for what was, comparatively speaking, a subordinate invention applied in connection with the central-valve patent.

After deliberating for a short time in private,

Lord WATSON said that their lordships were unable to come to the conclusion that the patentees had been inadequately remunerated by the patent, and that they would accordingly humbly advise Her Majesty that the petition ought to be refused.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE**—**The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

TENDERS INVITED.—The Municipal Council of Nova del Rey, Spain, require tenders for the concession for the electric light of the town for 20 years. Preliminary deposit £200, and if tender accepted £400. Offers should reach the Council by August 29th.

——— The Municipal Authorities of Odessa require tenders for the electric lighting of the new prison and a portion of the suburbs of the town. Tenders must be in by August 13th.

——— The Municipal Authorities of Estepa (Seville), invite tenders for the concession for the electric lighting of the town for ten years. Tenders to El Secretario del Ayuntamiento de Estepa (Seville), Spain.

——— The Great Indian Peninsular Railway Company invite tenders for telegraph stores. Tenders to the Secretary (Mr. F. L. Soare), 48, Copthall-avenue, London, E.C.

TENDERS INVITED.—The Bray Town Commissioners require tenders for alterations to their electricity station. Tenders to the Town Clerk, Town Hall, Bray, Ireland, by August 3rd.

——— The Mayoralty of Jassy (Roumania) require tenders for an electric light installation at the Frigorific Hall, about to be erected. Tenders (in Roumanian or French) must be sent to the Office of Works, Municipal Council, Jassy, by September 4th, 1898 (August 23rd, old style).

TENDERS ACCEPTED.—The West Sussex County Council have accepted the tender of Messrs. R. Crittall and Co. for wiring and for supplying the necessary machinery and fittings for the electric lighting of the West Sussex Asylum for £5,228. 7s.

——— In connection with the Leeds electric tramways scheme it will be remembered that the City Council originally decided to accept Messrs. Crompton and Co.'s tender for the supply of trolley wires and attachments at £3,370. This firm, however, withdrew their tender, and Messrs. Siemens Bros. and Co.'s tender, the next lowest, was accepted at £5,620. The latter firm have also decided to withdraw; and the Tramways Committee have now selected the tender of Messrs. Laing, Wharton and Down at £5,740 for acceptance.

——— At the last meeting of the Battersea Vestry the Electric Lighting Committee's report upon the tenders sent in for the electric lighting of the municipal buildings was considered. Thirty-five tenders were received, and upon the recommendation of the consulting electrical engineer (Mr. Robert Hammond) the following have been accepted by the Vestry:—

| | |
|---|---|
| Boilers and accessories—Messrs. Spurr, Inman and Co. .. ... | £668 10 0 |
| Engine house plant—Messrs. Johnson and Phillips ..... | 1,030 15 0 |
| Main switchboard and instruments—Messrs. Laing, Wharton and Down ..... | 143 0 0 |
| Accumulators—Chloride Electrical Storage Syndicate ..... | 314 0 0 |
| Wiring and fittings—Mr. A. H. Wood ..... ..... | 1,042 13 6 |
| | £3,198 18 6 |

It was also decided to apply to the London County Council for a loan of £4,200, in lieu of the sum of £3,000 previously sanctioned by the Vestry for the purpose of defraying the cost of the work.

——— The Exeter City Council have accepted the following tenders for supplying additional plant at the electricity works:—

| | |
|---|---|
| Easton, Anderson and Goolden, alternators ..... | £1,320 |
| Brush Company, three 30-kilowatt and four 10 kilowatt transformers ..... | 300 |
| Babcock and Wilcox (*Limited*), 300 I.H.P. boilers ..... | 630 |
| Fowler-Waring Cables Company, 3,650 yards of cable ..... | 685 |

——— The Edinburgh Town Council have accepted the tender of Mr. John Lownie, Edinburgh, for alterations and additions to the electricity supply station, at a cost of £4,397.

APPOINTMENTS.—Mr. F. Teague has been appointed resident electrical engineer by the Paisley Town Council at a salary of £200 per annum. Mr. Teague is at present resident engineer at the Coatbridge station of the Scottish House-to-House Electricity Company, and prior to his engagement to Coatbridge was engineer and manager of the Acme Electric Works.

——— The London Commissioners of Sewers have appointed Mr. W. Burch, M.I.C.E., resident engineer, to supervise the works of the Central London Railway, so far as they affect the streets, sewers and subways, at a salary of £6 per week.

APPOINTMENTS VACANT.—A Demonstrator in Mechanical Engineering is required at University College, Nottingham. Salary £120 per annum. Applications should reach the Secretary by August 12th.

——— The Sunderland Corporation invite applications for the post of resident engineer at their electricity supply station. The engagement will be for four years certain, the salary being £300 for the first year, £350 for the second year, and £400 per annum for the third and fourth years. Further particulars appear in our advertisement columns, and applications must be sent to the Town Clerk (Mr. Fras. M. Bowey), Town Hall, Sunderland, by Tuesday, the 4th prox.

EXTENSION OF WORKS.—Owing to increase of business the Directors of Thomas Parker (Limited) have decided to enlarge their works at Wednesfield-road, Wolverhampton. The necessary capital for the extensions, which include doubling the area of the principal workshops, has already been subscribed by the shareholders and their friends.

LIQUIDATIONS.—In consequence of the purchase by the Canadian syndicate of the undertaking of the Birmingham Central Tramways Company (Limited), it has been decided to wind up the Company voluntarily. Mr. Howard S. Smith has been appointed liquidator.

——— It has been decided to wind-up the Pure Carbon Company (Limited) voluntarily. Mr. P. Holme, 57, Moorgate-street, London, E.C., has been appointed liquidator.

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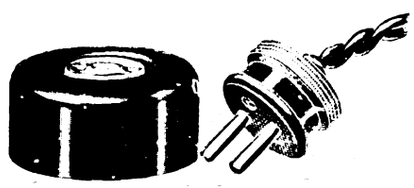
DISSOLUTION OF PARTNERSHIP.—Messrs. John Whitaker, Thos. Percival Pollitt and Samuel Heap, trading as manufacturing electricians, at 18 and 20, Blackfriars-street, Salford, Manchester, have dissolved partnership,

INSULATED WIRES AND CABLES.—A very useful and compact list is just issued by Messrs. Connolly Brothers (Limited), of Blackley, Manchester, dealing especially with the wire and cable branch of the Company's business. Since the last issue of this list it has been considerably extended. Higher qualities of insulation, concentric cables, lead and iron-sheathed cables, cotton and silk-covered wire, bell and telephone wires, &c., have been added; and the introduction of a systematic method of testing all vulcanised india-rubber-covered wires and cables sent out gives the Company confidence in submitting these goods to the trade. During the past year considerable increases have been made in the plant for manufacturing these goods, and arrangements have been completed for coping promptly with the requirements of an ever-increasing circle of customers. It may also be mentioned that Messrs. Connolly Brothers have purchased the cotton and silk-covering plant until recently owned by the Okonite Company, and as this plant has been thoroughly overhauled and brought up to date, large orders for dynamo and instrument wires can now be promptly executed. The list is well printed, and the tabulated particulars relating to the various types of cables and wires are clearly arranged, admitting of easy reference. A useful telegraph code is provided in the list for the use of the Company's clients.

TUDOR ACCUMULATORS.—We have received from Mr. A. B. Pescatore, of 5, Cross-street, Manchester, the representative in this country of the well-known Tudor accumulator, the latest list of stationary and portable types of this cell. A feature of the list is the attention given to the special type of plates for renewals, of which a large number have been already supplied for central-station work. Included in the list are some illustrations which show very clearly the appearance of these cells, improvements in the manufacture of which have enabled the makers to considerably reduce the price, especially for stationary cells discharging at from three to ten hour rates, the reductions in these cases being calculated to reach fully 15 per cent. It is claimed for the new types of portable cells that they have been perfected in all details, and can now be supplied for tramway work and for all other purposes where a highly efficient battery is required.

"DOT" WALL SOCKET.—The accompanying illustration shows the "Dot" wall socket, made by Mr. A. P. Lundberg, of the



Bradbury Electrical Works, Kingsland, N. This socket is made either in wood, ivory or porcelain. One excellent feature is the absence of metal parts at the back; and the interchangeability of the parts is also a recommendation.

THE JOURNAL.—Part 124 of the *Journal* of the Institution of Electrical Engineers is now ready, price 3s. 6d. The number contains the Papers on "Experimental Tests on the Influence of the Shape of the Applied Potential Difference Wave on Iron Losses of Transformers," by Messrs. S. Beeton, C. Percy Taylor and J. M. Barr; and on "The Utilisation of Water Power, especially with a Small Fall, with Some Examples of Plants for the Generation of Electrical Energy," by Mr. Alph. Steiger, together with the discussion thereon.

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ASYLUM LIGHTING.—The tender of Mr. T. Scott Anderson has been accepted for the installation of the electric light at the Bath and Somerset Asylum.

BERMONDSEY.—The Vestry have authorised the Electric Light Committee to obtain the opinion of a consulting engineer on the electric lighting question. The Committee are considering the advisability of applying for a Provisional Order, and before coming to a decision on the matter they wish to have some reliable figures as to the outlay which an electric light installation would involve, probable income, &c.

BRISTOL.—Colonel Marsh, R.E., held a Local Government Board inquiry at Bristol on Wednesday into the application of the Town Council to borrow £75,000 for electric light extensions. The Town Clerk (Mr. D. Travers Burges), who appeared in support of the application, stated that the present loan was required for the extension of the existing central station, increasing the plant, and laying distributing mains to parts of the city not at present supplied with the electric light, but which were within the area covered by their Provisional Order. Three loans had already been raised, namely, £66,000 in 1893, £24,000 in 1894, and £10,000 in 1895, making a total of £100,000, the whole of which had been spent. The capacity of the existing plant was equal to 34,000 8 c.p. lights, and customers using 32,285 had already been connected or had demanded to be supplied. After the last loan of £10,000 for the extension of the mains to districts where the light was used by private customers they found that a largely increased number could be supplied without materially increasing the working expenses. The extensions made in 1895 had proved to be a great success, as in April of that year the sum of £3,300 had to be provided out of the district rates to meet interest, sinking fund, &c.; but no such sum had been provided out of the rates for the subsequent two half-years; in fact, they had been able to pay the sinking fund instalments, as well as the interest, entirely out of the income earned by the works. The extension now proposed to parts of Clifton, Redland, Cotham, and Stapleton-road they hoped would prove equally profitable. Particulars of the new buildings were then given by the architect; and the Town Clerk having expressed the hope that the Inspector would recommend a longer period than 25 years for the repayment of the loan for the buildings (£18,880), the inquiry closed.

BUDA-PESTH.—A Reuter's telegram states that during the International Telegraph Conference, just terminated, an agreement was concluded between the British and Hungarian Telegraph Departments for the establishment of direct telegraphic communication between London and Buda-Pesth. Previous negotiations had invariably been unsuccessful.

CERTIFICATES OF ORIGIN FOR IMPORTS INTO SPAIN.—In anticipation of the growing demand for machinery for electric light and traction enterprise in Spain, the following information is of importance:—The British Consul at Madrid reports that, owing to the commercial estrangement of Germany and Spain, several attempts have been made to import German goods into Spain with French or Belgian certificates of origin. As a result the Spanish authorities have caused a very close inspection of such documents to be made, and the certificate formerly employed has been held to be inadmissible. The new form has been communicated to the English Chambers of Commerce. If exporters employ a certificate issued by a Chamber of Commerce, mayor, or Local Authority, the name of the manufacturer as well as the country of origin must be given; but if issued by a collector of customs the name of the manufacturer is not necessary, the formal declaration of the exporter being deemed sufficient. Great care should be taken to see that the proper form is employed, as the Spanish officials are extremely punctilious on this point. Most of the electrical plant and machinery in Spanish electricity stations has hitherto come from Germany. Several of the leading German manufacturers have agencies either at Madrid or Barcelona, but British firms have now a better opportunity of securing at least a fair share of Spanish orders for electrical plant, apparatus and accessories.

CHURCH LIGHTING.—St. Mildred's Church, Bread-street, in the City of London, is one of the latest churches to be lighted electrically, the work having been placed in the hands of the Tayler-Smith Electric Company, South Molton-street, W.

CORK.—At the last meeting of the City Council the Waterworks Committee recommended the acceptance of the tender of Messrs. Porte, Sykes and Co. for the erection of an electric light installation at the pumping station, for £187. 5s. The Committee anticipate being able to light the station much more efficiently by means of the electric light at a much smaller sum than is at present being paid for gas, £110 per annum. The matter has, however, been deferred until a city engineer has been appointed.

COVENTRY.—At Tuesday's meeting of the City Council Mr. West moved that Hertford-street, Broadgate, Cross Cheaping, Burges, Bishop-street, Smithford-street, High-street, and Earl-street, be lighted electrically. After discussion the motion was rejected.

EDINBURGH.—As the result of a further discussion on the subject of the formation of a special reserve or depreciation fund in connection with the electric lighting undertaking, the Town Council have remitted the matter to a joint committee of the Electric Lighting, Treasurer's, and Law Committees, for further consideration and report.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from July 15th to July 21st, with the ports of destination:—

*Argentina*—Buenos Ayres, £673 (including £211 telegraph material); Rosario, £1,258. *Australasia*—Brisbane, £120 (telephone material); Fremantle, £636 (including £293 telegraph material); Melbourne, £12; Rockhampton, £394; Sydney, £32; Wellington, £2,283. *Belgium*—Brussels, £22; Ostend, £27. *Brazil*—Rio de Janeiro, £820 (telegraph material). *British Guiana*—Berbice, £11 *Ceylon*—Colombo, £123. *Chili*—Boca, £194 (including £151 telegraph material). *China*—Shanghai £189. *Egypt*—Alexandria, £92 (telephone stores); Port Said, £8. *Holland*—Amsterdam £370. *Hong Kong*, £13. *India*—Bombay, £411; Kurrachee,

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£18; Rangoon, £62. *Japan*—Yokohama, £320. *Malta*, £111 (telegraph material). *Norway*—Christiania, £43 (telegraph wire). *Panama*—Santos, £25. *Russia*—St. Petersburg, £8. *South Africa*—Cape Town, £27; Durban, £218; East London, £108; Port Elizabeth, £60. *Spain*—Barcelona, £390 (telegraph cable). *Straits Settlements*—Singapore, £80. *Sweden*—Gothenburg, £550; Stockholm, £45. *Uruguay*—Monte Video, £348.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows:—

*Australasia*—Auckland, £20; Melbourne, £84.

EXETER.—The City Council have decided to light Northernhay electrically.

FOREIGN TRADE AND THE CONSULAR SERVICE.—On many occasions we have referred to the lack of assistance rendered by British Consuls and commercial attachés to British trade, and in our issue of the 17th inst. called attention to the energetic steps that were being taken by the German officials in Japan and the Far East to keep the home manufacturers in touch with the requirements of native traders in these countries. We are therefore glad to learn that this subject is receiving the attention of the Foreign Office. In the House of Commons, on Monday, in reply to a question by Sir Howard Vincent, Mr. Curzon announced that the Government were giving very attentive consideration to the question of British commercial interests abroad, and it had been decided to appoint two new commercial attachés—one to Germany, the Netherlands and Scandinavia, to reside at Berlin; the other for Spain and Portugal, to reside at Madrid. The commercial attachéship at Paris would in future cover France, Belgium and Switzerland, and the commercial attachéship in Russia and Western Asia had been reconstituted so as to embrace the south-eastern parts of Europe, while Asia had been excluded from its sphere. A Consul for Lombardy had been appointed to reside at Milan with a special view to the collection of commercial information, while the Siamese Consular staff would be increased by two new appointments. It was intended to appoint additional Consuls in Yunnan to promote the interests of trade in that quarter, and several new Consulships were in course of being created for the new ports that have been opened to foreign trade by the Treaty of Shimonoseki between China and Japan. Her Majesty's Consul at Canton (Mr. Brennan) had been despatched on a special mission of inquiry to the treaty ports of China, Corea and Japan, to report upon the manner in which British trade had been affected by the recent war. As the outcome of correspondence between the Foreign Office and the Association of Chambers of Commerce, supplementary instructions were in course of being issued to her Majesty's Consuls regarding assistance to trade, the collection of samples and information of a commercial nature, and in addition more complete arrangements have now been made for the immediate publication in the Press of invitations for tenders for work abroad. As a branch of this important subject, arrangements have been made for the official participation of Great Britain in the Exhibitions to be held next year at Brussels, and in 1900 at Paris, and Parliament will be asked to make grants for this purpose.

FULHAM (LONDON).—The County of London and Brush Provincial Company and C. W. Sax notify the Vestry that they intend to apply for Provisional Orders for the district. It has been decided to oppose both applications. The subject has been before the Vestry for the past three years, but nothing has been done.

GLASGOW.—At the last meeting of the City Council the minutes of the Health Committee recommended that, "with the view of utilising a portion of the waste power at the various refuse despatch works, arrangements be made for laying down an electrical installation at each." In reply to Bailie Murray it was stated that the probable cost would be £400 or £500. The minutes were agreed to. —— The Tramway Committee have decided to recommend the Town Council to equip the Springburn-Mitchell tramway route on the overhead electric traction system. The cost of a three-minute service of cars is estimated as follows:—

| | | |
|---|---|---|
| Overhead construction and rail bonding | | £3,300 |
| Power house | | 2,000 |
| Generating plant | | 6,000 |
| Feeders | | 2,200 |
| 15 new motor cars at £550 each | £8,250 | |
| Less cost of 15 ordinary cars required and hereby superseded, at £145 | 2,175 | |
| | | 6,075 |
| | | £19,575 |

HAMPSTEAD (LONDON).—The Vestry have decided to try a Ferranti automatic device for reducing the loss on transformers in one of their transformer chambers, at a cost of £50.

HORNSEY (LONDON).—In the course of a discussion on the proposal to erect 36 new gas lamps in the Stroud Green District, at an annual cost of £75, Mr. Perrin inquired if it was possible to arrange with the Islington Vestry for the electric lighting of the district; but the Chairman replied that this would be encroaching on the prerogative of the Hornsey Gas Company! Ultimately the proposal was carried.

HULL.—The Electric Light Committee have decided to again recommend the Town Council to borrow £42,000 for the erection of a new electricity supply station.

LEATHERHEAD (SURREY).—The District Council have received a notice on behalf of a company about to be formed of intention to apply for a Provisional Order.

LEICESTER.—The report of the Gas and Electric Lighting Committee for the six months ended June 30th states that the total output of electric current from the generating station during this period amounted to 90,786 units, against 29,778 units in the corresponding period of 1895, an increase of 61,008 units. There were 211 customers.

LEITH.—The Town Council will discuss at the next meeting a resolution in favour of applying to the Board of Trade for a Provisional Order.

LIMERICK.—Prof. Kennedy has presented his report on the electric lighting question. The Town Council are advised to erect an electricity supply station, capable of supplying current to about 3,000 lamps, at the gas works, at an estimated cost of £12,300. After discussion the Electric Lighting Committee decided to ask Prof. Kennedy to prepare plans and specifications of a scheme suitable for the supply of 4,000 lamps.

MUSIC HALL LIGHTING.—The Edinburgh Music Hall has recently been fitted up for the electric light by Messrs. King and Co., of Leith, to the specification of Mr. A. A. Campbell Swinton. The lighting of the hall has been arranged so as to give the most economical system of control. The lights have been divided up into several independent groups, any one of which can be turned on or off from the switchboard in the manager's room. The various side rooms, entrances, &c., as well as the manager's house, have also been wired, the total number of lamps provided for being an equivalent of 1,100 16 c.p.

NEW BRIGHTON.—It is stated that proposals have been made by a Manchester syndicate for the purchase of the Wallasey tramways, with a view to extending the system to New Brighton. The syndicate also propose to construct an electric tramway along the beach fronting the promenade.

SHOREDITCH (LONDON).—The Vestry have decided to oppose the application of the County of London and Brush Provincial Company for a Provisional Order for this district. The object of the application is to obtain powers to carry electric light mains from the Company's St. Luke's station through Shoreditch to Hackney.

STOCKTON-ON-TEES.—The lease of the present tramways expires in November next, and negotiations are in progress for the purchase of the Stockton Company's undertaking by a syndicate, who propose to equip the lines on the overhead system. The motive power at present employed is steam, and the Rural Council intimate their willingness to endorse any scheme for the improvement of the tramway service. Mr. J. G. W. Aldridge, who is acting for the syndicate, has also approached the Thornaby District Council.

SUNDERLAND.—The estimates of the Electric Lighting Committee for the half-year ending March 31, 1897, show an estimated profit of £309, against a deficiency of £450 for the same period of 1895-6. The Committee recently issued a circular to the ratepayers calling attention to the reductions made in the charge for current, and to the many advantages of electricity for lighting and motive power purposes. The price has been reduced from 6d. to 5d. per unit for lighting, and from 3½d. to 2½d. per unit for electric motors, and for heating and cooking purposes, subject to discounts ranging from 2½ to 20 per cent. The Committee claim that electric current at 5d. a unit will be found to be only slightly dearer than gas in Sunderland, light for light; but by economy in use it is possible to bring it down to the actual cost of gas, while the absence of heat, smoke, dirt, noxious fumes, risk of fire and explosion, more than warrants the adoption of the electric light. The Committee further point out that the electric motors are steady and reliable, with an entire absence of vibration, noise and smell.

SOUTHAMPTON.—The Works Committee have been empowered to engage an electric traction expert at a fee of 50 guineas to advise them on the probable life of the permanent way of the local tramways, its suitability for electric traction, the system of electric traction to be adopted, &c.

STOKE NEWINGTON (LONDON).—The County of London and Brush Provincial Company have notified the Vestry of their intention to apply for a Provisional Order for the district.

STORES LIGHTING.—The Masborough Co-operative Society have decided to introduce the electric light at their central stores, at an estimated cost of about £600.

WELLS.—Another long debate has taken place on the electric lighting question. By the casting vote of the Mayor it has been decided to proceed with the scheme for the establishment of electricity supply works.

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# COMPANIES' MEETINGS AND REPORTS.

## Eastern Telegraph Company (Limited).

The forty-eighth half-yearly ordinary general meeting of the Eastern Telegraph Company was held on Thursday, July 23, 1896, at Winchester House, Old Broad-street, under the presidency of the Most Hon. the Marquis of Tweeddale.

The SECRETARY (Mr. George Draper) read the notice and the minutes of the last general meeting.

The CHAIRMAN said: Gentlemen, is it your pleasure that those minutes be signed? (Hear, hear.) Having signed the minutes, and the report being taken as read, he continued: Gentlemen, before dealing with the ordinary business of the meeting it is my melancholy duty to refer to the grievous loss which the Company has sustained through the death of our late Chairman. His long and active life came to an end on July 7th last, and then closed a remarkable career, alike honourable to himself and beneficial to his country. You are no doubt aware that Sir John held a prominent—I think I might say a foremost—place in that small body of distinguished men who, believing in the feasibility of establishing telegraphic communication between England and America, aided in successfully laying the first cable between those two countries. Having accomplished that great enterprise he turned with characteristic energy and perseverance to the work of conferring similar benefits first on our Eastern possessions and later on the Continent of Africa. His efforts were crowned with signal success, and he happily lived to see India, China, Australia, Africa and South America in direct telegraphic communication with Great Britain. Among the companies formed to carry out this great work, none has had a better record than the Company whose report is submitted to-day for your approval. This Company was founded in 1872, with a capital of £3,397,000 and a cable mileage equal to 8,862 miles. It has now a capital of over £6,000,000, and its cable mileage has increased in the interval to 26,352 miles. It has paid quarterly dividends uninterruptedly from that day to this—never less than 5 per cent. and as high as 7 per cent, while its shares command a premium of between 60 and 70 per cent. Sir John's services have been recognised by our Government at home and by many foreign Governments as well. These rewards were warmly appreciated by him; but I believe that he prized even higher the good opinion of those who showed their confidence in him by investing in the companies which he controlled, and which found repeated expression at our public meetings. I think you will agree with me in deploring the loss of a vigorous, capable and far-seeing administrator—one whose name will be long remembered as the foremost pioneer of submarine telegraphy, and one whose memory is entitled to our gratitude and our respect.

Gentlemen, your Directors, in the exercise of their discretion, have done me the great honour to elect me to the vacant chair (cheers). I need not say that it will be my ambition to justify their choice. Of this, at least, I am certain—that I shall have the support and assistance of colleagues of great ability and unrivalled experience in the particular business of the Company. You will have also noticed, I am sure with entire satisfaction, that Mr. John Denison Pender will occupy the position of Deputy-Chairman, and continue to perform the duties of Managing Director (cheers), duties which he has discharged with marked ability and entire success ever since the lamented death of Sir James Anderson. With a Board consisting of such gentlemen, and with a Managing Director so competent, I think you may be quite satisfied that the affairs of the Company will be administered in the future with no less prudence and success than they have been in the past.

Now, gentlemen, turning to the report and accounts, I propose to offer a few observations on the more important figures in them. The gross revenue for the half-year under review amounted to £466,093, being an increase of no less than £45,567 over that of the corresponding period of 1895. A considerable portion of this increase was derived from traffic with Australia, more especially with West Australia. That is due to the activity which has prevailed in Australia in connection with gold mining enterprises. In South Africa the state of affairs in the Transvaal temporarily created additional traffic, but this has now resumed its normal proportions. The total ordinary expenses for the same period amounted to £99,152, or an increase of £1,092 as compared with those of the corresponding period of 1895. I believe this increase will be deemed moderate when you fairly consider the immense increase which has taken place in the traffic. The general expenses in London amounted to £9,458, or an increase on those for the corresponding period of 1895 of £556. This increase is partly due to the additional staff which, of course, is necessary to be kept with the increase in the traffic receipts, and it is also due to the regular augmentation in the salaries of our employés every year. These remarks apply to the working expenses at stations, which amounted to £82,135, or a slight increase of £915. With reference to one very important item, viz., repairs to cables, we find that they amounted to £33,955, as against £52,730 in the corresponding period of 1895, or a decrease of £18,775. Included in this item are the expenses of ships, which amounted to £32,372, or a decrease of £5,543. The large decrease in the cost of repairs is accounted for by the much smaller quantity of cable which it has been found necessary to employ in order to repair defective points in our cables during the half-year. This is, however, a very fluctuating item, and we cannot always expect to have the same good fortune each half-year as we have had during the past six months. None of the other items under the head of expenses call for any particular remark, I think. There are slight increases and slight decreases, but they are really so unimportant that I have not thought it necessary to dwell upon them. The principal increases and decreases have been referred to, and I have endeavoured to explain the reasons for them.

In order to balance the capital and capital expenditure accounts, and to enable us more fully to invest the amount standing to the credit of reserve fund, we have issued Four per Cent. Mortgage Debenture Stock to the amount of £110,000, at the substantial premium of £31,908. This premium has been carried to the general reserve fund, and more than wipes out the discount of £28,105 on the issue of Four per Cent. Stock, which was charged against the fund in 1835. In 1883 I daresay some of you may remember that we had some difficulty in issuing this stock at 95. In 1896 we were able to issue a considerable amount at 131—a striking illustration of the progress which this Company has made during the last 13 years and the increased confidence shown in it by the investing public.

You will have seen from the report that the International Telegraph Conference was held this year at Buda Pesth. These conferences, which occur, as some of you are probably aware, every five years, are a source of no little anxiety to your Directors, because resolutions are not infrequently submitted, which, if adopted, would seriously affect the submarine companies' interests. I need hardly assure you that your interests are carefully watched, both by your Directors and by the principal members of your permanent staff. The Conference came to an end the day before yesterday, and it is therefore too early to be able to express a definite opinion as to the effect which its decisions may have on the revenue of the Company. That there will be some loss on account of traffic it is probable; but I think I am justified in saying that that loss will not be a very serious amount.

Gentlemen, you will observe from the accounts that £125,000 has been placed to the general reserve fund. Of this, however, £70,000 has been taken to defray the balance due on account of the Aden-Bombay cable. This closes that account altogether. The whole of the cost has been debited to the reserve fund; and we shall have no further occasion to make any contribution on that account. That leaves a net sum of £55,000 to swell the reserve fund.

Now, gentlemen, in 1830 our reserve fund amounted to £606,999, and to-day it amounts to £563,295, or £43,704 less than it was six years ago. A reserve fund of £563,295 is totally inadequate in the case of a company with a capital of £6,000,000 and a cable mileage of over 26,000 miles. It only amounts to 9 per cent.—a percentage far too small in view of the number of our cables and the demands constantly made on us by the public, especially for lower rates. With respect to this question of rates, it has always been the policy of this Company to reduce rates whenever there was a reasonable prospect of developing traffic sufficient to warrant such a step; but you must remember that in fulfilling our duty to the telegraphing public we are bound not to overlook the interests of our shareholders, and we believe that the interests both of the public and of our shareholders are bound up in the strengthening of our reserve fund. It is a cardinal point in our policy to have a large reserve fund (cheers). You are aware that a reduction of rates, while bringing undoubtedly an increase of traffic, necessitates the laying of additional cables. In order, therefore, to avoid, as far as possible, burdening the Company with additional capital, a substantial reserve fund must be maintained. Such a fund we are endeavouring to build up, but some time must elapse before it reaches a figure which we shall consider adequate for a Company of this importance. In building up the reserve fund, however, there is no reason to doubt that we shall be able to continue the dividend we have been paying hitherto, and which, I believe, will be considered very satisfactory by all reasonable persons. Gentlemen, the net result of our operations during the half-year is that we are able to recommend a dividend of 2s. 6d. a share and a bonus of 3s., making, with previous payments, a distribution equal to 6½ per cent. for the year, and to carry a very substantial sum to the reserve fund. I think this is a result which will commend itself to the most exacting of our shareholders, and I beg, therefore, to propose the following resolution—

*"That the printed report and accounts of the Directors to March 31, 1896, submitted to this meeting, be and the same are hereby received and adopted; that a dividend on the Preference shares of the Company to June 30, 1896, at the rate of 6 per cent. per annum, be paid, less income tax; and that, in accordance with the Directors' recommendation, a dividend be and is now declared of 2s. 6d. per share, with a bonus of 3s. per share, both free of income tax, on the Ordinary shares of the Company, making with previous payments by way of dividend on account, a total payment of 6½ per cent. on these shares for the year ended March 31, 1896."*

The VICE-CHAIRMAN and MANAGING DIRECTOR (Mr. J. Denison Pender): I have the pleasure of seconding the motion; and will you allow me in doing so to thank you on behalf of my family and myself for the way in which you received the kind observations made by the Chairman with regard to my late father, Sir John Pender?

The CHAIRMAN: Gentlemen, if any shareholder has any observation to address to me I shall be very glad to hear him.

Mr. JAMES GIBB: I should like from this side of the table to move a resolution with respect to Sir John Pender. Those of us who have been in the habit of attending this Company's meetings do not need to be told that Sir John Pender had the interests of this Company thoroughly at heart; but I think we may go further than that, and say that not only was he concerned in the interests of this Company, but that he took a very large and statesmanlike view with respect to the question of telegraphy altogether. He always told us here that we had to consider not only ourselves, but the public, and not merely the commercial public, for he looked upon the wires as being something more than a means of commerce—as a means of promoting peace, and, by uniting the nations one with another, interesting

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them one in another. He therefore hoped and believed that he was doing a great work tending to the securing of peace in the world. What a wonderful thought it is—if familiarity does not kill the power of marvelling—that as we open our newspaper morning by morning we see pass before us, as in a panorama, what is taking place in Rhodesia; and then, turning to another page, we see, almost as if we were present, what is taking place at the Chicago Convention. How can these communications fail to create sympathy between people and people! This vast work, which has been done in comparatively a few years, has been done very largely by our late Chairman; and I feel, both as members of this Company, as members of this great country, and also as members of the human brotherhood, that we do well to record to-day our sense of the great work done by Sir John Pender. I beg to move—

"*That this meeting of shareholders of the Eastern Telegraph Company desires to express a sense it feels of the great loss the Company has suffered by the death of Sir John Pender, and to tender to Mr. John Denison Pender and the other members of the family its sympathy in their bereavement.*"

Mr. HENRY T. BURGESS: I have known Sir John Pender at these meetings perhaps longer than anyone, and I knew him for over forty years. I always found him courteous and kind to everyone; and certainly he was without exception one of the best Chairmen I have ever known. I therefore second this proposal, although with great regret in many ways, but it is one of those things which one must do as occasion requires. I should also like to add to what my friend said who proposed this resolution this remark—that it should be sent in writing to the members of our late Chairman's family. I am sure you will all agree with the opening remarks of our excellent Chairman. We could not possibly have done better than appoint the noble Marquis to the chair, and, to show our appreciation and gratitude to his late father, to appoint Mr. John Denison Pender as Deputy-Chairman of the Company.

Mr. JOHN NEWTON: I have great pleasure in supporting this motion—or the melancholy satisfaction of doing so. I think I can claim a longer acquaintance with, and knowledge of, the late Sir John Pender than our friend who has just sat down. It is more than forty years since I became acquainted with him, and I have known him in connection with this Company as long as it has existed, and some of the previous ones. I wish to join with the shareholders present in this expression of their sympathy to the family of Sir John Pender, and I am sure that the thousands of shareholders who are absent would be very glad to do so. You, gentlemen, who have worked so long with Sir John Pender must feel it a great blow to have lost him, but to his family his loss must be a still greater blow. They have, however, the great satisfaction of knowing that the life-work of Sir John Pender was accomplished, and that he had the extreme gratification of being the universally acknowledged head of the enterprise which he, to a large extent, had created by his energy. It is more than 70 or 80 years ago—perhaps it is 100 years ago—since it was thought that submarine telegraphy would be made scientifically successful; but science would have done nothing without the energy characteristic of such men as Sir John Pender, Sir James Anderson, and Mr. Cyrus Field, as well as of some others who are happily still living. I think it must be a great consolation to our late Chairman's family to know that, and it is also something of which the shareholders of this Company may be proud, because it was to a certain extent the success of this struggle in the Atlantic which brought Sir John Pender to see the future before him with regard to the cables in the East. While we are speaking of Sir John's work there is one matter which I should like to call attention to. I think that some memorial—some testimonial in some shape—should be taken in hand by the shareholders who have profited so immensely by the work he has done, although we all know that the greatest monument that could be raised to Sir John Pender would fail in its comparison with the wonderful memorial that exists in the success of the Eastern and Eastern Extension Companies. It has practically been the long-headedness, the shrewdness, and the great capability of our late Chairman that have brought about the success to which we have attained. The shareholders must know that these two Companies of which he was the head now stand at the pinnacle of gilt-edged securities—certainly of the gilt-edged securities outside Government Stocks. That is a monument of which his family may be proud, and they know that his name will always be connected with it. I hope that some lasting memorial of a permanent character may be originated, and it may be commended to the Directors to see that it is efficiently and worthily carried out.

The CHAIRMAN: I need hardly say that my colleagues and myself agree with every word that has fallen from Mr. Gibb who proposed the resolution, from Mr. Burgess who seconded it, as well as with the remarks that fell from Mr. Newton. Mr. Newton referred to what has suggested itself to the mind of almost everyone who was acquainted, however distantly, with Sir John Pender. It is a suggestion which is very proper, and it is a very acceptable one to us, and we shall be very glad to assist in every way possible in carrying out the suggestion which he has made. I believe it will be responded to, as he anticipates, by a large number of persons, and that a memorial worthy of Sir John's life and career will be the result. The resolution which is actually before you at this moment is—

"*That this meeting of shareholders of the Eastern Telegraph Company desires to express a sense it feels of the great loss the Company has suffered by the death of Sir John Pender, and tenders to Mr. John Denison Pender and the other members of the family its sympathy in their bereavement.*"

That is proposed by Mr. Gibb and seconded by Mr. Burgess, and those who are in favour of it will be good enough to signify the same in the usual way. Those of a contrary opinion. Carried unanimously.

Mr. JOHN DENISON PENDER: I have again to thank you for the resolution which you have just passed. I shall myself put it before the family, who will appreciate it more than anything they could have received, for of all the Companies that Sir John was Chairman of, he looked upon the Eastern as being *the* Company, and the beginning of the whole.

The CHAIRMAN then put the resolution for the adoption of the report and accounts, which was carried unanimously.

Mr. NEWTON: I beg to move a vote of thanks to the Chairman for presiding. I think we may congratulate ourselves that we have a very able successor to the late Sir John Pender in the person of the Marquis of Tweeddale as Chairman of the Company; and we may also congratulate ourselves that the Directors have thought proper to continue to identify the name of Pender with our Company by appointing Mr. John Denison Pender as Vice-Chairman and Managing Director. I believe we may feel confident that we shall have good results from the energetic discharge of his duties in that position. I now beg to propose a vote of thanks to the Chairman and Directors for their successful administration of our affairs in the past half year.

Mr. BAINES: I have had occasion to take part in the proceedings of these meetings from time to time, and I beg to second most cordially this vote of thanks. At the same time I think it right that I should express my deep sympathy at the loss which the Company has sustained by the death of Sir John Pender.

Mr. NEWTON put the motion to the meeting in the usual way, and it was carried unanimously.

The CHAIRMAN: I beg to thank you very warmly for the way you have received the vote. As I said before, I hope to show you that your confidence has not been misplaced. As I have also said, I shall be assisted by a most able Board and a most capable and competent Managing Director, and therefore I have no fear but that the Company will prosper in the future as it has done in the past. I may remind you that I have been now a Director of telegraph companies for twenty-eight years. That is a fact which is perhaps not so generally known, owing to my having had—I will not say the misfortune—to change my name. That has led persons to imagine perhaps a dual personage; but I was in fact the first Chairman of a cable company communicating with the East—the Anglo-Mediterranean cable, which proceeded from Malta to Alexandria, and which was afterwards absorbed by this very Company. I have therefore had some experience, at any rate, of the work connected with submarine telegraphy.

The proceedings then terminated.

## Direct United States Cable Company (Limited).

The thirty-eighth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, under the presidency of Mr. E. M. Underdown, Q.C.

The SECRETARY (Mr. T. Finnis) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, with regard to the report before you, the remarks that I have to make are of a sufficiently simple description; but it has been the custom to go into matters with a certain amount of particularity, and therefore I will call your attention to the revenue for the six months, which amounts in round figures to £42,456, and the working and other expenses, including income tax, but exclusive of the cost of cable repairs, absorb £19,692, leaving a balance of £22,764 as the net profit of the half-year, making, with £4,149 brought forward from the previous half-year, a total of £26,913. This has been appropriated as follows: Interim dividend of 2s. 6d. per share for the quarter to March 31, £7,589; final dividend of 2s. 6d. per share now proposed for the quarter to June 30th, £7,589; we transfer to reserve fund account £7,500, and we carry forward £4,235, which exhausts the amount. It is satisfactory to be able to say that the revenue has continued to improve during the past half-year, and as compared with the corresponding period of 1895 an increase is shown of £4,803, or nearly 13 per cent. Naturally, as we have a larger amount of business to attend to, the expenses have increased, but only by the sum of £783; that is to say, there has been an increase in the expenditure of only 4 per cent. against an increase in the earnings of 13 per cent. As regards the other items, the differences are so extremely small that it is hardly worth while to refer to them. There is a small item in the accounts which is subject to adjustment in connection with the preparation for, and attendance of the traffic manager, Mr. Moll and myself at the International Conference at Buda-Pesth. We have spent on cable repairs £8,243, and this has been charged, as usual, to the reserve fund account; but that account has, at the same time, been credited with interest on the investments, £4,978; a realised profit on the sale of a security, £3,730; and by the transfer, to which I have already alluded, from revenue of £7,500, bringing up the balance of the reserve fund account to £313,969. You will, however, remember that that figure is really one of cost, and that the value of our investments at the present moment exceeds by something like £64,000 the cost at which they were acquired. So far, I think, you may consider that matter to be satisfactory. Now, to return to the paragraphs in the report, I think there will be one subject present to all our minds, which is the one referred to in paragraph 5 of the report. We have to mention publicly, what we have considered among ourselves, the loss of our highly-esteemed colleague, Chairman and friend, the late Sir John Pender. It is now nearly 20 years since I and Sir John Pender began to sit together at this Board. Our relations were always of the most friendly kind, and I almost considered myself (almost, I may say, in the presence of his son) one of the family to a certain extent, because our relations were so extremely pleasant. I am sorry to say that in consequence of his death I stand here as the sole member of the Board of the original Company as reconstructed in 1877, so many losses have we sustained. One gentleman has ceased to act. Mr. Günther, whose place has been so well taken by his son, is still happily alive, but the other members have departed. My colleagues elected me on the death of Sir John

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Pender to the very important post which he so long and so well occupied. I should say that we have received from General Eckert, the President of the Western Union Company, our most important ally on the other side of the Atlantic, a sympathetic telegram directed to myself, which I will read. It is as follows:—"I regret to hear of Sir John Pender's death. Pray express my sympathy to his family and official associates." Our Board passed a resolution which I will read to you. I do not know whether you will be pleased to pass a separate resolution or not, or whether you will approve this as being the expression of the feeling of the Company, as it has been that of the Board:—

"*The Chairman having alluded in feeling terms to the great loss sustained by the death of Sir John Pender, G.C.M.G., late Chairman, and having referred to the leading part he had taken in the development of submarine telegraphy from its inception, and in which his energy and wide commercial experience had been so valuable, it was moved by the Chairman, seconded by Admiral of the Fleet, the Hon. Sir Henry Keppel, G.C.B., D.C.L., and unanimously resolved, 'That the Chairman be requested to convey to the family of the deceased the expression of the Board's deep sympathy with them in the bereavement they have suffered, and the profound regret of the Board at the loss they have sustained of a highly-valued colleague.'*"

Several points have, from time to time, been considered at this meeting, and have been very intelligently discussed by members of the Company. I am happy to say that what I think should be our leading and guiding policy of good relations with our colleagues in the pool is maintained. I believe we are working with the utmost friendship and co-operation with the Western Union Company, and that our relations with the Anglo-American Company are extremely satisfactory. They have met us and discussed with us many subjects of importance in which our common interests are at stake. Our relations with the Government are also satisfactory, and I am quite sure that our presence at the Telegraph Conference has contributed not only to put us on very friendly relations with the representatives of foreign Governments and foreign telegraphic authorities, but has also tended to show that this Company has really many merits of its own, is one whose policy has certainly tended generally to the improvement of telegraphic communication, and that we have very good opportunities for making ourselves useful, even although we are a Company with only one cable. There is one matter that has been standing over for some years. Some representations were made by our late Chairman to the Colonial Office as to our not getting what we should get, viz.: the messages from the Halifax-Bermuda Cable Company, the terms under which that Company enjoys a subvention from our Government not having been adhered to. An answer was given some years since which I thought, when I examined into it, was unsatisfactory on the part of the Government, and I am glad to say now, after communicating with the Government and the Admiralty, that I believe we shall have in future what we ought to have—our proper share of those messages, which, considering that the cable was subsidised under these conditions, we should have enjoyed a long time before, instead of their being allowed to pass away to a foreign company. Of course, as I said before, we are only one cable, as against a total of 11, including ourselves; but it is unnecessary to go back to the original formation of our agreements with other cable companies. Suffice it to say that the share of traffic we get is, taking all matters into consideration, a satisfactory one. To return for one moment to the subject of the reserve fund, some of our friends have favoured me with letters. I have received communications from two or three of the shareholders, the smaller shareholders, whose representations, however, should none the less be equally attended to. They say that we should not carry forward so much, and that it is unnecessary to add so much to the reserve fund. I think that most of us who are here have had some experience of what this business is. We have a cable which is, at all events, respectable from its age. It has held out well, and I sincerely trust it may continue to hold out for some years to come; but we must face contingencies. If we desire to have our share in the pool, we must have a perfectly good cable, and I do not think we ought to be contented until our reserve fund reaches a sum that would replace that cable if we were to lose it in consequence of any unforeseen contingency. But I would also have you remember that we must continue to replace the figure of our reserve fund, because we have expended during many years very considerable sums, and you must remember that 12 years ago our reserve fund actually stood at a higher figure than it does now. A single deep repairing operation some years ago cost us £59,000, and during the last three years the total amount placed to our reserve fund out of revenue has been only £33,500; but deducting from that the cost of repairs, £18,600, the net amount added to the reserve fund in that period has been only £14,900, which is equal to an average of only £4,966 per annum. I am sure you will all agree with me that that prudential course must be considered, at all events. With respect to what we carry over, you see what our income amounts to. At present we only make up 2¼ per cent. for the year, but we have paid 2½ per cent. now for two quarters, and I sincerely trust that the minimum we may expect for the future will be 2½ per cent., and let us hope it may be more. In order, however, to avoid the contingency of going back again, I think we should carry forward an amount that will enable us, at all events, to be reasonably sure of continuing this dividend. We were strengthened in this view by our auditors, who keep us in very good order as to what we ought to do, as far as the financial policy of the Company is concerned. I do not think there are any other topics to which I need call attention, but, of course, if any shareholder desires any information which it is in my power to impart I shall be most happy to give it. In my remarks relative to the improvement in our traffic I have spoken as to the past, but I am glad to say, with respect to the current half-year, that the traffic still continues to show some improvement. Of course, we cannot prophesy what it will be in the future, and perhaps our friends on the other side of the Atlantic are so occupied with politics now that they may be neglecting their business, and we may not be getting as many messages as we should like. Still, we have had a steady increase, and I hope we shall gradually work up to something like the prosperity of former days. The obstacle to that is the subject I have mentioned—that there are too many cables, or quite enough—at the bottom of the Atlantic. There has been a question of a German cable communication with America *viâ* Lisbon and the Azores; and this matter has been carefully attended to by this Company and our partners in the pool. Our reserve fund, however, is a very nice looking thing, and it presents a tempting appearance to others who may be disposed to look after the interests of other branches of the telegraph enterprise; but I think you will agree with me that we are right in holding on to our reserve, and in maintaining it, in order to keep this Company in a firm and sound position, so that we may retain our proper and agreed share in the earnings of the Atlantic telegraph system. I beg to move—

"*That the report of the Directors, dated July 14, 1896, together with the statement of accounts to June 30, 1896, annexed thereto, be and the same are hereby received and adopted; and that a final dividend be now declared of 2s. 6d. per share, free of income-tax, making, with the interim dividends already paid, a total dividend of 2¼ per cent. for the year ended June 30, 1896.*"

Mr. JAMES PENDER, M.P.: I beg to second that.

Mr. W. GRIFFITH observed that the Chairman had very clearly enunciated a policy which must commend itself to the minds of the shareholders. With reference to the reserve fund, it appeared somewhat strange that when other important companies had a reserve fund not much larger than this Company's, they, a small Company, should have a reserve fund of such an amount. The shareholders must, however, remember that it was essential for them to have a sum sufficient to enable them to procure one new cable if their venerable one at the bottom of the sea ceased to be of much service. If they had not an efficient cable their business must come to an end. The reserve fund of this Company was in a very favourable position as compared with the reserve funds of other companies in that it could be used for the purposes of equalising their dividends. He would like to have a little further information respecting the International Conference at Buda Pesth. He thought that if they were too closely connected with foreign Governments the latter would take certain views of matters and be forgetful of the interests of the shareholders. He should feel more confidence in these Conferences if they were more thoroughly Parliamentary, and not so closely connected with foreign Governments. He afterwards expressed great regret at the loss which they had sustained in the death of Sir John Pender, and remarked that in times past the deceased gentleman had given them much instruction, and in times of difficulty much encouragement. He felt certain that the shareholders would acquiesce in the sympathy expressed by the Directors in the resolution of the Board which had been read by the Chairman. While deeply regretting the death of Sir John Pender, however, he was glad to see that their late Chairman's place was occupied by so able a successor.

Mr. JOHN NEWTON could not agree that their cable was so venerable as might be imagined from what had been said. There was one which was still more venerable—he referred to that of the late Submarine Company—the line running from Dover, which was working as well as their own, for all that he knew. When this Company's cable was laid it was probably the best that had, up to that time, been made, and in all probability there had not been any very great improvements since in the manufacture of cables. No one had yet been able to say what the "life" of a cable was. He remembered the time when the period mentioned was ten years, but that estimate was probably made in order to reconcile shareholders to the building up of large reserve funds. If, too, their present cable should break down, another would be laid, and they might rest assured that the original cable would then be picked up. In that case the Company's position would be stronger than it was now, and he did not think the shareholders need be at all despondent as to the Company's future.

Mr. HANCOCK asked whether the Chairman could mention the amount which it was thought advisable that the reserve fund should reach.

The CHAIRMAN, in reply, thanked Mr. Griffith for the very kind way in which he had spoken of himself. With regard to the constitution of the Board, he could assure him that they had always in their contemplation the strengthening of the Directorate by the addition of mercantile men. With respect to the International Telegraph Conferences, they met from time to time to discuss the different communications, the mode of sending messages, tariffs, &c.; and it must be remembered that the whole theory and practice of telegraphy—extending, as it now did, all over the world—was regulated by the decisions of the Telegraph Conferences. The Atlantic companies did not, however—as Mr. Griffith had pointed out—form a portion, strictly speaking, of the Telegraph Conferences. They had been allowed to be present, however, and they had all recognised the tendency on the part of those who represented the different Governments to get as much as they could from their particular view of the case and to leave the companies out as much as they could. The object of the companies was, therefore, not so much to foment what was going on, as to take care that what was advocated did not prejudicially affect them. One of the proposals which they had thought prejudicial to the commercial community was the compilation and introduction of an entirely new vocabulary. It was largely due to the vigorous protests made by the representatives of the British Government and the Direct, Anglo, and Western Union Telegraph Companies that the consideration of this matter had been postponed to the next Conference. Owing to this postponement much time, labour, and expense would in the meanwhile be saved to the telegraphing public. There were other matters in connection with which they had had to guard their interests, although he need not refer to them. He thought they were much indebted to their traffic manager, who was at the late Conference during the whole of the time it sat. He was glad to say that it had terminated without doing any great harm to them, while it had done this good—that he believed the Direct cable was now recognised as being one of the leading communications between this country and the Atlantic

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With reference to Mr. Newton's remarks, he (the Chairman) had not for one moment intended to suggest that their cable was at all in a shaky state of health. On the contrary, it was in so good a condition that it could be worked efficiently by the duplex and automatic instruments. They also knew that if anything happened to a cable it could be picked up and repaired. He could compliment Mr. Pender on an achievement of that sort by a Company of which that gentleman was a Director, although for his own part he regretted that this effort had been so successful, for they had picked up the old French cable, which was now again working at the bottom of the Atlantic. The fact, however, that such a thing could be done gave them an additional sense of safety so far as their own position was concerned. With reference to Mr. Hancock's question, he would rather not mention specifically any sum; but their reserve fund was approaching an amount which he thought would be quite safe. He then put the motion, and it was carried unanimously. He afterwards proposed the re-election, as a Director, of Mr. John Varley.

Admiral the Hon. Sir H. KEPPEL seconded the motion, which was carried unanimously.

Mr. JAMES PENDER afterwards proposed and Mr. VARLEY seconded the re-election of Mr. Underdown, Q.C., to his seat at the Board, and the resolution was carried unanimously.

Messrs. Deloitte, Dever, Griffiths and Co. and Messrs. J. and J. Sawyer and Co. were afterwards re-elected auditors to the Company.

On the motion of Mr. GRIFFITH, seconded by Mr. NEWTON and supported by Mr. HANCOCK, the latter of whom also warmly testified to the eminent services rendered by Sir John Pender to the country and to the different companies with which he was connected from the inception of submarine telegraphy, the resolution read by the Chairman as expressing the Directors' sympathy with the family of Sir John Pender in their bereavement, was unanimously passed as also expressing the feeling of the shareholders.

Mr. JOHN NEWTON afterwards proposed a cordial vote of thanks to the Chairman and Directors.

Mr. GRIFFITH seconded the motion, which was carried unanimously.

The CHAIRMAN, in reply, observed that no one could feel more forcibly than he did the remarks which had fallen from Mr. Newton. They were only humble followers in the business, which had been established by other and greater men than themselves, and they could only do their best to see that that inheritance was not injured in their hands. He hoped that they would allow the vote to include the staff. Mr. Finnis was a most admirable secretary; and they might be quite sure that the technical business of their Company would be safe in the hands of Mr. Moll. He intended himself to visit the Irish station on the West Coast, where they had an old and experienced staff, who deserved great commendation for the way in which they discharged their duties.

The proceedings then terminated.

## Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors of this Company was held at Winchester House, Old Broad street, on the 24th inst.; the Marquis of Tweeddale presiding.

The SECRETARY (Mr. T. H. Wells) read the notice calling the meeting.

The CHAIRMAN remarked that a notable feature in the report was the increase of £11,917 in the traffic receipts, compared with those of the same period of last year. That was, no doubt, owing to the revival in trade which had been going on for some time. The Presidential Election campaign, no doubt, had a disturbing effect on business: and when that important matter was disposed of, and the financial policy of the United States was placed on a more stable basis than it was at present, they might, he thought, confidently look forward to an increase in commercial enterprise. The ship "Minia" had again added to their revenue account by earning £2,400 in connection with the repair of the Direct United States cable. The expenses of the head office and the stations again showed a decrease on balance of £181, affording evidence, he thought, that they had not lost sight of the desire which the shareholders had expressed that they should try as far as possible to reduce the working expenses. On the other hand, there had been an increase of £2,175 in the repair of cables; but these repairs had nothing to do with their deep sea cables, which had been in very fair working order in the last six months. The repairs had been in connection with the shorter cables in low water between Newfoundland and the coast; but they had now been put in thoroughly good condition, and they had every reason to believe that they would not be troubled by them again for a long time. Their renewal fund had reached the respectable figure of £651,700, the market value of which, at the middle price, was, he was informed, about £100,000 more. They were, therefore, making tolerably rapid progress towards the £1,000,000 which they had so often talked about in connection with the renewal fund of their Company. Their interests at the International Telegraph Conference were carefully watched over by two of the Directors besides himself and the manager, and on the whole he thought they might consider that they had come out of the ordeal satisfactorily. With reference to the case of the French cable, they would possibly remember that the Directors appealed from the decision of the French Court; for, although it was favourable to them to a certain extent, they had not considered it sufficiently so. The Company's case was lodged in the Chamber of Requests of the Court of Cassation, or Final Court of Appeal, last April. The Chamber had the power of refusing to allow an appeal. The documents lodged had to be examined by the Official Reporter to the Chamber, and afterwards by the Advocate-General, with whom it rested to give notice when he was ready to bring on the case for hearing. The consideration of the papers rested entirely with the officials of the Court, and nothing the Company could do would expedite the hearing. He wished them to understand that the matter was entirely in the hands of the French Court, and it would be disposed of as soon as those who were in authority took it in hand to complete it. The result of their operations for the half-year was a considerable increase in their dividend—3s. per cent. on the ordinary stock, 2s. earned in the first quarter, and 1s. in the second quarter. On the whole, he thought they would agree with him that the half-year's working had been satisfactory, and their prospects were encouraging. Since July 1st there had been a very substantial increase in their receipts. He concluded by moving the adoption of the report and accounts.

The DEPUTY-CHAIRMAN (Mr. Francis A. Bevan) seconded the motion.

A discussion followed, in which Messrs. Michael Davis, Kearsley, T. Smith (York), Fry, Edward Clark and W. Griffith took part.

The CHAIRMAN, in reply, said he did not believe that the shareholders would approve withdrawing from the French litigation. He felt sure that they would be able to recover any costs that had been incurred in connection with it; but they hoped to recover a much larger sum, and that was the object of their appeal. He believed that it was quite compatible with the interests of this Company that he should be Chairman of the Eastern Telegraph Company also. There were intimate relations between them, and the fact that he was on both Boards tended, he believed, to smooth any friction that might arise between the Companies. They had in the Eastern Company a large amount of traffic to deal with entirely under their control to America, and he believed he was right in saying that the Eastern Company gave a very large proportion of that traffic to the pooling companies.

A SHAREHOLDER: Why not the whole of it?

The CHAIRMAN replied that the other American cable companies must be dealt with fairly. The concession for the German cable was originally very different to what it was now; and for some years to come they would hear nothing of it except the opening of the line from Germany to Spain, which was entirely with the view of giving the Germans better communication with the East than they now had. The Eastern Company had no interest whatever in promoting a cable to America by the Azores; nor was it to the interest of the pooling companies to lay such a cable. Others might take up a concession of that kind, but they believed that no other Company could afford to lay a cable from the Azores to the United States. Mr. Griffith had described the renewal fund as a useless one—(Mr. Griffiths: The amount of it)—but the Directors regarded it as the backbone of their whole telegraphic system. He had mentioned the sum of £1,000,000, because that was practically the compromise come to many years ago with the general body of the shareholders—that the renewal fund should be increased to £1,000,000, and that any surplus beyond should be devoted to revenue purposes. As to whether the amount was to be £1,000,000 nominally or intrinsically, they merely dealt with the fund as it stood in their books. They could not tell what the price might be two or three years hence of the stocks forming the renewal fund. It was the earnest desire of the Directors to arrive at the time when they would be able to give something to the deferred stockholders. It must not, however, be forgotten that when the £1,000,000 was fixed upon as a *minimum*, their cables were many years younger than they were now. It was true that one cable was comparatively new, but the others were old, and had the infirmities of age, and they must look forward to the time when it would be necessary to renew them or to put in many miles of new cable. They must remember that the Company's share in the pool depended on their maintaining three cables for certain, and if anything happened to disable, for any considerable period, two out of the four cables they had, they would lose enormously out of the pool receipts. A subsidy had been granted by the French Parliament to the proposed French Atlantic cable, but he was very glad to say that the subsidy was a very bad one, and one which no sensible men would accept as sufficient to cover the risk that would be run.

Mr. JOHN NEWTON remarked that, as at present constituted, the pool was all-powerful; and, while true to itself, those who were connected with any new French or German Atlantic cable must come to terms with the pool.

The CHAIRMAN added that it could not be disguised that when Governments took to subsidising cables in competition with those which were carried on on commercial principles it was a serious matter. That was exactly what they said respecting the projected Pacific cable. They could not, however, prevent the French Government or the German Government from giving subsidies. He then put the resolution, and declared it carried, with four dissentients.

On the motion of Mr. GRIFFITH, seconded by Mr. T. SMITH, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN acknowledged the compliment, and the proceedings then terminated.

## National Telephone Company (Limited).

The eighteenth ordinary general meeting of this Company was held yesterday (Thursday), at the Cannon-street Hotel; Mr. James Staats Forbes presiding.

The SECRETARY (Mr. Albert Anns) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN, after a few preliminary observations, said: The paragraphs in the report appear exactly in the order in which they have appeared for several years past, with the object of condensing as much as possible the substance of what we have to say, and keeping up the continuity of that custom for the purpose of comparison between one report and another. Really, after all, they are divided into very small utterances—the income, the working expenses, and the net result. The income, as shown by the first paragraph, shows an increase of £33,295, and it is just as well to look back to the preceding year, 1895. In the

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corresponding half of that year there was also an increase of £33,963; but I suppose in this business, as in similar businesses, the time will arise when we can hardly expect increase upon increase from half-year to half-year in the same proportions; otherwise you would find on a very moderate calculation how enormously the figures would swell. The working expenses have also increased £18,622, which is one of the least favourable parts of the report, because they have gone considerably over those of the preceding half-year, from causes which I will explain when I enter into the details of the accounts. The net result leaves you with a balance of £12,150, of increase over that of the corresponding half of last year. Looking at the thing all round we are fairly satisfied with that result. No. 4 is a very pregnant paragraph, and extremely satisfactory, because it shows how much money you have already got in in respect to unfinished contracts, namely, £438,321, which has been received and is in our pockets for the good of the current period. That is an increase of £47,343 over the amount received for the corresponding half of last year. That is, of course, a measure of the progress of the business, and an earnest of what it may be in the present half-year. Well, how do you propose to deal with that? We have recommended the payment of a dividend on the same scale as in the corresponding half of last year, the same amount to be carried to reserve, and, as a consequence, a considerably larger amount carried to the account of the present half-year. We transfer £35,000, and carry forward £17,133, against £3,400 in the corresponding half of last year. Then we come to capital expenditure, which is a subject of great anxiety from half-year to half-year. You see it runs into large figures—£248,537, in one half-year; and it is unavoidable, being a necessity of our business, because I have explained over and over again that you cannot start a subscriber until you have spent the capital necessary to furnish the material. To give you some idea of what that means, let me say that we have had in this half-year a larger increase in the number of subscribers than we had in any period of the Company's history, namely, 5,956 wires, as against 4,257 in the corresponding half of the previous year, and 12,000 wires are a very large number to be dealt with. There is a paragraph in the report put in purposely to accentuate this question of capital expenditure:—"A not inconsiderable proportion of this outlay is attributable to the substitution of metallic circuits for single lines, and the construction of underground work in lieu of overhead wires; both these sources of expenditure having become necessary to ensure greater efficiency in the service to subscribers in the more important and crowded centres." That is a more or less extraordinary item, and is not in consequence of the mere erection of those 5,659 wires. The fact is, that we are paying the penalty of our original sin of adopting the single-wire system; but that, of course, has become quite effete in places where great pressure has been thrown on the Telephone Company, and where the subscriptions justify a much more expensive, and at the same time a more efficient, method of metallic circuit. I think that we may say with something like confidence, having taken the trouble to institute comparisons with systems which are used elsewhere, and which are supposed to be more popular, that in some of our centres, more especially in the north, our service is as good as any in existence. We spent in Manchester £45,000 during the half-year in the second item. The construction of underground in lieu of overhead wires throws great and growing difficulties in our way in erecting wires in every place, particularly in great towns. Of course, it is a very costly operation, but it is like sowing seed in our case, because this £45,000 spent in Manchester this year not only improves the efficiency of the service of existing subscribers, but it provides a large additional amount of capacity which the present overhead wires do not contain. We have, in fact, run out the capacity of the wires, and that money spent means money not spent in the improvement of existing, but for the cultivation of future business. It cuts two ways. The more efficient your service will become the more rapid will be the accession of subscribers. Every move in the direction of improvement, either by pressure of business or by improvements in science, means that you must keep up to date. We are going on spending your money at a very rapid rate—nearly a million sterling a year. That involves a very great risk, and it wants a great deal of skill and knowledge to face it; but we have no apprehension in facing it for some time to come. You will see that the amount expended for the last half-year on construction and exchange, and private lines is £243,537, and that already spent on land, buildings, and machinery, £44,850; but we are committed up to the present to spend in Dublin, Leeds, London, Birmingham, Bradford, and Manchester, a total of £205,000 in land and buildings, which are, of course, an essential portion of the machinery for carrying on the business. I think you will agree with me that this is not a bad use to make of a reserve fund which you will see is running up to very large proportions. And as we shall have to go on acquiring property in great cities and other places, I see no sounder way of investing it than by putting it into freehold or long leasehold property. The working expenses are a little heavier than they need be; but that arises from the fact that there is a great deal of transition work going on, and likely to go on for a very long time. In regard to net revenue account, there is one thing I must call attention to, and that is that we pay income tax on the ordinary capital, and we pay interest on our own reserve fund. With regard to the transfer of the trunk lines to the State, I may say that when the Government first expressed their intention to deprive us of our trunk wires, we told them that we thought they would make a great mistake, and ventured to say that we thought we could do the trunk business better than the Post Office; but that was rather putting the fat in the fire, but having no alternative we made the best bargain we could. We have got our money, and they have got their wires. They paid the money on April 4th, and have commenced partially the conduct of the trunk business. We are doing all that we can, according to our principles of scrupulous loyalty to the Post Office and to the public, to ensure an efficient trunk service; but you see what we say in the report: "This transfer, separating, as it does, the conduct of the trunk business from the working of the local exchanges in the numerous areas assigned to the Company, has naturally involved some inconvenience in connection with the 'through' telephone business of the country." Then we go on to say: "But as the authorities of the Post Office and the officers of the Company are loyally co-operating, with the object of securing to the public the most efficient service possible, it is hoped that the inconvenience adverted to may be speedily terminated." I cannot pass that without pointing out that the very objections we urged at the time are now presenting themselves in a practical form. In a business of this kind, if you have to transmit something from hand to hand by one machinery under one control, that does not involve anything like the risks, delay and complication which is involved in transmitting it, first of all, to the Post Office, and then by the Post Office to another post office, and then by that post office to the subscriber. There are four operations there, instead of two. There will be great difficulties created inseparably from that kind of business; but I daresay we shall overcome them some way or other. The Chairman then proceeded to speak of the great difficulties the Company experienced in London in laying its wires, and said: There is no law, no authority here for doing these things. People are more enlightened in the north, where they have the advantage of what we call local municipal life. London has at present no local municipal life. There seems to be no authority nor order in it. The public ought to know why the London service is so bad. We have so many orders now in London that we cannot attack them. People seem to think that if a wire goes over a house the house will be struck by lightning; whereas the contrary is the case, inasmuch as the wire is a source of infinite safety to the building by providing it with a lightning conductor. I now come to the question of the pension fund, which we have set out at some length. We have now got a large establishment of people. Many of them have been a great many years in the service, and a great many others are coming in. Ours is an occupation involving considerable self-denial, ability, and devotion; and in its nature is not, in comparison with other occupations, too well paid. Remembering that we are a commercial Company with a semi-public we consider that it is our duty to provide, what all people are pointing to, a pension fund for our employés, and we have devised a scheme—we have made a trust for them, and, as we have told you, we feel we shall have the support of our shareholders in a liberal fashion. It becomes a mere bagatelle compared to our enormous income, and it will be a blessing to many a man hereafter. Having intimated that the Directors had nominated the Right Hon. Sir James Fergusson, the late Postmaster-General, to fill the vacancy caused by the death of Sir Henry Calcraft, the speaker concluded by formally moving—

*"That the report and accounts be received and adopted, and that dividends be paid for the six months ended June 30th last at the rate of 6 per cent. per annum, less income tax, on the amounts paid up on the First and Second Preference shares, at the rate of 5 per cent. per annum, less income tax, on the amounts paid up on the Third Preference shares, and at the rate of 5 per cent. per annum, free of income tax, on the amounts paid up on the Ordinary shares."*

The Right Hon. Lord HARRIS, G.C.S.I., G.C.I.E., in seconding the resolution referring to the alleged inefficiency of the Company's service, said that having some pride in the Company, and recognising its responsibility to supply a good service, it rather hurt the feelings of the Directors to think that they were not doing as much as they ought to do. But they had gone into these matters, and they had called on Mr. Gaine, their manager, to explain every complaint as it came up, with the result that from his (the speaker's) point of view the President had given an absolutely correct and honest explanation of those complaints. These were due to the fact that for one reason the Company was, as regarded appliances, in a transition state, and for another reason it was dependent on the good will of persons over whose property they wished to erect their wires. Why there were not more subscribers in London was simply because they were unable to get permission to go over certain houses. He was especially glad to see in the report mention of the pension fund.

The CHAIRMAN, in answer to questions put by Mr. Galbraith Leek and others, said, with regard to the price paid by the Post Office for taking over the trunk lines, that the parties who settled the price were perfectly competent to take care of the interests of the Company. The experts awarded what they deemed to be the full value. He did not know what the Post Office thought, but the Directors were satisfied that the value put upon the wires was a fair value. His friend Mr. Galbraith had enunciated his opinion on the reserve fund many times. It was a thorny bush to put one's fingers into. But that gentleman seemed to forget that they ceased to have any life after 16 years; and they had to bear in mind the possibility that the value of so many millions in the balance-sheet might not be realisable as an asset at the end of that period. When their Company had, then, to be wound up and taken over, it was very desirable, to say the least of it, to anticipate such a possibility as he had hinted at. They spent their capital on short leases—not 99 nor 60, but 16 years. He was not going to alarm anybody, because he could not see a bit further into the future than other people, but there were certain risks which it was just as well to foreshadow. They were not yet out of the wood, but if at the end of this half-year they found it possible to pay, with due prudence and forethought, a 6 per cent. dividend, of course they would do it. But he would not make any prophecies. They could reason from induction as well as he could. They would know next January.

The resolution was then put and carried unanimously.

The CHAIRMAN, in reply to Mr. Hall, who asked for what term of years the pension fund would bind the Company, said that the Company's licence must cease at the end of 15 years, but telephony would not. Their theory was that the Government would take over the staff with the telephone, but the Company's obligation was limited to that period.

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The retiring Directors, the Right Hon. Lord Harris, G.C.S.I., G.C.I.E., Mr. Charles Swain Agnew, Mr. George Hunter Robertson, and Sir Albert Kaye Rollit, M.P., were all formally re-elected, as were also the auditors Messrs. Welton, Jones, and Co.

Mr. LAMB moved, and Mr. CHAPMAN seconded, a vote of thanks to the Chairman, Directors, chief officers and staff; and this having been cordially passed,

The CHAIRMAN briefly acknowledged the vote, and the proceedings ended.

## City and South London Railway Company.

The twenty-fourth ordinary general meeting of the proprietors of this Company was held on Tuesday, at Winchester House, Old Broad-street; Mr. Charles Grey Mott presiding.

The SECRETARY (Mr. W. F. Knight) read the notice convening the meeting.

The CHAIRMAN: I presume you will take the report as read, and we will take the usual authority to sign the register. It now becomes my duty to move the adoption of the report and accounts, and I am glad to say that, during the past half-year we have maintained, as we have done before, that safe and punctual working which has characterised this railway from its beginning, and which, I hope, will continue. There is no doubt that, so far as our experience has gone, there is no railway in existence that can boast a more punctual, a more convenient, or a safer working record than this line has done. I shall now deal with the accounts. In the first place, taking the capital account, there has been issued £3,000 of Preference shares, Debenture stock £7,530, and we have received in premiums on those shares and stock £3,780, making the total receipts £14,310. We have spent on various new works, additional rolling stock, and improvements £3,280; we have paid off terminable debentures £8,400. We have an increased balance of £564, and we have reduced our outstandings by £1,666. These items together make the £14,310 which we have received on capital account. You will notice that in the statement "capital authorised," there is a considerable change in the last half-year, because at the last meeting we created capital under the Act of 1893, and the difference is due largely to the authorised figures, although not to the amount issued. As regards the revenue, the receipts from passengers show an increase of £323; there is a small decrease in season tickets of £10, and there is a small decrease in transfer fees of about £3; but there is an increase in parcels of £30, in rents of £156, and in sundry receipts of £15, making a net increase of £509. On the other hand, maintenance shows an increase of £130. That is due to our having charged £150 against revenue as the cost of altering King William-street station. Of course we have doubled that station, enlarged the accommodation very much, and we thought that a portion of the cost ought to be charged to the revenue account, and that £150 has been charged this half-year; otherwise maintenance would have shown a decrease. Locomotive and generating power shows a decrease of £253; the item of carriage repairs exhibits an increase of £108; traffic expenses are less by £40; general charges show an increase of £11; passenger duty a decrease of £59; law charges a decrease of £5; and rates and taxes, as usual, an increase of £90. That makes a decrease in the expenses of £18. I think you will deem satisfactory the fact that we keep increasing our revenue, and that there is a decrease in our expenditure at the same time. Our net increased receipts being £509 and the net decreased expenditure £18, that makes us £527 to the good. On the other hand, our balance at the bankers has not been quite so much, and we have lost in interest £18 on that account. We have decreased debenture interest by £299, but we have increased preference by the sum of £182; we have therefore a decreased expenditure on these two items of £117, which makes us £626 to the good. Out of the balance we propose to pay an increased dividend of ¼ per cent., absorbing £787. That £787 is accounted for by the £626 net increased receipts for the half year, and we have taken out of the balance brought forward £147. Although we have taken £147 out of the balance brought forward, we carry forward more than £100 of an increase in our balance over that of the corresponding period of last year. Now, our working expenses during the half-year have been 60·02, as against 61·55 in the corresponding half of last year, so that we have decreased our working expenses 1½ per cent. Deducting the cost of the lifts, in order to give you a comparison with other railways, I may say that our working expenses this half-year have been 51¾ per cent., against 52 per cent. last half-year, the receipts per train mile are 2s. 2½d., against 2s. 2⅝d., showing $\frac{3}{16}$d. improvement. The receipts per passenger are 1·87d., against 1·82d. That receipt per passenger is the largest we have had since the first half-year that we opened, when we made a uniform charge of 2d. Our receipt per passenger is steadily growing. The locomotive expenses per train mile have been 5·80d., against 6·10d. in the corresponding half of the previous year, showing a steady decrease; and if you deduct the carriage and cartage of our coal, the rate per train mile would be reduced to 4½d. The largest number of passengers we have carried since the opening of the line occurred in June, 1894—two years ago—when the figures were 3,383,154 passengers. We were then so overcrowded that we raised our fares very considerably, and in the corresponding half-year of June, 1895, the number fell to 3,113,199. That number has been steadily increasing every half-year since. This half-year it is 3,192,672, so that notwithstanding the increased fares, which we have charged, and are still charging, the number of passengers keeps steadily advancing. The receipts from these 3,192,672 passengers, you will observe, are £24,021, at the increased fares; whereas, with the largest number of passengers that we carried in 1894, we received only £23,564; so that, although our passengers are very considerably fewer than they were two years ago, our actual receipts have risen by nearly £500. All this shows distinctly that the traffic of this line is making steady and regular progress, and that even with the increased charges, in order to keep down the pressure from overcrowding, its growth is not prevented; and we may look forward to the time when we shall reduce the charges to something less than they are, having regard to the large accession of traffic that we may have in the future when we get our extension open. We cannot do it, as you know, until that is done. I think that all these figures point to the fact that we may look forward in years to come with a very hopeful spirit as regards this railway. In order to carry this additional traffic, of course we have to run a very considerable number more trains and give more accommodation. The alterations in King William-street have enabled us to do that, and we have been able to complete, in our own shops, a new locomotive which is working very satisfactorily. We have also had our new carriages at work. The alterations in King William-street have proved very satisfactory in enabling us to keep things working smoothly, although they are only a temporary relief they have been a great blessing to us. I told you last year that we contemplated putting down condensing plant in order to save considerably in our fuel consumption. That plant is making rapid progress, and I hope to see it at work in a few months. It is a very large erection, and it has been put up very carefully, because, in this country, it is a novel way of going to work, but we have every reason to believe that everything will be very satisfactory. As regards the question of the extension you will be anxious to hear what we have been doing. We have three sites to get for the extension at Moorgate-street. One of them has been secured, and the arrangements are now complete for the purchase of that. Another of the sites we are in active negotiation for, and we hope before long to be in possession of it also. As to the third site we have told you the story in the last clause of the report, so that practically you know what has occurred. We have been very much harassed in regard to it from all directions, especially on the part of our opponents, who did not seem to know their own minds on the subject. At first they would not have the building removed, and then they said that they preferred that it should be pulled down. However, the Bill is still before Parliament, and I cannot give you any further information at present, but we hope in a few days to get some satisfactory settlement of the whole thing sanctioned by Parliament. But we have been put to very considerable expense, anxiety, and trouble, in connection with that church, and there seemed to me really no reason for this being so. You gave us power to issue the £20,000 Five per Cent. Preference shares, for the purpose of paying for this extension, and these have been issued, taken up, and paid for this month. We think that the issue has been made on satisfactory terms. At the last half-yearly meeting I was myself under the impression that these Preference shares would be made to run *pari passu* with the existing 15,000 shares, but we found, on examining the legal question, that they had to rank after the existing Preference shares, and, therefore, the operation was made much more difficult. I am thankful to think that they have all been taken up on satisfactory terms, because this Company is not to be charged with any dividends until two years and a-half have elapsed, and will not be paid until this meeting three years hence; so that we shall have time to complete our line without allowing our revenue to be trenched upon in any way for the dividend on those shares until the line is open and working. I do not know that there is anything more I can say. The tenders have come in for the extension and they are in the hands of the engineer at the present moment. Owing to the delay which the opposition to the Bill in connection with the question of the Church occasioned, and the opposition which came from our own shareholders, the carrying out of the extension has been kept back and the price of iron and labour has been rising, so that I am afraid we shall be landed in a little increased cost over what we at first expected. I am very sorry that we should have had these delays, but they were not of the Board's seeking (hear, hear). I beg now to move—

"*That the report and statement of accounts for the half-year ended June 30, 1896, now presented to the meeting be received and adopted.*"

Mr. SAMPSON HANBURY: I beg to second that.

Mr. DRAKE: The statements made to us show that the programme which the Board have recommended to us, and which on more than one occasion was adopted by the shareholders, was right. The increase of dividend, though small, coming at the end of a season not the most conducive to underground traffic, is extremely welcome. So far as the working of the line is concerned, I can bear testimony to the truth of what the Chairman said in respect to the punctuality and the safety of the line, seeing that we carry over 6 million passengers per annum. I hope that our esteemed consulting engineer will see his way to make the new lines without any of those objectionable curves and gradients that are usually met with in other lines. I am particularly pleased with the working of the line, and I must also say that I never hear anybody saying anything against it. This is the first time that we have touched £24,000 in receipts, and in many other respects I think the present report the most hopeful and satisfactory that we have yet had.

Mr. JEFFRIES: The accounts are very satisfactory, but there are one or two matters which I should like the Chairman to explain. I think, in your opening remarks, you said to us that the Preference shares would not be a cost to the Company; but later on I understood you to say that there was an increase of expense of 5 per cent. in the Preference shares. With regard to assessment, I note that this increases. I trust that watch is being kept that this assessment is not unduly increased.

The CHAIRMAN: I am very much obliged to Mr. Drake for his kind remarks in regard to the report. I am particularly glad that he does not find any fault with it in respect to the issue of our capital, because Mr. Drake is the head and front of one of our large banks, and is an authority on finance, and we thought he might have found fault with that. As regards Mr. Jeffries' remarks about the Preference shares, the interest on these referred to the Preference shares under the first issue. It has nothing to do with this second issue. When we pay off the terminable debentures we sometimes pay them by raising debenture stock; sometimes by the issue

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of Preference capital which is already in existence, of which there is a considerable amount not issued. Whichever pays the Company best we take it, and we get a large premium on it. As regards the season tickets, I ought to have mentioned that the real reason for the decrease in the season tickets this half-year is the fact that two years ago we raised the fares, and we had a very large increase in season tickets in consequence. A year ago we found that at one station it was desirable to slightly reduce the fares, and the consequence was that we have lost a few season ticket-holders. We have not lost traffic, but passengers prefer to pay every day to having season tickets. As regards the question of rating, I wish we could do anything in the direction which Mr. Jeffries suggests. But although we have appealed against all these assessments and we had, moreover, in our appeals a gentleman who is supposed to be one of the best rating officers in the Kingdom, and have done our best to keep the assessments down, we have not succeeded. I am sorry to say that the last quinquennial valuation resulted in a considerable increase to our valuations.

The resolution was then put to the meeting, and carried unanimously.

Resolutions in favour of the declaration of the dividends were duly passed, and a cordial vote of thanks to the Chairman and his colleagues terminated the meeting.

## Crompton and Co. (Limited).

The eighth annual general meeting of the members of this Company was held at the City Terminus Hotel, Cannon-street, on Monday; Mr. John Trotter presiding.

The SECRETARY (Mr. Francis R. Reeves) read the notice calling the meeting.

The CHAIRMAN said: I feel I have rather a difficult task before me in addressing you on the affairs of the Company, because probably most of you know more about its past than I do. I can only speak of matters that have occurred within my personal knowledge within the past few months, and we have fallen on a particularly bad year to deal with, owing to the fire at Chelmsford last November, with which you are acquainted. The effect of the fire was to destroy all the books and records that were in the offices at the time, and it has, therefore, been found impossible to prepare any profit and loss account this year. When the Directors became aware of this condition of things they at once took counsel with their advisers, and the only plan that appeared feasible was to prepare a fresh valuation of all the property you had, and to make a fresh start. That has been done, and the result of the valuation is set forth in the statement of accounts submitted to you. But although we have furnished you with a balance-sheet and a revenue account, there is no profit and loss account, and, therefore, it is rather difficult to compare the present year with previous years before the fire. The fire destroyed a large portion of the buildings and works at Chelmsford, and the stock and electric light plant. The only comparison I can submit to you is through certain items to which I will now draw your attention as compared with the same items last year. You see in the balance-sheet freehold property standing at £12,780, and plant, tools, furniture, fixtures, &c., at £38,999, making together a total of £51,779. Those figures are arrived at after having had the freehold premises carefully valued by Mr. Whitmore, an architect at Chelmsford; and the plant, tools, &c., were taken by Mr. Crompton and Mr. Brunton, the manager of the works. Taking that figure of £51,779, if you add to it the amount of insurance money applicable to those particular items, £26,585, you obtain a total of £78,364. Those figures last year before the fire stood at £70,197. We have since the fire spent upon restoring these things a sum of about £7,000, as closely as we can estimate it; and deducting that from the £78,364 I have mentioned, you will find that there was £71,000 odd represented by freehold property, and plant, tools, &c. Therefore there does not seem to have been any serious loss, if any, directly owing to the fire—that is to say, that the property was well kept up, and that we have been fairly well covered by insurance. The indirect loss to us through the fire was, however, very serious indeed. Practically, at one time the business was stopped, the manufacturing portion of it; and the cost of manufacturing everything was enormously increased through the work being spread about in temporary buildings. The effect of this is clearly shown in the balance sheet, where you will see that the balance to the debit of revenue account is £10,051, which I think we may say is directly traceable to the serious effects of this fire. There are other results from the fire which are more satisfactory. We have, for instance, learnt several lessons by it. It has been made clear to us, not only by the action of the insurance companies in their requirements, but in other ways, that the Chelmsford lighting must be kept distinct from the general manufacturing business of Crompton and Co. It is also clear that works of more than one story, with heavy machinery above are not suited to our present requirements; the works ought all to be on one story. Under these conditions it is abundantly clear that we have not got sufficient room at our present works. The Directors, therefore, went into the question at once to see what was the right course to adopt, and they came to the conclusion that it was absolutely necessary, for the future conduct of the business on satisfactory and economical lines, that new works should be established as speedily as possible. They looked about to see what could be done, and they were fortunate enough, after taking most careful surveys of all the places around, to secure a freehold site near Chelmsford. It is very close to our present works, and so near to the railway that it is possible to have a siding, which will make a material saving in the cost of transport. It is also on as high ground as you can get practically in the immediate neighbourhood of Chelmsford, and there is an excellent water supply. That site has been acquired, and the contracts are out for erecting the new works, avoiding any mistakes that there may have been in the old ones. The new works are to be constructed, as far as possible, of uninflammable materials, and they are to be arranged in such a way that we can add to them as the business requires, and with the offices separated from the works, so that there will be little or no danger of our books being destroyed again as in the recent fire. It so happened that just at the time when the fire occurred, your works were busier than they had been before, and but for this fire I think an era of prosperity might already have shone on the Company. I am pleased to say that the orders remain very numerous—quite as much as the Company can cope with: and with these new works and the possibility of executing the orders economically, and with the fresh work that we pretty clearly see ahead, I think when the new works are open they will begin to assist us to a much better condition of things than we are in at the present moment. The Board are doing all they can to hasten them forward, and the work has been begun there. With respect to the policy of the Board in the past year, every effort has been made to concentrate the business, and to get rid of any outside excrescences as much as possible, so as to concentrate matters. During the year various alterations have been made. A branch at Hove, near Brighton, has been sold very advantageously. The cooking department, on which a considerable sum has been spent, has been reorganised, and the expenditure of money on it checked, and in the opinion of the Board it looks as if we have some property there distinctly worth possessing. It may prove very advantageous to you. The branch at Lillie-road has been rather a cause of anxiety, and efforts have been made to get rid of it. One of your Managing Directors, Mr. Albright, has been to Australia, where he has been using all his efforts to get the business there more in hand. The Board has also been pressing forward the sale of the Company's manufactures abroad, in South Africa and India, as well as at home—places where there is good solid business to be done in the manufacturing portion of the Company's work. So much for the past, and for our hopes with regard to the future. I should like now to say a few words, coming rather as an outsider, in connection with the balance sheet. There are several features there which I should like to see dealt with. You will see on the asset side that there are several items which I may call non-realisable, and I think it would be a good thing if they were taken in hand and considered—such items, for instance, as the Chelmsford Electric Lighting and other subsidiary companies. As far as I can ascertain, these are good companies, but they are in some cases non-dividend paying. You also have a suspense account of £9,775, which is about the same amount as appeared last year. There is rather a large item, too, for patents account—that is, £13,790 this year against £14,147 last year. There is a distinct deduction in that item, but still it is a large amount. Then you have goodwill £30,000, and the debit to revenue account this year of over £10,000. Together these items make up a very considerable amount, and I think it would be a good thing, if you are of the same opinion, that we should this year try and arrange some scheme by which you might write a considerable portion of this sum off. Some of these items do not want much interfering with, but other items do, especially the two suspense accounts. I have no definite plan to propose to you, because these figures only came into the Directors' hands very shortly before they reached the shareholders, and it has not been possible to formulate any scheme. I believe, however, that it will be desirable to do so if there is evidence on the part of the shareholders that they also think it advisable. There are a great many interests to be considered, and any scheme that is formulated must be equitable to all parties I do not think it is impossible to arrange such a plan, and if you intimate that you think as we do in this matter we shall be encouraged to take it in hand. He concluded by moving the adoption of the report and accounts.

Mr. R. E. B. CROMPTON, in seconding the motion, said: The Chelmsford fire has filled our thoughts very largely, and I assure you that although things are pretty bad as far as regards the results of the fire, yet they might have been infinitely worse, and that they are not worse is due to our staff. Splendid things were done at the time of the fire, and we can never sufficiently thank the staff, who rendered invaluable services in preventing the fire from spreading more than it did and in saving the property. I need hardly add anything to what the Chairman has said as to the enormous difficulties of managing satisfactorily and at a profit, in these days of close competition, at a time when your plant is separated and divided all over the place, as it has been since the fire. At present the works are being carried on on the old site in single-story buildings, in which we have been doing our best to carry on the work satisfactorily. It is, however, carried on under considerable disadvantage, and we cannot hope to do as well as we should do until we get into our new premises. We have brought here the drawings of the buildings as they are now going to be put up, with a plan of the ground, and you will see that we have endeavoured to do things as plainly as possible, and to carry out the work as cheaply as possible. We may commence work possibly in from three to four months of the present time. I can only corroborate what the Chairman has said as to our prospects with respect to work, and, what is more interesting to some who are present, the improved price at which orders have been recently taken. The prospects are decidedly encouraging. No doubt some of you may think that we said the same thing last year, and that is so. Last year our prospects were extremely encouraging, and I think I am justified in saying that up to the time of the fire we were doing fairly well; and it was a most bitter disappointment to a man like myself, so bound up in the Company and holding such a large stake in it, to find all our efforts swept away just when things were improving.

The CHAIRMAN put the motion, which was carried unanimously.

Mr. CROMPTON afterwards proposed the confirmation of the appointment of Mr. John Trotter as Chairman of the Company—an appointment to which he referred in sanguine terms in connection with the prospects of the Company.

Mr. T. R. TUFNELL seconded the motion, which was carried unanimously.

The CHAIRMAN, in reply, assured them that he would do his very best to help them to put their affairs in order after the disasters caused by

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the fire and other adverse circumstances; and he trusted that when they next met their position would be more favourable than it was that day. He afterwards proposed the re-election as a Director of Mr. Carleton F. Tufnell.

Mr. CROMPTON seconded the resolution, which was carried unanimously.

The auditors, Messrs. J. H. Duncan and Co., were re-elected.

A vote of thanks to the Chairman and Directors terminated the proceedings.

## Globe Telegraph and Trust Company (Limited).

The twenty third ordinary general meeting of this Company was held on Tuesday last at Winchester House, London, under the presidency of the Most Hon. the Marquis of Tweeddale.

The SECRETARY (Mr. Sidney Collett) having read the notice convening the meeting,

The CHAIRMAN said: I have to ask your approval of the report and accounts, which I presume you will take as read. Before dealing with the general business of the Company, it is my mournful duty to refer to the loss which we have sustained through the death of our late Chairman, Sir John Pender, who so ably presided over the affairs of the Company from its inception. His administrative ability, his great business capacity, and his force of character are so well known to all of you, that it is unnecessary for me to dwell upon them. Nor is it necessary to say that we shall miss him very much, and feel his loss very acutely. His influence with those companies in which we hold so large investments was very great, and that influence was used when necessary to the advantage of this Company. The Directors have appointed me as Chairman in his place; and I have only to say that, with the assistance of my colleagues, I feel confident that the business of the Company will be carried on as carefully and as successfully as in the past. The receipts for the year ended the 18th inst., after paying all expenses, amount to £185,233, an increase over the previous year of £5,758. This increase is owing to the fact that we have received better dividends from companies in which we hold investments. We are able to recommend to-day the payment of a dividend of 4 per cent. on the Ordinary shares, which is three-eighths per cent. better than last year. You will see from paragraph 4 of the report that in future interim dividends will be paid on the 31st October, the 31st January, and the 30th April in each year. This is explained by the fact that one of the companies in which we hold a considerable investment now pays its dividends a week later than previously, and on two occasions we have had to borrow money to make up our interim dividends; and by the proposed arrangement we shall be able to save this money, and the work of the Company will be facilitated. With regard to our investments, the Anglo-American Telegraph Company, in which we have a very large holding, has paid us higher dividends this year than last, and a very small percentage of increase makes a considerable difference in the amount we receive from that Company, the amount on this occasion being no less than £4,276. During the past year we have re-arranged some of our investments, and in doing so we have carried into effect the principle on which this Company has always been worked—of distributing its funds in fairly equal proportions over the various important telegraph companies. The re-arrangement of these investments will secure to our ordinary shareholders a somewhat higher dividend. Having explained the changes made in the investments and the satisfactory nature of the reinvestments, the Chairman expressed the view that the Globe Telegraph and Trust Company had never stood in a higher position financially than it does to-day. The market value of its securities shows an enormous increase over the purchased price, and the price of its own shares stands higher than ever before in the history of the Company. He then moved the adoption of the report and accounts, and the declaration of the dividend as follows:—3s. per share on Preference shares, less income tax, and 3s. 9d. per share on the Ordinary shares (after income tax deducted), making, with previous payments, a total dividend for the year of 6 per cent. on the Preference shares and 4 per cent. on the Ordinary shares.

Mr. DAVIS called the Chairman's attention to an objection which had been taken at the meeting of the Anglo-American Telegraph Company last week as to the position held by the Chairman in several companies. The Chairman, in replying, said that he considered the discussion as to the Chairmanship of other companies was hardly relevant to the business of the Globe Company; but he would ask the shareholders of the Globe Company whether they thought that the fact of his being Chairman of other companies in which they had enormous holding was likely to be against the interests of the Globe Company. He, the Chairman, would have thought the opposite was the case. The Globe Company hold a million of stock of the Anglo-American Company, and, in fact, this was the ground upon which he was Director of the Anglo-American Company. He pointed to the fact that the important position of Chairman (so far as the Eastern Telegraph and its associated companies was concerned, was occupied by the late Sir John Pender, and he felt that it was impossible that the shareholders of the Globe Company could suffer in consequence.

Mr. NEWTON said that 20 years ago he raised the same point, and that he spoke with a great deal of earnestness upon it; but he was of opinion that the times were changed, and if there was any qualification that the shareholders required in their Chairman it was that he should prove himself successful. He (Mr. Newton) could not conceive how shareholders in the Globe Company would be benefited by altering the position, and they might make a very great mistake. He pointed to the fact that 20 years ago he purchased Globe Preference at £7. 10s., whereas they now stood at £18, and assuredly that was a more than satisfactory proof as to the success of the policy and efforts of the Directors. They had never missed a dividend on the Preference shares nor, so far as he knew, on the Ordinary shares. The Directors were, therefore, entitled to the shareholders' full confidence, and to their continued support. As to some of the Directors being on the Boards of a great many other telegraph companies, this was the greatest qualification for a Director in the Globe Company, and was evidence that their Directors were in the world of submarine telegraphy. They were, there could be no doubt, indebted, to a large extent, to the immense energy of their late respected Chairman for the results they had attained, and he felt sure they could not do better than support his successor, because his successor supported him throughout the whole period for the benefit of the shareholders.

The CHAIRMAN said he was obliged to Mr. Newton for the expression of his opinion, and pointed to the fact that he was the last of the original Directors of the Globe Company. In regard to other companies, although the Globe expected to be represented on the Boards in respect of their holdings, the Globe Board did not, as a Board, interfere actively in the management of other companies. They, however, endeavoured to bring their influence to bear. That was the principle they had always acted upon.

The report and accounts, and the declaration of the dividends, was carried unanimously.

The CHAIRMAN then moved the re-election of Mr. James Pender, M.P. as a Director of the Company: and this was seconded by the Hon. St. John Brodrick, M.P., and carried unanimously.

The CHAIRMAN moved the re-election of Lord Sackville A. Cecil as a Director of the Company.

This was seconded by the Hon. ST JOHN BRODRICK, and carried unanimously.

Mr. NEWTON then said he wished to interpose before the formal business was completed. He desired to propose—

"*That this meeting tenders to the family of the late Chairman of the Company, Sir John Pender, their sympathy at the loss they had sustained.*"

He stated, in submitting the motion, that it was only right, in the case of a Company in which Sir John Pender took so much interest, that they should tender such a resolution as this. If they looked into the question of what had been accomplished by submarine telegraphy, they might fairly ask themselves what the world would have been without it. Doubtless the advantages of submarine telegraphy would have been obtained at some time without the efforts of their late Chairman; but by his great business capacity and force of character, he had effected its completion a generation before it would have been but for his untiring energy.

Mr. W. GRIFFITH heartily seconded the motion, which was carried unanimously

The re-election of Messrs. Deloitte, Dever, Griffiths and Co., and Mr. W. Griffith as auditors of the Company was unanimously agreed to.

Mr. W. GRIFFITH, in returning thanks for the appointment, testified to the satisfactory nature of their securities, and the admirable manner in which the bookkeeping of the Company was done. He then referred to the loss which the Company had sustained in the death of Sir John Pender. They had lost the standard-bearer in the fight; but, fortunately, they were not without an able leader to take his place. Their present Chairman had been associated with the Company from its foundation, and was therefore versed in all the details of the business. He then moved a vote of thanks to the Chairman and Directors for their able administration of the Company's affairs.

This was seconded by Mr. COWBURN, and carried unanimously.

The CHAIRMAN briefly returned thanks, and the proceedings terminated.

## Chili Telephone Company (Limited).

The following is the Directors' report to the 31st March last:—

The aggregate number of subscribers at all centres at the end of the year was 4,252, compared with 4,015 at the beginning, or a gain of 237 for the year. The gross revenue from all sources compares favourably with that of the previous year. In 1895-6 it was $519,826 and in 1894-5 $555,551, an increase during the past year of $64,275.

The expenditure in Chili during the year shows an increase over 1894-5 of $20,502, and the net income in Chili from all sources shows therefore an increase of $43,772. The average rate of exchange for the year was 17.27d. compared with 13.61d. in the previous year, which gives a sterling increase in revenue for the year of £6,068. The increase in the value of the liquid assets over liabilities in Chili, due to this rise in exchange, amounts to £351, which has been carried to reserve. The expenditure in London is £61 in excess of the previous year. This leaves the net profit of the whole business at £8,551, an increase on the year of £2,538. The reserve account now stands at £15,500. A dividend of 4s. per share (4 per cent. per annum) is recommended, leaving £557. 16s. 1d. to be carried forward. During the year there has been an increase in the wire mileage of 302 miles, the total being 6,722 miles 269 yards.

**MEMORANDA**.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31⅜d. per oz. (July 30th). Consols (2¾ per cent.) 113¼—113⅜ for money. 113 5/16—113 7/16 for account; 2½ per cent. 108—108¼ (July 30th). Stock Exchange Settling Days: Consols, Aug. 4th; Stocks and Shares Continuation Day, Aug. 11th; Ticket Day, Aug. 12th; Pay Day, Aug. 13th; Mining Share Carry-over Day, Aug. 10th.

**BRISTOL TRAMWAYS AND CARRIAGE COMPANY (LIMITED)**.—The report of the Directors of this Company for the half-year ended June 30th states that the gross receipts for the period under review amounted to £54,456, working expenses and renewals to £42,810, and net revenue to £11,646. It is now proposed to pay a dividend at the rate of 6 per cent. per annum, and to place £2,410 to reserve for redemption of leased premises, renewals and contingencies. The St. George and Kingswood electric line has been worked to general satisfaction, and it is intended to apply in the ensuing Session of Parliament for powers to employ electricity on the other portions of the undertaking.

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## Waterloo and City Railway Company.

The report of the Directors of this Company for the half-year to June 30th, to be submitted to the meeting to be held at Waterloo Station, London, on Thursday next, at 2 p.m., states that the expenditure amounted to £90,453. 2s. 10d.; that the third call upon the share capital, due on April 1st last, has been received in full; and that the arrangement with respect to the City terminus, referred to in the last report, has been completed, and the necessary agreement executed between the Company and the Central London Railway Company.

The engineers' (Messrs. Galbraith and Greathead) report states:—

Towards the City one tunnel has been driven to Queen-street, the western end of the terminal station, while the other is within 80 yards of the same point. The large shield for driving the station tunnels is nearly finished, and will be delivered on the works at an early date, when operations will be commenced.

At the Waterloo end of the railway one of the tunnels has been driven under compressed air up to within 25 yards of the South-Eastern Railway viaduct, which is now being underpinned and secured; the other tunnel has been completed to the western side of Cornwall-road, Stamford-street. The total length of tunnel driven during the past six months has been 1,100 yards. The total length of single tunnel completed is now 3,936 yards, leaving a total length of single tunnel to be constructed between the terminal stations at either end of the railway of 464 yards.

The contract for the terminal station at Waterloo was let in January last, and, notwithstanding that some delay has arisen in obtaining possession of the land and a temporary loss of labour owing to the recent building strike, good progress has been made by the contractors. The underpinning of the South-Western Company's General Offices is well advanced, and the work underneath Waterloo Station is making rapid progress.

The plans for the generating station are being prepared, and will be ready for letting the contract shortly.

## CITY NOTES.

**BRITANNIA MOTOR CARRIAGE COMPANY (LIMITED).**—At the statutory meeting of shareholders of this Company last week, the Chairman (the Hon. J. H. H. Berkeley) called attention to certain criticisms which had been made upon the prospectus issued by the Company some time ago, the principal of which was that they had omitted to mention in the prospectus that their motors were driven by electricity. The Chairman pointed out that the drawings and diagrams which were issued, showed the carriage and motor; and as it was claimed that neither heat, smoke, smell, or steam accompanied their motor in its work, the Directors and those responsible for the prospectus, assumed that t would be taken for granted that electricity was the motive power. The criticism required notice chiefly from the fact that they had been accused of purposely withholding the information he referred to. It was also objected that no reference had been made to the fact that an electric battery would be necessary, and that a battery would naturally add very considerably to the weight of the motor. His answer was that they were only advertising a motor, that they were pledged to no particular sort of battery, and that the market was open to them for this apparatus. The matter of weight, all things considered, and taking into account the weight of the horse omnibuses and similar vehicles when filled with passengers, was a matter of small moment, as their two-horse-power motor was only asked to do about one-fifth of what the omnibus horses do every day in London. The final criticism he would deal with was with regard to the recharging of the batteries. Whatever power they employed, it would have to be recuperated or recharged. Some questions were put as to the type of primary battery which the Directors would recommend to be used with the motor; but the information forthcoming was not of much technical interest, the Chairman stating that they had been offered a primary battery which "if it fulfils all it is said to do" would answer every expectation.

**BROCKIE-PELL ARC LAMP (LIMITED).**—As notified in our last number this Company has iasued a prospectus inviting subscriptions for 50,000 £1 shares, payable 5s. on application, 5s. on allotment, and the balance as may be required. Of the entire capital of £80,000 in £1 shares the vendors take 25,000, and 5,000 shares are reserved lor further issue. Since the publication of the prospectus a large order has been given by the Hammersmith Vestry for the Brockie-Pell lamps; the lamp has been also specified by the Shoreditch Vestry in connection with their electric lighting scheme; and further, a large number have been ordered for the lighting of the streets of Durban (Natal). The lists opened on Monday and closed at 4 p.m. on Tuesday for town, and at noon on Wednesday for the country. We understand that the issue was well received by the investing public.

**CALLENDER'S CABLE AND CONSTRUCTION COMPANY (LIMITED).**—This Company has been formed to acquire and take over, as a going concern the well-known business of manufacturers of electric light cables and accessories, carried on for the last 14 years by Callender's Bitumen, Telegraph and Waterproof Company (Limited), at Erith, London and elsewhere. The whole of the share capital (amounting to £100,000, in £5 shares) has been taken by Callender's Bitumen, Telegraph and Waterproof Company in payment of the purchase money. There is also Four and a-Half per Cent. First Mortgage Debenture Stock to the amount of £90,000, of which £40,000 will be allotted in exchange for debentures of that amount in the old Company at par. The prospectus, inviting applications for the balance (£50,000) at a premium of 3 per cent., gives a long list of electricity supply stations (both home and foreign) for which the Company has supplied and laid, or with whom there are contracts for supplying, electric mains. The Company, having successfully constructed the entire track of the Dublin Southern Tramways, very naturally looks forward to a large increase in its operations in connection with the conversion of existing tramways into electrical lines. The assets of the Company have been taken at £175,773. 5s. 9d, the figure at which they stood in the balance-sheet on December 31st last, and the average annual profits for the five years ended December, 1895, have been calculated at £11,500 net, while the profit for 1895, after deducting £3,000 for depreciation, amounted to £16,279. 2s. 10d. The debentures of the old Company now to be paid off bear a higher rate of interest than 4½ per cent., and the proceeds of the issue will also be used in clearing off the mortgage on the factory, paying off temporary loans, and for the extension and the general purposes of the Company's business. The trustees for the debenture-holders are Sir David Evans, K.C.M.G., and Alderman J. T. Ritchie; while the Directors are Messrs. Henry Drake (Chairman), W. O. Callender, D. P. McEwen, Lieut.-Col. G. A. Elliot, Wm. Mackenzie, and T. O. Callender (Managing). The lists opened on Wednesday morning, and closed at 4 p.m. on the same day for both town and country.

**CAMBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED).**—The Directors of this Company announce an interim dividend at the rate of 4 per cent. per annum for the half-year ended June 30th. The revenue returns for the half-year show a sale of 92,682 units, and receipts of £2,644. 17s. 9d., against 67,223 units and £1,964. 3s. for the corresponding period of last year. The figures for the quarter ended June 30th are 27,257 units and £865. 5s. 10d., against 21,436 units and £685. 9s. 10d. in the corresponding quarter of 1895.

**CENTRAL LONDON RAILWAY COMPANY.**—The half-yearly ordinary general meeting of this Company will be held at the Cannon-street Hotel, E.C., on the 11th prox., at 3 p.m. An extraordinary general meeting will afterwards be held for the purpose of considering resolutions relative to the division of the existing shares of the Company into Preferred half and Deferred half shares respectively, and as to the payment of interest and dividends thereon.

**CHARING CROSS AND STRAND ELECTRICITY SUPPLY CORPORATION (LIMITED).**—We are informed that the recent issue of 10.000 Four and a-Half per Cent. Preference shares, of £5 each at par, in this Company was subscribed for nearly four times over. Letters of allotment and regret have been posted.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended July 26th were £813, against £827 in the corresponding week of 1895, a decrease of £14. The total receipts for the half-year amount to £3,488, against £3,421 for the corresponding period of 1895, an increase of £67.

**DUBLIN UNITED TRAMWAYS COMPANY (LIMITED).**—At the recent half-yearly meeting of this Company the purchase of the undertaking of the Dublin Southern Electric Tramways Company was enthusiastically approved, the Chairman stating that since the purchase was mooted the value of the Company's shares had increased by £120,000. The electric lines have hitherto been well patronised, partly owing to the service being efficient and rapid, and also to the extension of the penny fare system.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—This Company notify that the coupons on their Five per Cent. Debentures due August 1st, will be paid on and after that date at the banking house of Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C. Coupons should be left three clear days for examination.

**EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).**—This Company announce the payment, by warrants on August 1st, of interest for the half-year ending 31st instant, on their Four per Cent. Mortgage Debentures. The transfer books will be closed till August 1st inclusive.

**ELEKTRICITÄTS-AKTIEN-GESELLSCHAFT VORM. W. LAHMEYER & CO.** At a recent extraordinary general meeting of the shareholders of this Company it was decided to increase the capital from £85,000 to £150,000.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 26th inst. amounted to £1,301. The amount for the corresponding week last year was £1,197; increase, £104.

**MILWAUKEE ELECTRIC RAILWAY AND LIGHT COMPANY.**—Notice is given that after payment of the final instalment, due August 1st, the fully-paid allotment letters can be exchanged for definitive bonds at the Company's bankers, Messrs. J. S. Morgan and Co.

**ROLLER BEARINGS COMPANY (LIMITED).**—We are informed that letters of allotment for the recent issue of capital by this Company have been posted.

**STOCK EXCHANGE NOTICE.**—Application has been made to the Stock Exchange Committee to allow the further issue of £100,000 Five per Cent. Debenture Stock of the City of London Electric Lighting Company (Limited) to be quoted in the official list, in lieu of the provisional certificates now quoted. The Committee have also ordered £82,850 Five per Cent. First Mortgage Registered Debentures (numbers 1 to 743 and 901 to 1,070) of Crompton and Company (Limited) to be quoted in the official list.

**VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).**—Coupon No. 12 of the Five per Cent. Mortgage Debentures of this Company, due 31st inst., will be paid at the Consolidated Bank, Threadneedle-street, E.C., and at Messrs. Westendorp and Co.'s Bank, Amsterdam.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended July 24th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,695.

**WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).**—The Directors of this Company have declared an interim dividend for the half-year ended June 30th at the rate of 6 per cent. per annum, payable on September 1st next.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Divi. dend. | Name. | Previous Week's Price, July 22. | Price Wednesday, July 29. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending July 25. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 50 52 | 50 52 | .. | Jan., Apr., July, Oct. | 51⅛ | 50 |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 94½ 95½ | 96½ 97½ | 5 2 7 | " " | 96 | 93⅞ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 9 9⅛ | .. | .. | 9⅛ | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 2 | January and July | 101 | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 9 10 | 8½ 9½ | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15½ 15⅝ | 15½ 15⅝ | 4 8 11 | Mar., June, Oct., Dec. | 15⅝ | 15⅜ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 6 7 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 2 4 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ 13½ | 12½ 13½ | 5 18 6 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20 21 | 20 21 | 4 5 3 | " " | 20¼ | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ 4½ | 3½ 4½ | 5 0 0 | April and October | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £80,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% 110% | 107% 110% | 4 2 1 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9⅜ 10¼ | 9⅜ 10¼ | 4 3 0 | Jan., Apr., July, Oct. | 10⅛ | 9⅞ |
| 400,000 | 10 | 2/6 | Eastern | 17⅜ 18¼ | 17⅜ 18¼ | 3 11 2 | " " | 18¼ | 17⅝ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 19 | 18½ 19 | 3 3 2 | " " | 19 | 18⅝ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 3 0 2 | May and November | 132 | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 106 109 | 106 109 | 4 13 11 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 17⅜ 18⅛ | 17⅜ 18⅛ | 3 16 9 | Jan., Apr., July, Oct. | .. | .. |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 132 135 | 132 135 | 3 0 2 | February & August | 133 | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 3 17 4 | January and July | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 100 104 | 100 104 | 3 17 4 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 109 | 106 109 | 3 14 9 | February & August | 108½ | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% 114% | 111% 114% | 3 10 10 | May and November | 111¾ | .. |
| 180,227 | 10 | 2/6 | Globe Telegraph and Trust | 11 11½ | 11¼ 11⅜ | 3 13 7 | Jan., Apr., July, Oct. | 11¼ | 11⅛ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17⅜ 18¼ | 17⅜ 18¼ | 3 5 9 | " " | 18 | 17⅝ |
| 150,000 | 10 | 5/0 | Great Northern | 23½ 24½ | 23½ 24½ | 4 1 8 | Jan., April, and July | 24 | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 105 108 | 105 108 | 4 14 4 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 53 56 | 53 56 | 4 9 3 | May and November | 54½ | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 111 114 | 111 114 | 5 7 7 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel.4% Guar. Debs. "Red" 1942 | 103 111 | 108 111 | 3 12 4 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | .. | .. |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 137 142 | 140 145 | 4 2 9 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 6 7 | 5 6 | 5 0 0 | January and July | 105½ | 104 |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 104 107 | 104 107 | 4 15 3 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. | January and July | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 99 101 | 99 101 | 7 15 0 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | .. | .. | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 12 | 5 0 0 | May and November | 11⅜ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | 10⅜ | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 10 6 | June and December | 110 | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8⅞ 9⅛ | 8⅞ 9⅛ | 4 17 7 | May and November | 9⅛ | 9 |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6¾ 7¼ | 7 7½ | 5 0 0 | " " | 7½ | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2¼ 2⅝ | 2¼ 2⅝ | .. | " " | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 105 109 | 105 109 | 5 13 2 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 105 109 | 105 109 | 5 13 2 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 3 7 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 104 107 | 104 107 | 5 14 10 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3½ 4 | 3½ 4 | .. | " " | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const.& Manufacturing | 1/16 1/8 | 1/16 1/8 | .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅜ ⅝ | ⅜ ⅝ | 5 11 3 | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7⅜ 7⅝ | 7⅜ 7⅝ | 3 9 10 | June and December | 7⅝ | 7⅜ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16 17 | 16½ 17½ | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅞ 7¼ | 6⅞ 7⅛ | 3 10 2 | " " | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 3 9 | January and July | 108½ | 106½ |
| 58,000 | 5 | 4/0 | United River Plate | 3⅞ 4¼ | 3⅞ 4¼ | 4 14 2 | July | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 101 103 | 101 103 | 4 14 9 | January and July | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 14½ 15½ | 14½ 15½ | 3 4 6 | February & August | 15½ | .. |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ 17 | 16½ 17½ | 3 8 7 | January and July | 16⅛ | .. |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 133 137 | 133 137 | 2 13 3 | June and December | 136 | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | .. | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 8¼ 8¾ | 8¼ 8¾ | .. | .. | .. | .. |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | .. | .. | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8½ 9⅛ | 8 9 | .. | .. | .. | .. |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 14½ 13⅞ | 13½ 14 | 4 5 9 | .. | 13½ | 13⅜ |
| 8,322 | £5 | .. | House-to-House Electric | .. .. | .. .. | .. | .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. .. | .. .. | .. | .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. | January and July | .. | .. |
| 45,000 | £5 | .. | Liverpool Electric Supply (fully paid) | .. .. | .. .. | .. | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | ¾ 1½ | ¾ 1¼ | .. | .. | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13½ 14 | 13¼ 13⅞ | 2 18 2 | .. | 13⅛ | 13⅛ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 119 123 | 119 123 | 3 9 4 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 10½ 11½ | 11 12 | .. | .. | 10½ | .. |
| .. | .. | .. | Rand Electric | 1⅜ 1⅝ prem. | 1⅜ 1½ prem. | .. | .. | .. | .. |
| 19,980 | £5 | 5/3 | St. James and Pall Mall | 12 13 | 12 13 | .. | .. | 12⅛ | 12½ |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 9½ 10½ | 9½ 10½ | 3 6 8 | .. | .. | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 11 12 | 11 12 | 2 18 4 | .. | 12 | 11 |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1 1½ | 1 1½ | .. | .. | .. | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅜ 1⅝ | 1⅜ 1⅝ | .. | .. | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 112 115 | 112 115 | 3 19 10 | March & September | 112⅜ | 112½ |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1⅞ 2⅛ | 1⅞ 2⅛ | 6 13 4 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 5 2 | January and July | 106 | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. .. | .. .. | .. | .. | .. | .. |
| 110,000 | 2 | .. | Electric Construction | 1⅜ 1⅝ | 1⅜ 1⅝ | .. | .. | 1⅝ | 1⅞ |
| 12,845 | 2 | 2·2⅞ | Do. 7 per Cent. Cumulative Pref. | 2⅜ 3 | 2⅜ 3 | 4 13 4 | September | 2⅝ | 2⅜ |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ ⅞ | ⅝ ⅞ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. | .. | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 21 23 | 22 23 | 4 6 11 | February & August | 22⅛ | 22⅝ |
| £200,000 | 100 | .. | * Do. 4 per Cent. Debentures | 105 108 | 106 109 | 3 13 5 | March & September | 109 | 107½ |
| 15,995 | £10 | .. | International Okonite Ordinary | .. .. | .. .. | .. | .. | .. | .. |
| 16,000 | £10 | .. | Do. 8 per Cent. Preference | .. .. | .. .. | .. | December and June | .. | .. |
| 20,000 | £5 | £5 | Manchester Edison-Swan "A" (£1 10s. paid) | ⅝ ¾ | ½ ¾ | .. | .. | .. | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 37 40 | 39 42 | 4 5 9 | March and July | 41 | 39½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 105 | 102 105 | 4 15 8 | January and July | .. | .. |
| 37,514 | £5 | .. | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. .. | .. .. | .. | .. | .. | .. |
| 41,098 | £5 | .. | Do. Preference (fully paid) | .. .. | .. .. | .. | .. | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 17½ 18½ | 17½ 18½ | 4 10 1 | March & September | 18⅜ | 17⅞ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 17½ 18½ | 17½ 18½ | 3 15 8 | " " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 114 | 109 114 | 4 0 4 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1½% | City and South London Railway Con. Ordy. | 45 47 | 45 47 | 2 13 2 | January and July | 47⅛ | 46 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14⅜ 15¼ | 14⅜ 15¼ | 3 6 5 | " " | 15¼ | 14⅛ |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 135 137 | 135 137 | 2 18 5 | May and November | .. | .. |
| 87,500 | £10 | 3½% | Liverpool Overhead Railway | 13⅛ 14⅛ | 13⅜ 13⅝ | 2 3 0 | " " | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 17⅛ 17⅝ | 17⅛ 17⅝ | 2 17 7 | " " | .. | .. |
| 175,000 | Stock | 4% | Do. 4% Debenture | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July | .. | .. |

In calculating the yield on this security, allowance has been made for accrued interest but *not* for redemption.

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TELEPHONE No. 15,077. TELEGRAMS: "INDICES LONDON."

**WHEATLEY KIRK, PRICE & COULTY**

*(ESTABLISHED 1850),*

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**AND ARBITRATORS.**

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## TENDERS INVITED.

### VESTRY OF ST. PANCRAS.

TENDERS are invited for SUPPLYING and ERECTING about 80 ARC LAMP COLUMNS, similar design to those now in use in the Hampstead-road; height from ground about 19 feet.

Further particulars can be obtained upon application at the Electricity Department Offices, No. 57, Pratt-street, Camden Town, N.W.

Tenders to be sent to the undersigned, endorsed "Tender for Arc Lamp Columns," by 12 o'clock noon on MONDAY, 24th August, 1896.

The Vestry do not bind themselves to accept the lowest or any Tender.

C. H. F. BARRETT, Vestry Clerk.

Vestry Hall, Pancras-road, 4th August, 1896.

### CITY OF BATH.

The ELECTRIC LIGHTING COMMITTEE of the Corporation of Bath are prepared to receive TENDERS for the SUPPLY and ERECTION of the following PLANT:—

Section A.—BOILER-HOUSE PLANT—Boiler and Fittings, Feed Pump, &c.
Section B.—ENGINE-HOUSE PLANT—Steam Alternators, Oil Filter, Fittings, &c., Steam, Exhaust, Feed, Blow-off, and Sundry Pipes, Valves, &c.
Section C.—MAINS.
Section D.—CRANE.
Section E.—ARC LAMPS and POSTS.

Tenderers are at liberty to tender for either Section, but not for part of a Section.

The Ground Plan of Plant, and Specification, with Terms and Conditions of Tenders and Contract, may be obtained at the Office of Mr. Robert Hammond, the Consulting Engineer to the Corporation, Ormond House, Great Trinity-lane, London, E.C., on and after Thursday, the 13th inst., on payment of £2. 2s., which sum will be returned on receipt of a bona fide Tender.

Tenders, sealed and marked "Tender for Electric Lighting," must be addressed to me at 3, Wood-street, Bath, and be delivered on or before MONDAY, the 31st inst.

The Committee do not bind themselves to accept the lowest or any Tender.

F. H. MOGER, Clerk.

3, Wood-street, Bath, August 5th, 1896.

### COUNTY BOROUGH OF OLDHAM.

The ELECTRIC LIGHT COMMITTEE invite TENDERS for supplying them with an ELECTRICALLY DRIVEN FEED PUMP, capable of delivering 2,000 gallons of water per hour against 125lb. steam pressure.

Specification and Form of Tender may be obtained on application to Mr. Arthur Andrew, Gas and Water Offices, Oldham, to whom Tenders are to be sent on or before TUESDAY, August 18th, 1896.

A. NICHOLSON, Town Clerk.

Oldham, 4th August, 1896.

### ELECTRIC CABLES.

THE DUNDEE GAS COMMISSIONERS invite TENDERS for the Supply of INDIA RUBBER COVERED CABLES for Electric Lighting in the Overgate, Wellgate, and Whitehall Street Districts of the City.

Particulars as to Quantities, &c., can be had from the Electrical Engineer, Dudhope Crescent-road, Dundee.

Persons willing to undertake the Supply required, to send in Tenders to the Clerk of the Commissioners, City Chambers, Dundee, on or before the 19th AUGUST, 1896.

THOS. THORNTON, Clerk.

City Chambers, Dundee, 5th August, 1896.

THE

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LIMITED.

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*Chairman*—Sir CHARLES RIVERS WILSON, G.C.M.G., C.B.

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**Senior Instructor: C. CAPITO, M.I.E.E., M.I.M.E.**

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### CITY AND GUILDS OF LONDON INSTITUTE.

SESSION 1896-97.

THE COURSES OF INSTRUCTION IN ENGINEERING AND CHEMISTRY at the Institute's Colleges commence in October, and cover a period of two to three years. The MATRICULATION EXAMINATION of the **Central Technical College** will be held on September 21st to 24th and the ENTRANCE EXAMINATION of the Day Department of the **Technical College, Finsbury,** on September 22nd

**CITY AND GUILDS CENTRAL TECHNICAL COLLEGE**

(Exhibition-road, S.W.), a College for Higher Technical Instruction for Students not under 16 years of age preparing to become Civil, Mechanical or Electrical Engineers, Chemical and other Manufacturers, and Teachers.

THE MATRICULATION EXAMINATION will be held on September 21st to 24th, and the new Session will commence on October 1st.

Professors:—O. Henrici, LL.D., F.R.S. (Mathematics); W. C. Unwin, F.R.S., M.I.C.E. (Civil and Mechanical Engineering); W. E. Ayrton, F.R.S. (Physics and Electrical Engineering); H. E. Armstrong, Ph.D., F.R.S. (Chemistry).

**CITY AND GUILDS TECHNICAL COLLEGE, FINSBURY**

(Leonard-street, City-road, E.C.). The DAY DEPARTMENT provides Courses of Intermediate Instruction for Students not under 14 years of age, preparing to enter Mechanical or Electrical Engineering and Chemical Industries.

THE ENTRANCE EXAMINATION will be held on September 22nd, and the new Session will commence on October 6th.

Professors:—S. P. Thompson, D.Sc., F.R.S. (Electrical Engineering); R. Meldola, F.R.S. (Chemistry).

JOHN WATNEY, Hon. ecretary

City and Guilds of London Institute,
Gresham College, Basinghall-street, E.C.

### UNIVERSITY COLLEGE, BRISTOL.—CHEMICAL DEPARTMENT.

Professor—SYDNEY YOUNG, D.Sc., F.R.S.
Lecturer—FRANCIS E. FRANCIS, B.Sc., Ph.D.
Junior Demonstrator—E. HALFORD STRANGE, B.Sc.

The SESSION 1896-97 begins on OCTOBER 6th. Lectures on Inorganic, Organic and Advanced Chemistry will be delivered during the Session. The Laboratories are fitted with the most recent improvements for the study of Practical Chemistry in all its branches. In the Evening the Laboratory is opened and Lectures on Inorganic Chemistry, at reduced fees, are delivered. Several Scholarships are tenable at the College. CALENDAR, containing full information, price 1s. (by post 1s. 3d). For prospectus and further particulars apply to JAMES RAFTER, Secretary.

### THE DURHAM COLLEGE OF SCIENCE, NEWCASTLE-UPON-TYNE.

DEPARTMENT OF ENGINEERING AND NAVAL ARCHITECTURE.

The College offers complete COURSES of INSTRUCTION in MECHANICAL, MARINE, ELECTRICAL and CIVIL ENGINEERING, NAVAL ARCHITECTURE, MINING and METALLURGY.

The Laboratories contain Quadruple Expansion Experimental Engines, 100-Ton Testing Machine, Compound Horizontal Engines, Dynamos, &c.

The Degrees and Titles of the University of Durham are open to Students.

The NEXT SESSION begins 28th SEPTEMBER, 1896.

The Calendar (1s.) and Prospectuses on application to the SECRETARY.

## APPOINTMENTS VACANT.

### CITY AND COUNTY OF BRISTOL.

The Electrical Committee are prepared to receive applications for the APPOINTMENT of a CHARGE ENGINEER, at a salary of £2 per week.

Applications with testimonials (copies only) stating age and experience, must be delivered on or before Tuesday, August 11th, and addressed to

H. FARADAY PROCTOR,
City Electrical Engineer, Temple Back, Bristol.

### ELECTRIC TRAMWAYS.—The Corporation of Leeds

require the services of a competent person as CLERK OF WORKS for Construction of Electric Overhead Tramway from Roundhay to Kirkstall (seven miles of double track, to be completed in six months). Applications, stating applicant's experience and salary required, to be sent, addressed The Town Clerk, Leeds, and marked outside, "Tramway Clerk of Works," not later than 22nd August.

July, 1896. JNO. HARRISON, Town Clerk.

### CITY AND GUILDS OF LONDON INSTITUTE.

In consequence of Mr. Rhodes' appointment at Salford there is a VACANCY at the City and Guilds Central Technical College for an ASSISTANT, with a good knowledge of mathematical and experimental physics. Salary commencing at £150 per annum. Apply in the first instance by letter to Professor Ayrton, Central Technical College, Exhibition-road, London, S.W.

JOHN WATNEY, Honorary Secretary.

### THE DURHAM COLLEGE OF SCIENCE, NEWCASTLE-UPON-TYNE.

The COUNCIL invite applications for the post o ASSISTANT LECTURER and DEMONSTRATOR in PHYSICS. The stipend attached to the appointment is £120 per annum.

Duties will commence on October 1st next.

Applications and testimonials must be sent on or before August 20th to the undersigned, from whom further particulars may be obtained.

H. F. STOCKDALE, Secretary.



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## SITUATIONS VACANT AND WANTED.

TRAVELLER, to sell Electrical Fittings in Provinces, on salary and commission. Must have good connection and references.—Apply, UNIVERSAL ELECTRICAL FITTINGS Co., Ltd, Suffolk-road, Sheffield.

WANTED, a competent MAN used to testing and adjusting arc lamps.—Write, stating age, wage expected, and experience, to 2246, *Electrician* Office, Salisbury-court, Fleet-street, E.C.

WANTED, a young man as ELECTRICIAN, to take charge of lighting plant for workshops, &c.—Apply, stating experience, age, and wages required, to 7896, *Electrician* Office, Salisbury-court, Fleet-street, E.C.

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REPRESENTATIVE WANTED by the undersigned firm; must be able to manage a new separate business in the electrical trades. Premises are large and in good position. They are suitable for an exhibition of electro-technical articles.

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ELECTRICIANS.—NOTICE to EMPLOYERS.—Please note we have a number of First-Class ELECTRICAL MEN upon our Books. Kindly send us particulars of any VACANCIES you may have. We can introduce you, free of charge, to the best men now at liberty.

Address, CHAS. RICHARDSON and CO., Engineers' Bureau, 342, Strand, London, W.C

PARTNERSHIPS.—ELECTRICAL ENGINEERS and others WANTING PARTNERS, or wishing to SELL, can be introduced to Clients with Capital; and GENTLEMEN Seeking Investments can obtain personally (or through their solicitors) particulars of bona-fide OPENINGS. Strictest confidence observed.—Address, CHAS. RICHARDSON and CO., 342, Strand, London, W.C.

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ELECTRICAL SUPPLIES of Every Kind.

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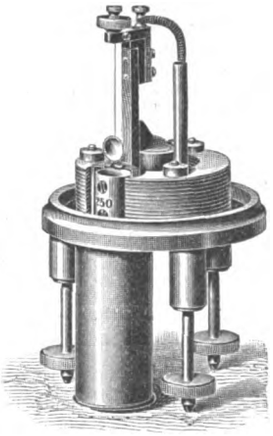

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MAKERS AND PATENTEES.

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INVENTORS' MODELLER & SCIENTIFIC APPARATUS MANUFACTURER,

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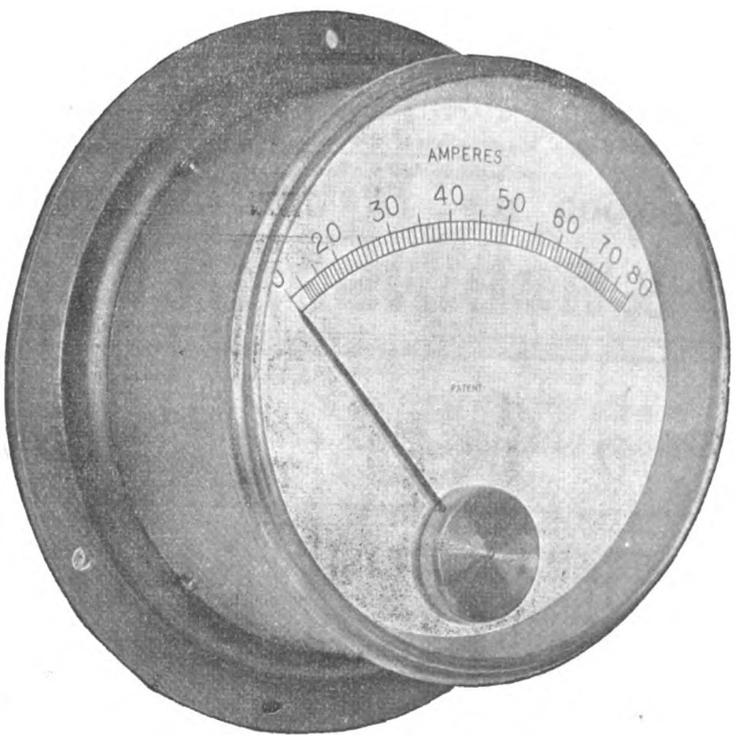


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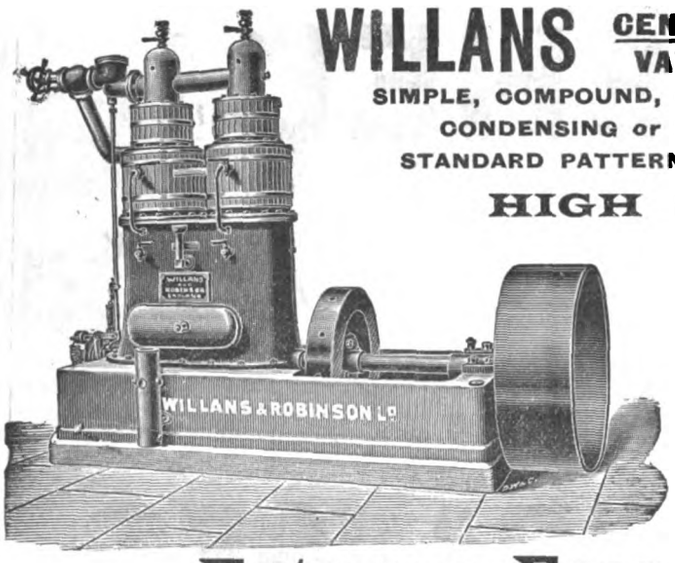


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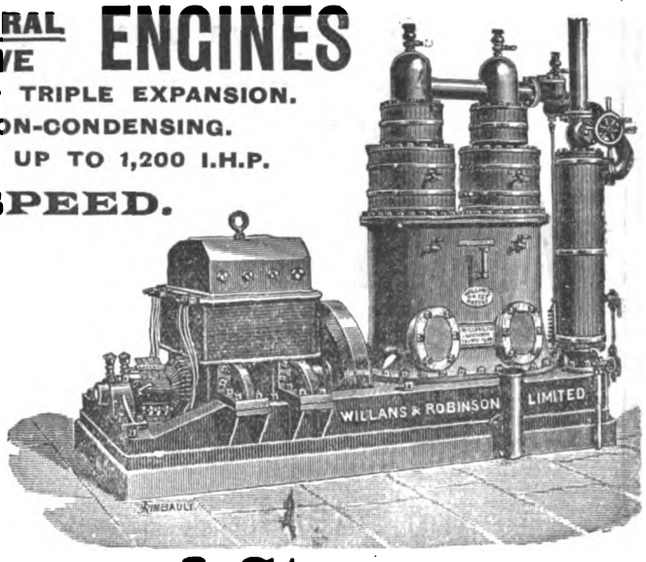
SIMPLE, COMPOUND, or TRIPLE EXPANSION.
CONDENSING or NON-CONDENSING.
STANDARD PATTERNS UP TO 1,200 I.H.P.

**HIGH SPEED.**

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**GREAT SAVING OF OIL. LITTLE ATTENDANCE REQUIRED.**

SMALL SPACE OCCUPIED and corresponding reduction in first cost of buildings.

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**OVER 130,000 H.P. IN USE OR ON ORDER.**

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*Crompton & Co., Ltd.* | *See Important Announcement on page xxvii.*

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Engineers and Boilermakers.

**Specialty: STEADY RUNNING ENGINES FOR ELECTRIC LIGHT INSTALLATIONS.**

MAKERS OF

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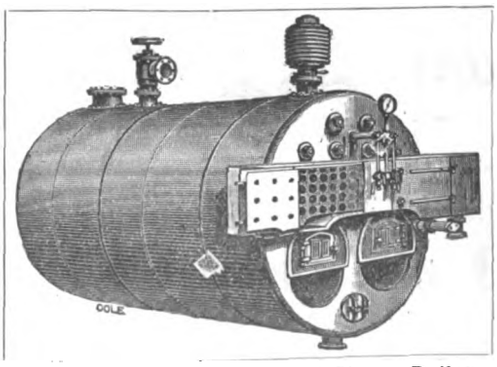

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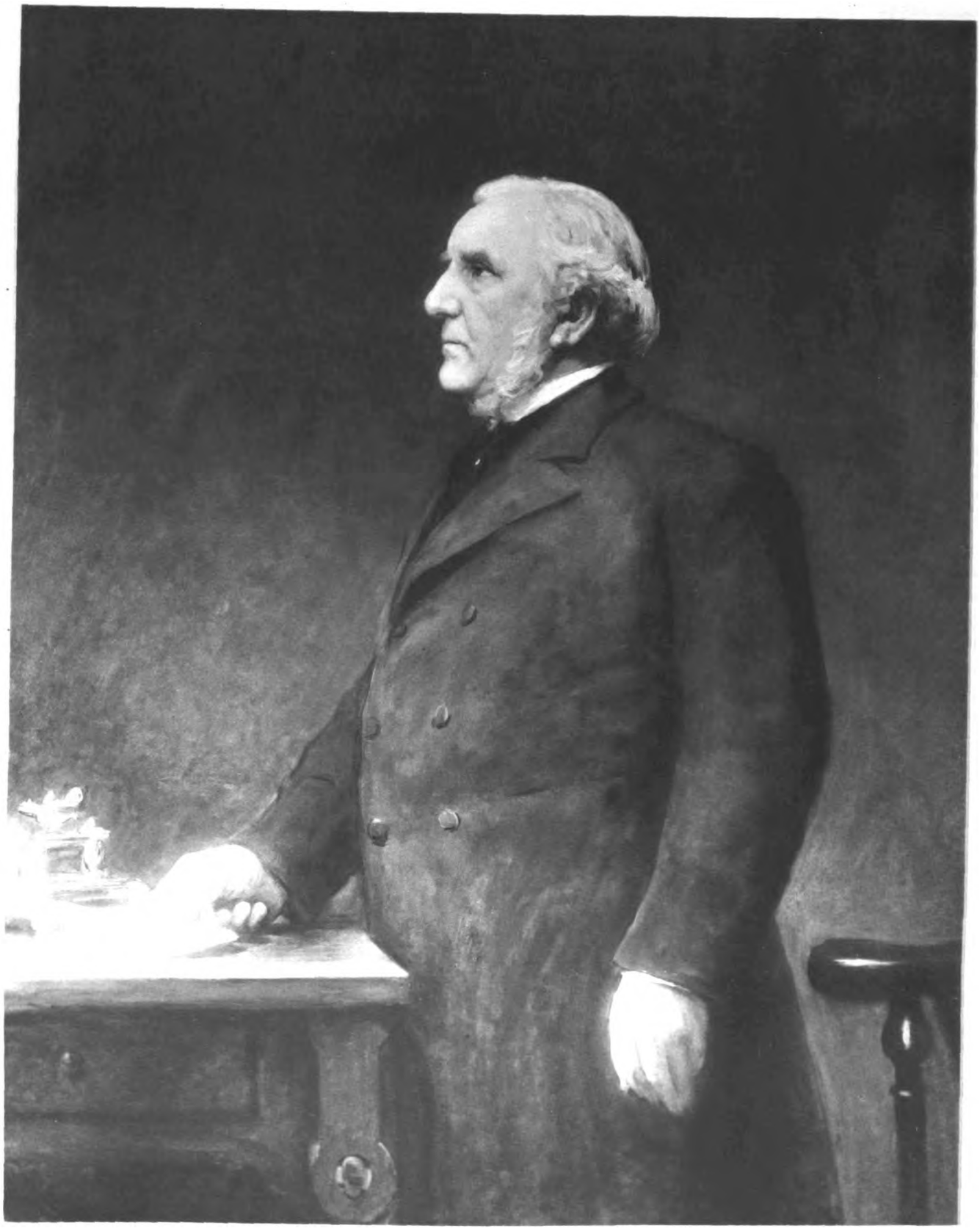

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 951. [Vol. XXXVII. No. 15.] FRIDAY, AUGUST 7, 1896. PRICE SIXPENCE.

## NOTES.

We are pleased to be able this week to present our readers with an excellent portrait of the late Sir JOHN PENDER, the announcement of whose death and a biographical account of whose career appeared in these pages on the 10th of last month. This picture, which is a faithful reproduction of the well-known oil painting by HERKOMER, presented to Lady PENDER, will be welcome wherever submarine telegraphy is known. In his lifetime an enthusiastic promoter of a great practical application of electrical science, Sir JOHN has earned for himself a title to be kept in honourable remembrance; and this more particularly by readers of *The Electrician*.

"THE Electrical Development and Finance Corporation (Limited)," with a small but distinguished Board, is inviting the public to subscribe for one-half of its nominal capital of £500,000. The primary object of this concern is "the promotion and development of undertakings for utilising electrical power in all its industrial applications" at home or abroad, a "considerable revenue" being anticipated more particularly from the promotion and development of electric traction. The Corporation intends commencing operations the moment it gets its money, and has under consideration: (1) The exploitation of a new and improved system of electric traction; (2) the electric lighting of an important and rapidly-growing district; (3) an interest in a new and thoroughly practical self-starting alternating-current motor; (4) the construction of a system of electric generating stations and the transmission of power in a mining district of South Africa—mysteriously worded announcements, which recall the floating of an historic company which was formed "to carry on an undertaking of great importance, but no one to know what it is." The electrical industry as a whole, and electric traction in particular, cannot certainly complain of lack of financial support with so many concerns now in existence, the sole and singular *raison d'être* of which is to supply the requisite cash; indeed, if we are to believe what we hear, money is so plentiful just now that it is a little difficult to realise the necessity for yet another special electro-financial company.

ELECTRIC traction of the heavier sort has received once more its customary six-monthly encouragement from the Liverpool Overhead Railway, the accounts of which for the half-year ended June 30, 1896, have just been published. Alike from an engineering and a business point of view, everything connected with this concern, from its inception to the present time, has been uniformly successful. During the first half of this year some 313,010 train miles were run over the six miles of line now working, and 3,739,575 passengers have been carried. The revenue accruing from passengers, together with the carriage of parcels, &c., has amounted to 23·9d. per train mile; while the total expenditure out of revenue has not exceeded 15·1d. per train mile, or approximately 63·2 per cent. Out of this last-named sum, the total generating expenses at the power station have absorbed 3·39d. per train mile, of which only about one-halfpenny per train mile has been paid for fuel. The rolling stock, consisting of 38 coaches of 56-passenger capacity, or 19 trains of 112-passenger capacity, has not been increased; but work has been pushed forward on the extension of the line, and the additional mile or so which is now being constructed will, it is expected, be completed by next autumn. Well-earned and well-deserved is the £11,166. 7s. 5d. available for the 5 per cent. dividend on the Preference shares, and the 2¾ per cent. dividend on the Ordinary shares.

THERE seems to be something beneath the surface, some reason partly or completely concealed, in the dead set which the Electric Light Committee of the Belfast Corporation has made against the use of gas engines in the electric supply station. As Councillor WOODSIDE put it, "apparently there was something that members of the Corporation, and especially those who were not members of the Electric Light Committee, knew nothing about." Although vaguely admitting that the present gas-engine station is working "fairly satisfactorily," and that there has been a "small profit," the Committee seem unanimously disposed to wash their hands of all responsibility for the station, and to throw the "blame" upon the Gas Committee, who called it into being. The only definite and explicit statements that seem to afford any clue to the unhappy ending to this gas-engine-station experiment are the remarks of Councillor ANDREWS, who observed that "they were at present paying about three times as much for fuel as they would with a steam-driven station, and that the new gas engines would be more efficient than the original engines, which were of a different type." These last-named, it seems, "never gave satisfaction"—at any rate, not to Councillor ANDREWS.

EXAMINATION of the accounts for the past year will show that at Belfast gas-fuel has cost 1·45d. per unit sold. As we

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have previously remarked, there are many electric supply concerns driven by steam, which, though larger than the Belfast gas-engine station, make a poorer showing in the matter of expenditure for fuel. Indeed, we very much doubt whether a station of the size of the one under discussion would be likely, in the first year of its existence, to make a very much better showing than Belfast has done; and we regard it as extremely improbable that its fuel bill would be only one-third that of Belfast. We do not deny, however, that the achievement is possible. In the matter of wages, also, Belfast stands high, but not so high proportionately as many steam-driven stations of greater size. Mr. McCowen, the electrical engineer at Belfast, asserts that a gas-driven plant requires more attention than a steam plant of equal capacity. It is scarcely probable, however, that in these reasons we have the whole ground of the Committee's objection to gas plant. A glimpse of another reason is afforded by a remark which Mr. Greenhill made at the meeting of the Institution of Mechanical Engineers, where the Belfast station was described. He said that "electric lighting was introduced into Belfast to relieve the gas works." If this means that to greatly extend the gas-engine electric supply station would involve the gas works in corresponding extensions, the reluctance of the Belfast Corporation to adopt this course is at once explained.

Official reports are not, as a general rule, interesting reading—at any rate, not until those who penned them and those for whom they were penned have become "as a tale that is told," and a poet-historian has arisen capable of weaving a fascinating story out of any unpromising material he may alight upon in the Record Office. Ever and anon, however, a vigorous personality breaks through the swathes of red tape and tradition, and we have "the new diplomacy" or an official document which has some interest for contemporary readers.

We have before us a collection of reports upon some important proposals for a network of electric tramways in the southern suburbs of Cape Town. It is refreshing, after the paeans of undiluted praise that are ever being sung in honour of electric traction, to find that the Cape Government have in their adviser one who will not be deterred from giving sound advice by the fact that it will not be exactly palatable to influential individuals. And, apart from the particular interests of Cape Town, it is altogether to the general interest of the electrical industry that a high standard should be insisted upon in electric traction; indeed, the higher the standard, within reason, the better for home manufacturers. At the same time the reports of the Electrical Adviser to the Cape Government will, no doubt, leave upon the minds of many concerned in the development of electric traction a somewhat mixed impression—

> "Perhaps it was right to dissemble your love,
> But—why did you kick me down stairs?"

Advocates of the conduit system will not be pleased to learn that the conduit is expensive and the slot a nuisance, and will scarcely be mollified by the counter irritant administered in the shape of an impartial summary of advantages, nor will they be consoled by the discovery that the trolley-system on the span-wire plan fares no better. However, since at any rate one system—the trolley-system with bracket arms—is supported, one section of the electric traction trade will have cause for thankfulness; and so will the inhabitants of the southern suburbs of Cape Town, whose "frontages" have been saved from desecration.

Whenever electric traction is under consideration by Town Councils or other local authorities the usual practice is to appoint a committee to visit the best existing electric lines in this country and on the Continent, and report on them. Now, by way of contrast, it would be a good thing to show these deputations how the work ought not to be done. A striking instance of this would be afforded by the electric Vevey-Montreux-Chillon tramway. The overhead construction of this ancient line is simply amazing. The two conductors consist of iron tubes about one inch in diameter, having an underrunning slot in which the collectors slide. These tubes are suspended from a bearer wire, and this again is carried by brackets fastened to houses or wooden posts. All the feeders are carried overhead, too; and in places where the line is double the mass of wires and iron work looks most formidable to the passer by. But all this is as nothing compared with a ride over the line on a top seat. The line is about six miles long, with single track, which is now on one side and then on the other side of the road. The connecting cables between the sliding contacts and the car hang down anyhow, and when the overhead conductors run from one side of the road to the other, or when the line runs round a sharp curve, an outside passenger is in danger of being strangled. It would be well for peripatetic committees to see for themselves what an electric line may become without proper control.

**University College, Bristol.**—The 1896-7 session begins on October 6th. Particulars of the chemistry lectures are given in our advertisement columns.

**New Periodical.**—A new periodical, specially devoted to acetylene its manufacture and use, has appeared in Italy under the name of "L'Acetylene e le sue Applicazioni," and is published at Milan.

**Durham College of Science.**—The 1896-7 session commences on September 28th. Some particulars of the courses of instruction in mechanical, electrical, and civil engineering, &c., appear in our advertisement columns.

**Jubilee Number.**—Under July 25th, the *Scientific American* published a special number in honour of the fiftieth anniversary of its birth. The number is well got up, and contains an historical review of the progress of science and mechanical industry during the past 50 years.

**Horseless Carriage Exhibition.**—The Crystal Palace International Exhibition of Horse and Horseless Carriages closed last Friday. The jurors appointed in connection with the exhibits are Sir David Salomons, Prof. D. E. Hughes, and Messrs. W. Worby Beaumont, W. Hancock, H. Mackenzie, A. R. Sennett, and M. Marillier.

**Cable Interruptions and Repairs :—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique ..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Nagasaki—Gutzlaff ..... .... | July 22, 1896 ... | Aug. 2, 1896. |
| Gibraltar—Tangier..... | July 28, 1896 ... | — |
| Para—Maranhao..... | Aug. 6, 1896 ... | — |

**Engineering at Cambridge.**—Mr. Stanley Dunkerley, M.Sc. (Vict.), has been appointed to the Demonstratorship of

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Mechanism and Applied Mechanics under Prof. Ewing at Cambridge, which became vacant by the election of Mr. W. E. Dalby to the chair of Mechanical Engineering at the Technical College, Finsbury, in succession to Prof. Perry. Mr. Dunkerley is a distinguished graduate of Owens College, and has, for the last three years, been Demonstrator and Lecturer in Engineering at University College, Liverpool. He is author of a Paper published in the *Philosophical Transactions* on the "Whirling and Vibration of Shafts."

**The Island of Trinidad.**—According to a *Times* telegram, dated Lisbon, August 5th, a note has been communicated to the Press from the Portuguese Foreign Office to the effect that the good services of Portugal, which were offered for a friendly solution of the question of the ownership of the Island of Trinidad, having been accepted by England and Brazil; and Portugal, after due examination of the affair, having placed before the British Government her reasons for the conviction that the island belonged to Brazil, the British Government has acknowledged the rights of Brazil to Trinidad. Reuter's Agency states that it learns on trustworthy authority that the announcement of the recognition by the British Government of the sovereignty of Brazil over the Islet of Trinidad is premature, although a solution in favour of the sovereignty of Brazil over the islet is not impossible.

**Railway Motors under Water.**—The amount of water that modern electric railway apparatus will stand is remarkable. Early last spring, says the *Street Railway Review* of Chicago, the streets of Danbury, Conn., were flooded by a freshet. In order to bring the employées living on the east side to the sheds so that cars could be started in the morning it was necessary to run a motor car across the causeway. This car, which was equipped with two motors, ran through water twenty-two inches deep, and the wave motion caused by the rapid motion of the car made the water come up and wash across the front platform, so that during half of each trip the resistance was practically submerged. After getting the employées over, the car continued in regular operation for two hours. After each trip the water was drained out of the motors at the bottom plugs, but there was very little.

**Mason College: Professorhip of Engineering.**—At the last meeting of the Council of Mason College it was unanimously resolved to approve of a recommendation of the Engineering Board of Studies, and to appoint Mr. Frederic W. Burstall, M.A. Cantab., Whitworth Scholar, Assoc. M.Inst.C.E., to the vacant professorship of civil and mechanical engineering. Mr. Burstall entered upon an apprenticeship to Messrs. J. Stewart and Son, engineers and boiler-makers, Blackwall, in 1881, and went through the pattern, machine and fitting shops till 1885, when he gained a Whitworth Scholarship, and proceeded to University College, London, where he was awarded the Rothschild Scholarship in Mathematics. In 1886 Mr. Burstall entered St. John's College, Cambridge, and was elected a foundation scholar in 1888, graduating as Sixteenth Wrangler in 1889, in the following year being placed in the first division in the second class in Part II. of the Mathematical Tripos. On leaving Cambridge Mr. Burstall entered the office of Prof. Kennedy, F.R.S.; and in October, 1891, he was appointed demonstrator of mechanical engineering at King's College, London, which position he is now giving up in order to take charge of the Department of Civil and Mechanical Engineering in Mason College. There were thirteen candidates for the vacancy.

**Sir John Pender's Will.**—The gross value of the personal estate of the late Sir John Pender has been entered at £348,179. 4s. 3d., but the net or actual value is not stated, and the value is also not stated of the real estate, if any. The executors of the will are Mr. John Denison Pender, Admiral Lord John Hay, and Mr. Richard Enfield, to each of whom the testator bequeathed for the executorship £100; to his said son, John Denison Pender, £50,000; to his grandson, Henry Denison Pender, £2,000; to his four sisters, Mrs. Renwick, Mrs. Reid, Mrs. Wake, and Mrs. Duncanson, £100 each; to Mrs. Renwick a life annuity of £120; to the children of the testator's daughter Dame Marion Des Vœux, £1,000; to Lord John Hay, £2,000; to Eleanor White, formerly governess to the testator's daughters, a life annuity of £100; to his coachman's wife a life annuity of £52; bequests to other servants; and to trustees a sum of £150, to apply from the income thereof £5 a year in continuance of a prize at Wellington College given by the late Lady Pender. Sir John Pender confirms the settlements made on his marriage, and having appointed to his daughter Lady Des Vœux on her marriage £10,000, he appoints the real estate of the settled trust to his son John Denison Pender, and the personal estate of the settled trust as to fifty-four 158ths thereof to his said son, as to fifty-four 158ths to Lady Des Vœux, and as to fifty 158ths to his daughter Miss Ann Denison Pender. Sir John Pender bequeathed his gold and silver presentation plate to his son Mr. James Pender, M.P., for life, and after his death to his eldest son, with remainder to Mr. John Denison Pender, to the last-named of whom he bequeathed the Holme and Denison plate and his diamond stars and tiara, which are to be in trust for Mr. J. D. Pender's eldest son. The testator bequeathed his portrait by Herkomer to his son John, and he bequeathed the portraits of his two daughters by Millais, upon which he placed great value, to Miss Pender for life, and after her death to Lady Des Vœux. Sir John Pender's residuary estate is to be taken as divided into 405 shares, of which 227 are to be in trust for his son James, 123 for his son John, 50 for his daughter Lady Des Vœux, and five for Miss Pender, but in the event of the death of either of his sons without issue the share of such son is to be in trust for the surviving son and Lady Des Vœux, but so that the share of the surviving son shall be four times as much as that of Lady Des Vœux. Mr. John Denison Pender is to bring into hotchpot against his share of the residuary estate the sum of £50,000 bequeathed to him, and Mr. James Pender is to execute a bond securing a sum of £14,000, which is to be held in trust as to 123-178th parts for Mr. J. D. Pender, as to 50-178th parts for Lady Des Vœux, and to 5-178th parts for Miss Pender. Sir John Pender's estate is left in trust for sale and realisation, but with certain powers of postponement, and the trustees have liberty of investment on the security of landed estate in England, Scotland, and Wales. Lady Des Vœux has power to appoint from the income of her fortune £1,000 a year to her husband during the remainder of his life if he survives her.

**Contemporary Electrical Science.**—The Aurora Borealis was the subject of much discussion at the Lübeck conference of German physicists and physicians. Herr Ebert described some experiments, summarised in Wiedemann's *Beiblätter*, which attained a considerable measure of success towards imitating the celestial phenomena in question. Spheres, plates, and cylinders of brass and of iron, were exposed in a vacuum to electromagnetic waves. Halos and auroras were observed to encircle them, and these were powerfully influenced by magnetic forces. Up to a certain point their luminosity increased with the strength of the magnetic field, but where the lines of force impinged vertically on the surface the aurora was thrust aside. All this points to the explanation that the sun sends out electromagnetic waves which produce the aurora at the more intense points of the earth's magnetic field. Another speaker, Herr Paulsen, of Copenhagen, inclined rather to the view that the aurora, especially the steady glowing kind, is due to a fluorescence of the air under the influence of cathode rays emitted by the sun, the distribution of the fluorescence being governed by the earth's magnetic field. Since these rays facilitate the production of ozone, and the latter is a strong cloud-former, we have also an explanation of the cloud formations which almost invariably attend the displays.——In the *Physical Review* we have another lady student of the electric arc. Miss Caroline Baldwin studied the spectrum of the arc photographically, and found that the banded carbon spectrum is chiefly formed at the negative carbon, and its brilliance is increased by zinc, cadmium, or copper cores. The carbon bands are only few at the positive carbon; and cores of the light positive metals, potassium, sodium, lithium, and others, so effectually screen them that it is not surprising they escaped Prof. Snow's bolometer altogether.

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## DISPERSION.

BY OLIVER HEAVISIDE.

A short time since Prof. J. J. Thomson in his Rede Lecture and then (*The Electrician*, July 17th) Prof. Lodge directed attention to Helmholtz's (1893) electromagnetic theory of dispersion. This was followed next week by Dr. Howard's translation of that paper. The celerity was wonderful. I wish the paper itself could be as quickly understood as translated.

The subject is exceedingly important and exceedingly difficult. In one respect only is it easy. It is perfectly easy to make a mathematical theory of dispersion, or 20 theories in an hour, if desired. But it is not easy to make a mathematical theory which shall agree with the facts, which are rather complicated, and vary from one body to another. And as for a physical theory, the case is worse still. Our knowledge about atoms and molecules is quite nebulous, and an hypothesis concerning the mutual action of ether and matter, or of electromagnetic and material vibrations, must be highly uncertain, even if we have a fairly good mathematical theory. The subject demands and deserves study from several points of view. At present I only desire to direct attention to some obscurities and inconsistencies I find in Helmholtz's theory. The objections are made entirely in an enquiring spirit.

Let $\mathbf{D}$ be the displacement in Maxwell's theory, extended to formally include convection currents, $\rho$ the density of electrification, $\mathbf{u}$ the velocity of $\rho$. Then $\rho\mathbf{u}$ is the convection current, and $\dot{\mathbf{D}}+\rho\mathbf{u}$ the true current, the curl of the magnetic force, in a dielectric. Let the time integral of $\rho\mathbf{u}$ be $\mathbf{d}$. Then the first circuital law is

$$\text{curl}\,\mathbf{H}=\dot{\mathbf{D}}+\rho\mathbf{u}=\dot{\mathbf{D}}+\dot{\mathbf{d}}, \tag{1}$$

and the second is

$$-\text{curl}\,\mathbf{E}=\mu\dot{\mathbf{H}}, \tag{2}$$

if $\mathbf{D}=\kappa\mathbf{E}$. If now $\mathbf{d}$ can be defined in terms of $\mathbf{D}$, we shall have the essentials of a complete system.

Now $\mathbf{D}$ is the $(f, g, h)$ of Helmholtz's paper (translation), and $\mathbf{d}$ is the same in a thicker type. But I desire to use my usual vector notation (and rational units of course), and the reader will find that it produces a great simplification. $\mathbf{E}$ is (P, Q, R) the electric force, and it is given that $\mathbf{D}=\kappa\mathbf{E}$ and $\mathbf{d}=\theta\mathbf{E}$, and that $\kappa$ and $\theta$ are constants. [Equation (2) and the one preceding (4)]. Here is the first inconsistency. If $\theta$ is constant, we cannot have a theory of dispersion. A homogeneous dielectric of the common kind is the result. $\theta$ must be a differential operator of some sort. And it is so, later on in the paper, although the supposed constant $\theta$ is retained, which makes a second inconsistency.

The density of the electric energy, say $U_1$ [equation (4)] is made to be

$$U_1=\frac{1}{2}\frac{\mathbf{D}^2}{\kappa}+\frac{1}{2}\frac{\mathbf{d}^2}{\theta}-\frac{\mathbf{Dd}}{\kappa}, \tag{3}$$

and if $\mathbf{D}$ and $\mathbf{d}$ are parallel, this reduces to

$$U_1=\tfrac{1}{2}(\kappa-\theta)\mathbf{E}^2. \tag{4}$$

I cannot clearly understand this, either when $\theta$ is regarded as a constant, or in the form (3).

The density of the magnetic energy is as usual [equation (5)]; say, if $\mathbf{B}=\mu\mathbf{H}$, where $\mathbf{B}$ is the induction, then $T=\frac{1}{2}\mu\mathbf{H}^2$ in my notation.

But Helmholtz introduces another sort of energy, called the electromagnetic, which is wholly incomprehensible to me. It is defined in terms of the vector potential $\mathbf{A}$, and the true electric current in the old-fashioned way [equation (8)], say in my notation, $\Sigma\mathbf{AC}$, if $\mathbf{C}$ is the true current. But by a well-known transformation, this is the same as $\Sigma\mathbf{HB}$, since $\mathbf{C}$ is the curl of $\mathbf{H}$, and $\mathbf{B}$ the curl of $\mathbf{A}$, as may be seen in the paper itself. [Equations (6), (7), (8), and the one between (12) and (13).] So the "electromagnetic energy" density is twice the magnetic energy density. What can it be?

There is also the kinetic energy of disturbed ions, which is represented by the product ½ mass of ion × square of convection current. Obviously this makes the kinetic energy $\times\rho^2$. That is a small matter. There is also the friction assumed to act on disturbed ions.

Finally, there is the Principle of Least Action. Now, Least Action has no more to do with the matter than the man in the moon, so far as I can see. It is quite unnecessary, to begin with. Next, it obscures and complicates the matter, so much so as sometimes to lead to serious error. I make this remark advisedly, remembering previous applications of the Principle of Least Action to electromagnetics, which is much clearer without it.

Lastly, we come to the circuital equations [equations (13), (14)]. One is equivalent to

$$\text{curl}\,\mathbf{H}=\dot{\mathbf{D}}+\dot{\mathbf{d}}, \tag{5}$$

in the sense before explained. The other is equivalent to

$$-\text{curl}\left(\frac{\mathbf{D}-\mathbf{d}}{\kappa}\right)=\mu\dot{\mathbf{H}}. \tag{6}$$

I understand (5). I cannot understand (6). Compare with (2) above. I do not see how $-\mathbf{d}$ gets in. The Principle of Least Action may do it, or else the reckoning of the electric energy as in (4) above, or the astonishing electromagnetic energy; but as no details are given, and there are the inconsistencies alluded to, the matter is hopeless at present.

Note that if the $\theta$ in $\mathbf{d}=\theta\mathbf{E}$ is really constant, then (5), (6) with $\mathbf{d}$ eliminated make a simple homogeneous dielectric, with no dispersion. But as a matter of fact, the relation between $\mathbf{D}$ and $\mathbf{d}$ is [equations (17)]

$$\mathbf{D}=(a^2+hp+mp^2)\mathbf{d}, \tag{7}$$

(where I change $k$ to $h$ on account of another $k$), so that $\theta$ is an inverse operator, as is required in practical theories of dispersion.

Now (7) can be understood broadly without going through the previous obscurities. It says that the ordinary mechanical force $\mathbf{E}\rho$ on $\rho$ produces motion of $\rho$, and that there is opposing elastic resistance, and frictional resistance, and inertial resistance. This is a reasonable elementary hypothesis, though when applied to atomic charges some process of averaging must be gone through. Besides that, the real force on $\rho$ is not $\mathbf{E}\rho$, but $\mathbf{E}\rho+\mathbf{VCB}$. Pass this correction by.

If we take out the $\mathbf{d}$ from equation (6), reducing it to (2), then since (5) is the same as (1), I should be inclined to assert that the auxiliary hypothesis (7), without necessarily entering into details regarding the nature of the frictional force, &c., would give an intelligible dispersion theory. For (7) is simply an ordinary "equation of motion" introduced as an auxiliary to the circuital laws.

But I could not say the same if $\mathbf{d}$ is to be retained in equation (6), because of its unintelligibility. It might work, or it might not. Further examination, given below, raises doubts as to its physical possibility.

To construct electromagnetic theories of dispersion rapidly, proceed thus. Write the two circuital laws in this way:

$$\text{curl}\,\mathbf{H}=\text{Y}\mathbf{E}, \quad -\text{curl}\,\mathbf{E}=\text{Z}\mathbf{H} \tag{8}$$

where Y and Z are operators, functions of $p$, the time-differentiator. In a common homogeneous dielectric, after Maxwell, $\text{Y}=(k+\kappa p)$, $\text{Z}=\mu p$. As is well known, this fails to account for the facts of dispersion, being only suitable for slow working. But Y and Z may be any operators we choose, provided they represent possible electrical arrangements of coils and condensers (elementary). They may be direct or inverse, rational or irrational. In any case, when we treat simply periodic states, we reduce the circuital laws to the form

$$\text{curl}\,\mathbf{H}=(\text{K}+\text{S}p)\mathbf{E}, \quad -\text{curl}\,\mathbf{E}=(\text{R}+\text{L}p)\mathbf{H}, \tag{9}$$

by the assumption $p^2=-n^2$, where $n/2\pi$ is the frequency. If the four constants were independent of the frequency, the case would be that of a homogeneous dielectric of constant inductivity, permittivity, electric conductivity, and magnetic conductivity, whose theory I have described in Chap. IV., Vol. I, "Electromagnetic Theory." But in general they are functions of $n^2$. And note that even though there be no magnetic conductivity in reality, we are usually obliged in the above way to use an effective magnetic conductivity.

To make a large scale model, use the line integrals of $\mathbf{E}$ and $\mathbf{H}$. Say, V and C. Then, for plane waves,

$$-\frac{d\text{V}}{dx}=(\text{R}'+\text{L}'p)\text{C}=\text{Z}'\text{C}, \quad -\frac{d\text{C}}{dx}=(\text{K}'+\text{S}'p)\text{V}=\text{Y}'\text{V} \tag{10}$$

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express the resultant forms. They may be interpreted in terms of a generalised telegraph circuit, with R′ the resistance of wires, K′ the conductance between them, L′ the inductance, S′ the permittance, all per unit length, and all being the effective values at the frequency concerned. We can concentrate the four quantities in lumps, and regard the circuit as made up of a number of Z″s in series, with leaks represented by the Y″s (*see* "Electromagnetic Theory," Vol. I., §§ 221, 222, for this generalisation of the circuital laws, and the resulting formulæ).

If we assume Y′ and Z′ to represent any real electrical arrangements of coils and condensers, we can, I think, be quite certain beforehand that the resulting theory of dispersion will be a consistent one in all parts, containing no electrical impossibilities. That is one thing. Another is, that if we translate a theory of dispersion to the telegraph circuit theory, or to the equivalent theory for plane waves in a doubly conducting medium, and do it properly, we can see whether it really represents a possible arrangement. If it does not, if the telegraph will not work properly, neither will the homogeneous medium; and, finally, it raises a very serious question whether the theory of dispersion is an admissible one.

Test Helmholtz's theory in the way described. Eliminate **d** from (5) and (6) by means of (7). For plane waves we get

$$-\frac{d\mathrm{H}}{dx}=\kappa p\left(1+\frac{1}{a^2+hp+mp^2}\right)\mathrm{E}, \tag{11}$$

$$-\frac{d\mathrm{E}}{dx}=\mu p\left(1-\frac{1}{a^2+hp+mp^2}\right)^{-1}\mathrm{H}. \tag{12}$$

Put $p=ni$, then

$$-\frac{d\mathrm{H}}{dx}=\left\{\frac{h\kappa n^2}{\mathrm{X}}+\kappa p\left(1+\frac{a^2-mn^2}{\mathrm{X}}\right)\right\}\mathrm{E}, \tag{13}$$

$$-\frac{d\mathrm{E}}{dx}=\left\{\frac{\mu hn^2\mathrm{X}+\mu p\mathrm{X}(\mathrm{X}-a^2+mn^2)}{(\mathrm{X}-a^2+mn^2)^2+h^2n^2}\right\}\mathrm{H}, \tag{14}$$

where

$$\mathrm{X}=(a^2-mn^2)^2+h^2n^2. \tag{15}$$

Or, if we expand the reciprocal of Z, we have, more simply,

$$\mathrm{Z}^{-1}=-\frac{p}{\mu n^2}+\frac{h\mu n^2+\mu p(a^2-mn^2)}{\mathrm{X}\mu^2n^2}, \tag{14A}$$

Comparing with

$$-\frac{d\mathrm{H}}{dx}=(\mathrm{K}+\mathrm{S}p)\mathrm{E}, \qquad -\frac{d\mathrm{E}}{dx}=(\mathrm{R}+\mathrm{L}p)\mathrm{H}, \tag{16}$$

which are the special forms of (9) for plane waves, we see that the effective electric conductivity is positive, the effective permittivity may be positive or negative, likewise the effective inductivity, and the effective magnetic conductivity is positive. The rate of waste per unit volume is $\mathrm{KE}^2+\mathrm{RH}^2$. (Divide by 2 if the amplitudes are in question.) The negativity of S and L is admissible at certain frequencies, but it is not allowable to have R negative under any real circumstances. It is impossible for R to be negative when we construct Y and Z out of really possible combinations of coils and condensers, either in the telegraph theory, or in its analogue in a medium. Effective resistances and conductances are always positive, because they arise out of the positive waste in Joules' law and its magnetic analogue, or from the positivity of the real ultimate electric conductivity and its analogue.

I make these remarks because in my first translation into the telegraph theory, a stupid mistake of my own made R come out negative. So far as the above goes, Helmholtz's system is not impossible. But let us see what arrangements the operators in Helmholtz's theory lead to. Translate to V and C. Say as in (10) above. Then, first we have

$$\mathrm{Y}=\kappa p+\frac{1}{\frac{a^2}{\kappa p}+\frac{h}{\kappa}+\frac{m}{\kappa}p}, \qquad \mathrm{Z}^{-1}=\frac{1}{\mu p}-\frac{1}{\mu p(a^2+hp+mp^2)} \tag{17}$$

in (11) (12). Now imagine the proper changes made in the constants to suit V and C, instead of E, H. It is unnecessary to introduce fresh symbols. If we consider a short finite portion of the telegraph circuit, to which Y and Z belong, we see that the leak Y consists of a condenser without shunt, in parallel with another condenser without shunt which is itself in sequence with a resisting coil. *I.e.*, Y is a conductance operator; $\kappa p$ stands for the conductance operator of the first condenser, and the denominator of the big fraction in Y is the resistance operator of the other condenser $a^2/\kappa p$ in sequence with the coil $h/\kappa+mp/\kappa$. (Dimensions are of no importance here, since it is only the structure that is in question.) Thus Y makes a proper and intelligible arrangement.

But Z does not. It is the resistance operator of the short piece of the circuit, and $\mathrm{Z}^{-1}$ in (17) is the corresponding conductance operator. So we see that there are two arrangements in parallel, one of which is a coil of no resistance (resistance operator $\mu p$), and the other has the resistance operator $-\mu p\,(a^2+hp+mp^2)$. Here, $-a^2\mu p$ represents a coil of no resistance and negative inductance, whilst the rest, $-\mu p^2(h+mp)$ is not electrically intelligible, although in simply periodic states, when $-\mu p^2$ becomes $\mu n^2$, it is equivalent to a coil of positive resistance and inductance. For this reason, then, in simply periodic states, we do get positive resistance, and if the effective inductance is negative, that does not matter. But in general, unlike Y, the operator $\mathrm{Z}^{-1}$ is electrically unintelligible.

This brings us back to Helmholtz's second circuital equation again, and the question what **−d** is doing there? If we omit it altogether, as before suggested, we do away with the unintelligibility. Y is as before in (17), whilst Z is $\mu p$. Then putting $\mathrm{Y}=\mathrm{K}+\mathrm{S}p$, $\mathrm{Z}=\mathrm{R}+\mathrm{L}p$, in the simply periodic case, we find

$$\mathrm{K}=\frac{h\kappa n^2}{\mathrm{X}}, \qquad \mathrm{S}=\kappa\left(1+\frac{a^2-mn^2}{\mathrm{X}}\right), \tag{18}$$

$$\mathrm{R}=0, \qquad \mathrm{L}=\mu, \quad \mathrm{X}=(a^2-mn^2)^2+h^2n^2, \tag{19}$$

The type of a wave is

$$\mathrm{E}=\mathrm{E}_0\epsilon^{-\mathrm{P}x}\sin(nt-\mathrm{Q}x), \tag{20}$$

when $\sqrt{\mathrm{YZ}}=\mathrm{P}+\mathrm{Q}i$; and

$$\mathrm{P}\text{ or }\mathrm{Q}=(\tfrac{1}{2})^{\frac{1}{2}}\{(\mathrm{R}^2+\mathrm{L}^2n^2)^{\frac{1}{2}}(\mathrm{K}^2+\mathrm{S}n^2)^{\frac{1}{2}}\pm(\mathrm{RK}-\mathrm{LS}n^2)\}^{\frac{1}{2}} \tag{21}$$

"Electromagnetic Theory," Vol. I., § 221, equation (16). The same symbols are used here, only it is now E and H that are concerned, so R, L, K, S refer to unit volume.) Note that P and Q are always real and positive, for all values of the quantities R, K, L, S. For the square of $(\mathrm{RK}-\mathrm{LS}n^2)$ is less than $(\mathrm{R}^2+\mathrm{L}^2n^2)\,(\mathrm{K}^2+\mathrm{S}n^2)$. When R is zero, take the positive value of $(\mathrm{L}^2n^2)^{\frac{1}{2}}$, whether L is positive or negative.

So the wave speed $\mathrm{Q}/n$ may be zero or infinite, but cannot be negative or imaginary. Having the square of the wave speed negative at certain frequencies is not desirable.

It is true that S may be negative, and then $\sqrt{\mathrm{LS}}$ is imaginary when L is positive, and the square of the wave speed seems to be negative. But that does not seem to me to be the right way to look at it. Say R = 0 first, then

$$\mathrm{P}\text{ or }\mathrm{Q}=(\tfrac{1}{2})^{\frac{1}{2}}\{\mathrm{L}n(\mathrm{K}^2+\mathrm{S}^2n^2)^{\frac{1}{2}}\mp\mathrm{LS}n^2\}^{\frac{1}{2}} \tag{22}$$

$$=(\tfrac{1}{2}\mathrm{L}n)^{\frac{1}{2}}\{(\mathrm{K}^2+\mathrm{S}n^2)^{\frac{1}{2}}\mp\mathrm{S}n\}^{\frac{1}{2}}. \tag{23}$$

Here L is + in the case under consideration, so the outside radical causes no trouble. Now if K = 0 also, we shall have dispersion but no waste; then P = 0, and $\mathrm{Q}=(\mathrm{LS}n^2)^{\frac{1}{2}}$ apparently; and therefore, apparently, Q is imaginary if S is negative, as it may be within certain frequencies. But this is wrong. We should take the + value of the radical; then, when S is negative, $=-\mathrm{S}'$ say, it is P that is $(\mathrm{LS}'n^2)^{\frac{1}{2}}$, and Q zero. In fact, the type of the wave is now $\epsilon^{-\mathrm{P}x}\sin nt$; a stationary vibration.

It is easier to follow when K is not quite zero. If quite zero and P = 0, then if by decrease of $n$, S becomes zero, we have Q zero, and $v$ infinite; and when S goes on further the same way and becomes negative, Q remains zero, but P is finite. When, on further decrease of $n$, S become positive again, then Q becomes positive again, and P zero. If this is not the correct interpretation, I shall be glad to be corrected myself.

In the case (18) (19), L is constant, K is always + and is proportional to the square of the frequency, and by (13),

$$\mathrm{S}=\kappa\left(1+\frac{a^2-mn^2}{(a^2-mn^2)^2+h^2n^2}\right). \tag{24}$$

Also, by (23), if V is the wave speed,

$$\mathrm{V}^{-2}=\frac{\mathrm{Q}^2}{n^2}=\frac{\mathrm{L}\mathrm{K}}{2n}\{(1+y^2)^{\frac{1}{2}}+y\}, \tag{25}$$

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where $y = Sn/K$. Or

$$V^{-1} = \frac{Lh\kappa n}{2X}\{(1+y^2)^{\frac{1}{2}} + y\}. \quad (26)$$

Here X is always +, whilst $y$ is generally +, but may vanish twice. When so, then P = Q; but in the region between the critical frequencies P and Q change places, as compared with their values when S was positive to the same extent as it is now negative. In the limit, if K = 0, one of the vanishings of S on decrease of $n$ takes place by the route $-\infty, 0, +\infty$. Then P rises to $\infty$ as $n$ goes from the higher to the lower zero.

The two values of $n^2$ making S = 0 are

$$n^2 = \frac{1}{2m^2}\{m(1+2a^2) - h^2 \pm \sqrt{(m-h^2)^2 - 4mh^2a^2}\}. \quad (27)$$

Between these frequencies, when possible, S is negative. But if

$$h^2 = m(1+2a^2) - 2ma(1+a^2)^{\frac{1}{2}}, \quad (28)$$

the two critical frequencies coincide, making

$$n^2 = \frac{a}{m}\sqrt{1+a^2}. \quad (29)$$

Therefore, when $h^2$ exceeds the value given in (28), the region of negative S does not exist. The general characteristics are much the same as in Helmholtz's theory.

If we imagine a plane electromagnetic sheet travelling through the ether to enter a material dielectric permeated by the ether, it is a matter of first principles that the very front of the disturbance goes on at the same speed as before, that is, as much or little as manages to get through at all at that speed. It may be infinitesimally little. The practical speed of the sheet in the material dielectric is different, being less. The thin sheet becomes widened by retardation, and the bulk of the disturbance is left behind the first front. It is far more complicated in reality when we come to simply periodic waves (though so much simpler in the mathematics); the values of P and Q are determined by actions proceeding both ways, ultimately tending to establish a stably progressive condition under the influence of a continued simply periodic impressed wave. To allow of this, frictional resistances causing waste should be positive.

Another way of testing Helmholtz's theory is by forming the equation of activity, and seeing if it accounts for the work done. Take first the simple system consisting of equations (1), (2), and (7). Then the equation of activity is

$$\text{conv}\,V\mathbf{EH} = \mathbf{E}\,\text{curl}\,\mathbf{H} - \mathbf{H}\,\text{curl}\,\mathbf{E}$$

$$= \mathbf{E}(\dot{\mathbf{D}} + \dot{\mathbf{d}}) + \mathbf{H}\dot{\mathbf{B}}. \quad (30)$$

Here $\mathbf{E}\dot{\mathbf{D}} = \dot{U}$, the rate of increase of the electric energy $U = \frac{1}{2}\mathbf{ED}$ according to my reckoning. Similarly, $\mathbf{H}\dot{\mathbf{B}} = \dot{T}$, the rate of increase of the magnetic energy. The remaining term $\mathbf{E}\dot{\mathbf{d}}$ is $\mathbf{E}\rho\mathbf{u}$ or $\mathbf{Fu}$, if $\mathbf{F}$ is the moving force on $\rho$. That is, it is the activity of $\mathbf{F}$, and is, by (7) accounted for thus

$$Fu = u(a^2 + hp + mp^2)\frac{u\rho^2}{\kappa p}$$

$$= \frac{a^2\rho^2}{\kappa}u\frac{u}{p} + \frac{hu^2\rho^2}{\kappa} + \frac{m\rho^2}{\kappa}up u, \quad (31)$$

showing that the rate of waste is $hu^2\rho^2/\kappa$, the potential energy is $\frac{1}{2}(a^2\rho^2/\kappa)\,(p^{-1}u)^2$, and the kinetic energy is $\frac{1}{2}(m\rho^2/\kappa)u^2$.

The activity is therefore fully accounted for. But in Helmholtz's system equations (5), (6), and (7), we obtain

$$\text{conv}\,V\mathbf{EH} = \dot{U} + \dot{T} + \mathbf{F}u - \mathbf{H}\,\text{curl}\,\mathbf{d}/\kappa, \quad (32)$$

and I am unable to see how to interpret the additional term. Of course, in (32) it is assumed that $V\mathbf{EH}$ is the flux of energy, just as in (30). It may be objected that this is not the case, but that the flux of energy should be $V(\mathbf{E} - \mathbf{d}/\kappa)\mathbf{H}$. But this does not help much. The convergence is

$$\frac{\mathbf{D} - \mathbf{d}}{\kappa}(\dot{\mathbf{D}} + \dot{\mathbf{d}}) + \mathbf{H}\dot{\mathbf{B}}; \quad (33)$$

The curl of $\mathbf{d}$ does not now appear, but (33) does not account for the increase of electrical energy as reckoned by Helmholtz, or for the strange "electromagnetic energy."

## THE CAPILLARY ELECTROMETER IN THEORY AND PRACTICE.*

BY GEORGE J. BURCH, M.A.

(*Continued from page 437.*)

*Measurement of the Potential Difference indicated by Rapid Movements of the Mercury of the Capillary Electrometer.*—In all other electrical instruments measurements are effected by noting the amount of a completed deflection. It was a new thing to attempt the estimation of an E.M.F. by determining the initial velocity of the excursion caused by it. I had long believed that this would be possible in the case of the ballistic galvanometer, and accordingly set myself to determine the time relations of the capillary electrometer with a view of putting the method into practice. While the photographic apparatus was being made I had studied the physical constants of the instrument, and was now ready to attack the more important problem. I knew the conditions to be complex. A mechanical effect was produced by an electric cause, and the rate of movement might be determined by either or by both. In the former case the flow of liquid might be governed by Torricelli's law or by Poiseuille's, or it might take place according to some intermediate formula. But if electrical causes predominated, then there were the possible variations of sensitiveness and capacity, and the inevitable alteration of resistance, as the mercury approached the end of the tube, to take into account. It would have been futile to seek hypotheses. I therefore made experiments.

(1) Dilution of the acid beyond a certain point lessened the rapidity of an excursion without diminishing the extent of it. This afforded additional evidence of the effect of electrical resistance.

(2) Shortening the capillary, so as to reduce the length of the acid column above the mercury, made the instrument act more quickly. But here both frictional and electrical resistance were lessened.

(3) The shape of the tapering part of the tube as well as of the orifice, had a marked influence on the rapidity of the excursions. This was clearly a mechanical effect.

(4) The next step was to ascertain whether there was any delay between the communication of a P.D. to the electrometer, and the commencement of the movement of the meniscus.

This was done by photographing a normal excursion in the manner already described, although not with that apparatus, which had not then been constructed. An examination of the photograph showed that the fall of the signal was synchronous with the commencement of the excursion.

The signal key was then arranged to actuate a rheotome, by which short currents of known duration were thrown into the electrometer. The photographs obtained showed that with such differences of potential as would be employed in practice, the mercury ceases to move directly the source of electromotive force is withdrawn, *i.e.*, the instrument is practically dead-beat.

It has been generally stated that it is perfectly dead-beat, but this is only true of "slow" instruments. A strong condenser charge communicated to a quick electrometer such as I employ, will in some cases cause the meniscus to overshoot its final position of rest by as much as 10 per cent. of the excursion, if there is no resistance in circuit. But the insertion of 50,000 ohms makes it dead-beat, without seriously reducing the rapidity of the action. Overshooting is more marked with the condenser charge than with rheotome experiments. The legitimate conclusion to which these observations tend is that in practice *the meniscus commences to move the instant a potential difference is communicated to it, and stops directly it is withdrawn.* Moreover, the movement commences quite suddenly. No trace can be detected, even with a lens, of gradual acceleration. The inference follows that "*the velocity of the meniscus at any moment must be some function of the accelerating force at that moment*," *i.e.*, it is independent of any previous motion and contributes nothing to the velocity with which it moves during the next interval.

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MSS. received October 17, 1895.

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It remained to determine the form of this function. This I did in two ways, with electrometers differing as widely as possible.

For "slow" instruments I employed the method of direct observation with the rheotome already referred to. The potentiometer was arranged so as to give with 150mm. of wire a total excursion of 126 divisions of the eyepiece micrometer. The rheotome was then switched on to the circuit, and the period of closure adjusted until it produced an excursion of exactly half the previous extent—namely, 63 divisions. This required a closure of 0·414sec. The rider of the potentiometer was then shifted to 50mm. This gave, with the constant current, an excursion of 42 scale divisions, and with the rheotome 21 divisions. With the rider at 25mm. the total excursion was 21 divisions, and that given by the rheotome 10·5 divisions. The experiments were repeated with the direction of the currents reversed and with other electrometers, and the results were similar.

There is one simple function that fulfils these conditions.

Let $y$ = the distance through which the meniscus has to move before reaching its position of rest under the action of a constant current.

Let $x$ = indefinite time required to complete the excursion. Then, if $x$ and $y$ be so related that

$$\log y = -c\,x,$$

we shall have

$$\log\left(\frac{y}{2}\right) = \log 2 - c\,x;$$

that is to say, the time occupied in tracing the *first half* of a curve having $x$ and $y$ for its co-ordinates will be independent of the initial values of both $x$ and $y$.

I had not expected to find so simple an expression for the time relations of the excursion, and it still remained to be seen whether in the more rapid electrometers used for photography the same relation would hold good. I accordingly took a number of photographs of normal excursions, using first the hydraulic motor, and afterwards the more perfect pendulum machine.

The results are embodied in my Paper, "On the Time Relations of the Capillary Electrometer," published in the *Philosophical Transactions*, Vol. 183A, p. 81.

Briefly, it may be stated that although the complete expression for the time relations of the excursion is very complicated, it is easy to select instruments in which the two principal sources of error neutralise each other, and that these instruments fulfil the following laws*:—

1. The distance of the meniscus from its zero position at any instant is proportional to the P.D. of the charge contained in it at that instant.

2. The velocity of the meniscus at any instant is proportional to the difference between the E.M.F. of the external circuit at that instant, and the E.M.F. of the charge already contained in the electrometer.

3. In all cases in which the action is dead beat, the algebraic sum of the P.D. represented by the distance through which the meniscus has already moved, and that indicated by the velocity with which it is still moving, equals the total E.M.F. acting upon the electrometer at that instant.

This law holds good during the most rapid changes in the direction and intensity of a current.

I now come to the most important part of my discovery, viz., the method of analysing the photographic records and expressing in volts the variations of E.M.F. indicated by the electrometer.

I shall here deal only with the method as it relates to the curves obtained with the pendulum machine, because with these the process is more simple and more accurate. The principle of the operation is shown in Fig. 10, and the measuring machine itself will be shown in Figs. 12, 13 and 14.

Since the plate is carried through a circular arc, and the capillary coincides with a line passing through the centre of motion, the curve given by the excursion is most naturally expressed in polar co-ordinates. In Fig. 10, $o$ is the pole and $o\,r$ the radius vector, the plate A B being supposed to move from right to left. The position of a point $p$ upon the curve is given by the length $o\,p$ and the angle $q\,o\,p = \theta$, through which the plate has moved since the arbitrarily selected initial point $q$ passed the fixed line $o\,r$. The dotted line $c\,c$ is called the reference circle. It corresponds to the upper limit of the slit, and being sharply defined on the negative is used to measure from. The dotted line $z\,z$ is the circle of zero-potential on which the point $q$ is situated.

At the point $p$ the excursion has already commenced. It is required to find the E.M.F. acting on the electrometer at that instant, and two operations are necessary.

($a$) Measure the distance through which the meniscus has already risen. This is done by turning the plate about the centre $o$ till the initial point $q$ comes under the line $o\,r$. Let the distance between $q$ and the reference circle be $c\,q$ millimetres. Measure $c\,p$ in the same way. Then

$$c\,q - c\,p = \Delta\,r,$$

where $\Delta\,r$ is the distance through which the meniscus has already risen in millimetres.

But each millimetre of rise or fall of the meniscus corresponds to a certain P.D. easily ascertained once for all by calibrating the electrometer. Let $k$ be the factor which turns scale-readings into volts. Then the portion of the E.M.F. indicated by the rise that has taken place,

$$v = k\,\Delta\,r \text{ volt.}$$

($b$) The remainder of the E.M.F. is indicated by the velocity with which the meniscus was moving at the point $p$. As the angular velocity of the plate is constant, the time $t$ is directly proportional to $\theta$, and the velocity of the movement of the meniscus is the differential $d\,r/d\,\theta$. But this, by a well-

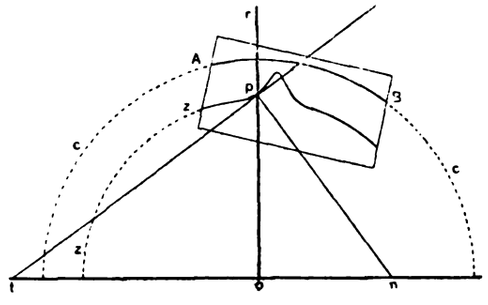


FIG. 10.—Diagram to Explain the Theory of the Subnormal.

known property of polar curves, can be easily ascertained. Draw $p\,t$ tangent to the curve at the point $p$, and draw $p\,n$, the normal, at right angles to the line $p\,t$. Through the pole $o$ draw a line at right angles to $o\,r$, cutting the normal at $n$. The line $o\,n$ is called the polar subnormal, and

$$o\,n = d\,r/d\,\theta = \mathrm{N}.$$

In other words the length of the subnormal N is directly proportional to that portion of the E.M.F. indicated by the velocity with which the meniscus is moving at the point $p$. And if $l$ be the factor which turns subnormal scale-readings into volts, we have for the total E.M.F. at the point $p$

$$\mathrm{V} = k\,\Delta\,r + l\,\mathrm{N}.$$

It is necessary to observe the signs of both terms of this expression. At the apex of the curve, where the tangent is horizontal, the sub-normal is reduced to zero, and then only is the total E.M.F. directly proportional to the extent of the excursion. But on the descending portion of the curve the sub-normal passes to the left side of the pole, and the formula becomes

$$\mathrm{V} = k\,\Delta\,r - l\,\mathrm{N},$$

and before the mensicus has descended $\frac{1}{2}$mm. the opposite P.D. indicated by its downward velocity may be greatly in excess of that corresponding to its position. Should this state of the circuit continue the meniscus would descend below the zero line, when the formula would be $\mathrm{V} = -\mathrm{K}\,\Delta\,r - l\,\mathrm{N}$.

*(To be continued.)*

* Since my results were published, Prof. Einthoven, of Leyden, has arrived independently at the same conclusions, and I desire to acknowledge his courteous recognition of my claims to priority in the matter.—G. J. B.

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## ENERGY LOSSES IN ELECTRIC MACHINES DUE TO THE ARMATURE CURRENT.

BY OTTO T. BLÁTHY.

During the last few weeks I have had an opportunity of making detailed experiments on the load-loss of a typical dynamo, the results of which, together with certain conclusions, I give in the following.

Two perfectly identical continuous-current machines, type C. 40, by Ganz and Co., were joined by direct coupling, one of them acting as motor and the other as generator. The characteristic data of these machines are: Type C. 40, 110 volts and 400 amperes, at 450 revolutions per minute; six poles, each covering 185mm. of the circumference; armature cores, 500mm. in external diameter, and 300mm. internal diameter; axial length of armature, 400mm.; bore of magnets, 512mm. The armature is provided with 96 grooves, 30mm. deep, 7·5mm. wide, each groove containing four wires of 5·6mm.; 32 coils give 110 volts. The winding is perfectly symmetrical, and there are 96 sectors on the commutator.

Resistance of the armature at 27°C = 0·006 ohm.
Resistance of the shunt circuit = 19 ohms.
Maximum exciting current = 4·2 amperes.

At 450 revolutions and 110 volts, and with 405 amperes in the armature, the energy-losses are distributed as follows:—

| | |
|---|---|
| Friction and air resistance ..... | 730 watts. |
| Hysteresis and eddy currents (no load) | 880 ,, |
| Excitation ..... | 460 ,, |
| Ohmic loss in armature ..... | 985 ,, |
| Load loss ..... | 740 ,, |

This makes the efficiency of these dynamos at full load 92 per cent., which is increased to 93·5 per cent. by leaving out the load-losses.

A series of tests was made on this machine in order to determine the relation of the load-loss to the current in the armature circuit, to the speed, and to the field. First, one of the machines was employed as a motor and the other short-circuited and only very feebly excited, so as to obtain the armature currents corresponding to the short circuit. In a second experiment the two armatures were connected in series, the one working as motor and the other as dynamo, with the same current, the energy consumed being restored by a third dynamo with its armature also in the circuit of the other two machines, after the method first described by Dr. Hopkinson. In this way the losses of energy are measured direct, and a far higher accuracy is attainable than by measuring the total energy supplied to the motor and given out by the dynamo. The pressures of motor and dynamo were arranged so that their mean was 110 volts. The subjoined table gives the probable means derived from a long series of tests:—

| Revolutions per min. | Armature current $i$ amperes. | Ohmic armature loss $r \cdot i^2$*. | Local loss B V. | $\frac{B V}{r \cdot i^2}$ | Remarks. |
|---|---|---|---|---|---|
| 154 | 410 | 1,040 | 350 | 0·34 | Armature short-circuited. |
| 136 | 590 | 2,150 | 1,050 | 0·49 | |
| 280 | 410 | 1,020 | 760 | 0·74 | |
| 287 | 570 | 2,000 | 1,500 | 0·75 | |
| 455 | 400 | 960 | 1,140 | 1·19 | |
| 446 | 570 | 2,000 | 2,300 | 1·15 | |
| 540 | 410 | 1,050 | 1,450 | 1·38 | |
| 590 | 590 | 2,180 | 2,970 | 1·36 | |
| 266 | 422 | 1,070 | 460 | 0·43 | At 110 volts. |
| 345 | 395 | 940 | 550 | 0·58 | |
| 468 | 375 | 850 | 660 | 0·78 | |

An inspection of the table shows: That the load-loss is nearly proportional to the square of the armature current; that it is nearly proportional, other things being equal, to the speed of the machine, with both feeble and normal fields; that the load-loss is considerably higher with a short circuit and feeble field than with normal pressure and a strong field.

These results justify a conclusion regarding the nature of the load-loss. It appears to be work spent in reversing the magnetisation of the iron, and consists of Foucault currents and hysteresis. For the sum of these would theoretically increase as the 1·75th power of the current, and slightly more rapidly than the rate of alternation of the poles. It would naturally be smaller in a mass of iron already magnetised by other influences (in this case the field due to the magnets), than when only the armature currents producing the loss are in operation.

* In calculating $r \cdot i^2$ the small changes of $r$ due to temperature are not taken into account.

## THE USE AND ECONOMIES OF RECTIFIERS FOR ARC LIGHTING.*

BY JOHN HESKETH.

The first practical use of electrical energy for lighting purposes was by means of arc lamps, and this method still remains to-day the most economical means of lighting possible in the present state of our knowledge. It is only reasonable, therefore, to expect that the theory and practice of arc lighting, and the knowledge of the arc lamp with its accessories and special plant, should be the most fully developed and perfected of all our electrical knowledge. But such, unfortunately, is not the case. Of all the existing systems of arc lighting, whether public or private, scarcely one exists in which some glaring inefficiency does not appear. The fact that we have all known of this lamentable condition of affairs for many years in a dim uncertain way has perhaps hardened our hearts, and made us condone a technical sin, sanctioned by common consent.

Perhaps too, the fact that, until recently, arc lighting has not been very largely adopted in England has influenced our views; the result, from whatever cause, has been that, speaking broadly, the thought and care given to machines, systems, and schemes for incandescent lighting has not been extended, except in a half-hearted way, to arc lighting. In England arc lighting has been a side show, and incandescent lighting the main purpose of electricity works; and even in America, where in many stations the order is reversed, the inefficiencies still exist—but it is only fair to admit, in a greatly reduced degree.

It is not with any intention to discuss the whole of this problem that the present Paper is undertaken, but only to detail recent experiences in the use of one special form of apparatus and system of generating the necessary energy. The question of distribution and utilisation of such energy in arc lighting is sufficiently wide to form matter for Papers for a complete session. In special reference to the subject of this Paper, it is interesting to note that the first arc lamps used in French lighthouses were supplied from alternators fitted with commutators, and so were virtually rectified current arc lamps.

In the earliest installation of public arc lighting plant in England, of which I think Blackpool was the first example, the practice was to run each lamp from a separate machine; so that, in such a station, one or more engines running on to a counter-shafting drove the dynamos and exciters. Each dynamo feeding its own arc lamp through a separate lead, and a common uninsulated and buried return. That such a system of generation was most inefficient is very apparent—the system of distribution and utilisation of light was perhaps equally so; and it was not long before the system, not only of distribution, but of generation, was altered completely. Installations of arcs connected in series and run from special machines, such as Brush or Thomson-Houston, began to appear, and although the machines were admittedly inefficient, and in their ordinary sizes have not been much improved, they still continue to be most generally in use. We are aware that recently the efficiencies obtained in America by the use of 50 to 55 kilowatt Brush dynamos (100 to 110 arc machines) has risen considerably above any known in England, but the conditions of practice there are widely different from those in England.

The need for a public supply of incandescent lighting led, in one or two instances, to the expedient of running incandescent lamps in series with arc lamps from Brush machines, but as the demand for private lighting increased much more rapidly than that for public lighting, separate machines and systems gradually were adopted, and the question of generation for series arc lighting was allowed to lapse for a while. But recently, the fact has been recognised that two different types of generating plant being allowed to exist in one building for purposes which could very well be fulfilled by one, was most illogical and inefficient, and has resulted in a reopening of the question. This is assisted by the fact that the arc lamp is at last being recognised as the only rational means of public lighting, and its use is therefore being very rapidly extended.

On continuous-current supply systems, the problem of arc lighting is not difficult of solution. The ordinary network has its coefficient of service increased by connecting the public lighting to

* Abstract of a Paper read before the Northern Society of Electrical Engineers.

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it, but in alternating-current supplies the case is different. The alternating-current arc lamp is not so efficient a generator of light as the continuous-current arc. The reasoning of Prof. Forbes in his recent Cantor lectures to the contrary is very interesting; but as it is in direct conflict with the results of all experiments hitherto made, we are bound to confess that, in the present state of our knowledge, the alternate-current arc is not so efficient for public lighting as the continuous current. The examples of public lighting by alternate-current arcs, which have been recently carried out in various places, may be excellent in themselves, but comparatively their efficiency is not equal to that of continuous-current arcs.

This is so far as we at present know. The investigations being carried out by many authorities on this subject may result in the discovery of a more rational proportion between current strength and size of carbon or other factor which may influence the luminous efficiency, but for the present we will discuss matters as they are. The blue tinge of the alternating arc is an objection which may be got over by colouring during diffusion, or alteration in the constitution of the carbons.

Among the possible solutions are the following:—(*a*) Alternate-current arcs with a separate transformer for each lamp; (*b*) arcs three in series off 100-volt network or separate transformer for three arcs; (*c*) any number of arcs in series off an alternate-current transformer giving varying voltage and constant current and delivering alternate currents into the lamps; (*d*) as in *c*, but with commutator or rectifier in the secondary circuit so that pulsating currents are delivered into the lamps. But the inefficiency of the alternating-current arc will veto the adoption of the solutions *a*, *b*, or *c*, unless the efficiency of one generating plant over two is so great as to justify the consequent loss in utilisation. The fact that the first two systems have been practically adopted and the third suggested, is evidence of the feeling that an advantage is to be gained by having only one type of generating plant.

All these reasons speak with even greater force in favour of the solution *d*, for in addition to every economy gained by systems using only one type of generating plant, it possesses the great advantage of giving arc lamps having a photometric curve very approximately equal to that of an ordinary continuous-current arc. Having gone thus far into the reasons for the adoption of a rectifier it may be well to describe the apparatus, and discuss the various points arising from its use.

*Description of a Rectifier for Arc Lighting.*

The rectifier consists of two points—a constant current transformer and a synchronous motor on which is fixed the rectifier commutator. A transformer, with switches for regulating the secondary voltage, drives the synchronous motor The two primary coils are fixed on to the horizontal limb of the iron circuit. The four secondary coils are movable, and on either side of the fixed primaries. Counterpoises are fixed to the suspending rods of the movable coils, so that the repulsion between the primary and secondary is just balanced when the normal current is given out by the secondary—any increase tends to make the movable coils widen out and a decrease allows them to close together again. The nett result is that the varying current at constant pressure, which is sent into the primary, is transformed into a constant current at varying voltage in the secondary. But this current is still alternating; so it is led to the commutator fixed on the end of the motor shaft. The brushes are adjustable by hand, and are so set that the current is commuted when it is at zero. As has already been stated, this shape of current is quite suitable for arc lamps, and allows them to derive all the advantage of continuous currents while the uniformity of plant in the generating station is maintained.

The most natural divisions into which a consideration of the uses of the rectifier falls are:—1. Efficiency of rectifier, *per se*, both apparent and real. 2. Influence of rectifier on the total efficiency when used in conjunction with private lighting plant. 3. Effect of rectified currents on arc lamps, and other points in the practical use of rectifiers, and miscellaneous notes. In considering this question the comparative figures are necessarily taken from Blackpool station, where Brush machines, rectifiers, and alternating arcs, on both simple parallel three-wire and three-in-series systems, are in use. The figures may vary with each particular case, but the broad principle in unchanged.

*Efficiency of Rectifier.*

The apparent efficiency of a rectifier is of almost as much importance as its real efficiency, for if the power factor be low the apparent current being high prevents the generating plant being used at its highest capacity, for it is the current density in the armature which almost always is the measure of a safe load on any machine. It is, therefore, highly important that the power factor of the rectifier should be high. This is, unfortunately, opposed to the attainment of a very high percentage of regulation, for it is equally important that with a varying load from, say, 10 per cent. to full load, the current should remain sensibly constant, and this result can only be obtained by a certain loss of efficiency.

However, in the more recent types of rectifier, an apparent efficiency of 90 per cent. and a true efficiency of 95 per cent., is obtained with good regulation between one-tenth load and full load. The results with the earlier types were not so satisfactory on account of greater attention being paid to regulation than to efficiency, but seeing that on public lighting circuits the load ought never to fall below 50 per cent. of full load, there is no necessity for good regulation below that point except in the case of a blow over on to the secondary commutator, but even in this case the regulation need only be such as to prevent damage to the windings through overheating or fusion of the brushes.

*Influence of Rectifier on the Total Efficiency of a Lighting Plant.*

For a modern steam alternator an efficiency $\frac{\text{E.H.P.} \times 100}{\text{I.H.P.}}$ of 85 per cent. is unusually high.

And as the efficiency of the rectifier complete is 90 per cent. it follows that the efficiency $\frac{\text{Energy in lamps} \times 100}{\text{I.H.P.}}$ is equal to 95 per cent. of 85 per cent. = 80·75. This is looking at it in its barest and least favourable light. If we compare the efficiency of an alternate-current plant and rectifier with a Brush or Thomson-Houston plant, the comparison is still more favourable. The following are results of tests of a Brush 55-lighter set at Blackpool under ordinary working conditions: The engine was a horizontal compound engine by Fowler and Co., cylinders 9in. and 14in. by 16in. stroke, speed 150. The dynamo was a Brush 8 L machine. The indicator cards for this type of engine do not show any abnormal characteristics, excepting want of balance between the high and low-pressure cylinders. This, however, would not affect the efficiency to any great extent.

TABLE I.

| Date. | No. of card. | High pressure. | | Low pressure. | | Total I.H.P. | Volts. | Amp. | E.H.P. | $\frac{\text{E.H.P.} \times 100}{\text{I.H.P.}}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M.E.P. | I.H.P. | M.E.P. | I.H.P. | | | | | |
| July | | | | | | | | | | |
| 25 | 1 | 53·62 | 40·560 | 12·2 | 22·579 | 63·199 | 2,300 | 9·9 | 30·522 | 48·34 |
| — | 2 | 54·75 | 41·410 | 12·45 | 23·042 | 64·452 | 2,300 | 9·9 | 30·522 | 47·35 |
| — | 3 | 55·00 | 41·600 | 12·58 | 22·299 | 64·899 | 2,300 | 10·0 | 30·831 | 47·507 |
| — | 4 | 55·50 | 41·979 | 12·45 | 23·042 | 65·021 | 2,300 | 9·8 | 30·214 | 46·469 |
| — | 5 | 53·57 | 40·518 | 12·58 | 23·299 | 63·817 | 2,300 | 9·8 | 30·214 | 47·346 |
| — | 6 | 55·05 | 41·637 | 12·77 | 23·635 | 65·272 | 2,300 | 10·0 | 30·831 | 47·235 |

Mean efficiency 47·37 per cent., as against 80·75 per cent. for rectifier and alternator. I am quite aware that the results are low. Indeed they have been exceeded at Blackpool, where the same plant when new gave slightly better results. The difference, however, was not more than 5 per cent. The efficiency of some American plants using larger sizes of Brush machines is as high as 75 per cent. But this is exceptional.

But the comparison is by no means ended here. As already indicated, 55-lighter (30 kilowatts) arc machines are about the largest generally in use in England, and such a dynamo rope driven from an ordinary engine takes up a floor space of about 500 sq. ft. This is leaving a space 2ft. wide round the plant for attendance. Such a plant direct driven would take up only 220 sq. ft., or 16 sq. ft. and 7 sq. ft. per kilowatt respectively. A modern 300-kilowatt steam alternator would occupy 500 sq. ft., or 1·6 per kilowatt. If space for 300 kilowatts of rectifiers be included this will add 200 sq. ft. to the last figure, and make the gross space per kilowatt 2·3 sq. ft. The importance of this point is most apparent. The fact that a power equal to 10 55-lighters can be generated by one steam alternator and attended to by one man is another.

So far the arguments have been confined to those in favour of rectifiers *versus* other types of machines for series arc lighting only. The next point worthy of consideration is that, the load of the rectifier being dealt with by the energy lighting plant, its efficiency should really be $\frac{\text{Energy in arcs}}{\text{Added energy in engines}}$.

For example, suppose a station to have a load of 200 kilowatts, and to have 100 kilowatts in rectifiers added. The true measure of the efficiency should be not $\frac{300 \text{ k.w.}}{\text{I.H.P.}}$, but $\frac{300 \text{ k.w.} - 200 \text{ k.w.}}{\text{I.H.P.}_2 - \text{I.H.P.}_1}$. Where $\text{I.H.P.}_1$ is the I.H.P. to drive the ordinary load, and $\text{I.H.P.}_2$ to drive the combined loads.

*Effect of Rectified Currents on Arc Lamps.*

Rectified currents, when sent through circuits having self-induction, produce effects intermediate between those observed with direct and alternating currents. To observe the extent of this effect the following experiment was carried out with the results tabulated. A measured current was sent through a choking coil and the voltage at the terminals of the coil noted. With a current of 9·52 amperes flowing the voltage at the terminals of the impedance coil were—For continuous current from a Brush machine, 5·76 volts; for alternating currents 83 volts per second from an

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E.C.C. alternator, 83 volts; for the above currents rectified, 57·5 volts. It therefore follows that in arc lamps intended for use with rectified currents main cores should be laminated and the bobbins split. It is not necessary that this be done for the shunt coils. The "pull" on the core is rather less and more sluggish than with a continuous current, so that a fresh adjustment requires to be made. The lamps are also perceptibly longer in "striking" than with continuous currents.

The illumination from a rectified arc lamp is not perceptibly different from that of a continuous-current arc.

*Effect of Rectified Current Series Arc Lighting Circuits on Telephones.*

There is an undoubted influence on telephone circuits when rectified currents are used in series circuits as generally arranged. The means for the prevention of such interference are peculiar to each case; but, speaking generally, they are such as apply to the prevention of interference of one telephone line upon another—that is, perfect electrical balance on the circuit, and perfect insulation.

*Maintenance of Rectifier.*

The apparently heavy sparking at the brushes of a rectifier is not so damaging to the commutator as might be imagined; with care the commutator will last quite as long as those of other types of arc lighting machines. Care has to be exercised in the set of the brushes, both on the low-tension or motor end, and on the high-tension or rectified end. The influence of the method of driving the alternator on the motor is very perceptible—with one machine the motor current is as steadily low as possible, while with a small machine, lightly loaded, on which the ropes jump, the motor current has to be set fairly high if steady running has to be obtained. The danger from the use of a rectifier for currents at such high tension, which has been mentioned by one or two people, has not shown itself in practical use with us. The maintenance of the apparatus has been a matter of much greater ease and economy than of any other arc-lighting plant in the station. This is not difficult to understand, as only two coils are movable, and these need not move more than 6in. a day. Excellent insulation is obtained, and altogether there is every facility for easy maintenance.

*Conclusion.*

It is with the hope that a discussion on the various systems of generation for arc lighting may be opened that this Paper has been prepared. It is undoubted that there are more inefficiencies in our present arc-lighting systems than in any other branch of electrical engineering, and the most lively satisfaction of the writer will be experienced if a closer investigation into all the details of this most important branch is provoked.

## ELECTRIC LIGHTING IN BELFAST.*

BY VICTOR A. H. McCOWEN.

Belfast, like many other large centres, was slow to make advances towards the adoption of a system of electricity supply, the chief reason being that the Corporation preferred that others should experiment, and that they themselves should profit by the experience thus gained. The Belfast Corporation, being the owners of the gas works, and justly proud of the reputation they had gained of having their thoroughfares well lighted by gas, and the undertaking being also a paying concern, had no intention of allowing private companies to occupy the field. No fewer than seven of the latter in 1882 served notice of their intention to apply for provisional orders for power to supply electricity within the city. All these applications were successfully opposed; the Corporation remained in possession, and for seven years no further active steps were taken. During these seven years the output of gas had risen from 615 million cubic feet in 1882 to 907 million cubic feet in 1889, and absolute necessity was shown for the extension of the gas works to cope with the enormously increased consumption. A great difficulty arose as to where a suitable site for that extension could be found. The Gas Committee were thus led to consider the question of the introduction of electric lighting. In September, 1889, they reported that in their opinion the time had arrived when the Council should obtain powers to supply electricity for lighting purposes, &c., within the city, and they also recommended that authority should be given to apply to the Board of Trade for a provisional order for that purpose. Application was duly made and granted, the necessary power being contained in the Belfast Electric Lighting Order, 1890, and by the Belfast Corporation Various Powers Act, 1890. The Gas Committee were authorised to pay £50,000 out of the surplus profits of the gas undertaking towards the establishment of the electric light. Mr. James Stelfox, engineer and manager of the gas works, reported to his Committee regarding the proposed extensions, that "it must remain with the Committee to decide to what extent they would anticipate the success of the electric, or any other method of lighting, resulting in a decrease in the demand for gas. . . . . I believe that as yet the use of electricity in any place has never resulted in a lessened demand for gas, and I see no reason to believe that such a result is now probable." The Gas Committee subsequently reported to the Council that they had had under consideration the question of the introduction of lighting by electricity, and that, taking into account the importance of the matter, they recommended the Council to appoint a special committee to procure all the information requisite for the guidance of the Council thereon, and to draw up a report embodying the same. This committee was appointed, and, after visiting the principal electrical installations in and around London and the Electrical Exhibition at the Crystal Palace, reported in October, 1892, in favour of the establishment of an installation of 10,000 lamps of 8 c.p., with room for extension. It was next decided to obtain the assistance of a consulting engineer, and Prof. Alexander B. W. Kennedy, F.R.S., of London, was appointed. On account of the saving in capital cost, and other circumstances of the case, he recommended the system about to be described.

*Area supplied.*—The area at present supplied with electricity in Belfast comprises probably the best part of the city. It includes first-class shops and offices, hotels, clubs, theatres and churches; and in Howard-street and College-square private houses. The following table gives the percentage in lamps connected of different classes of consumers.

| | % | % |
|---|---|---|
| Shops, closing late | 8 | |
| „ „ early | 30 | |
| „ „ „ but late on Saturday night | 25 | |
| | — | 63·0 |
| Offices | | 11·0 |
| Hotels and clubs | | 6·0 |
| Theatres | | 12·0 |
| Churches | | 4·8 |
| Private houses | | 2·0 |
| Motors | | 1·2 |
| Total | | 100·0 |

As shops and offices together form a large percentage of the total consumption, the shape of the load curves depends greatly on their hours of closing. The Saturday curve shows the effect of the late closing of some shops, a much better load being then given, with no very objectionable peak. The distance of the farthest lamp from the station is as yet only about 800 yards, as the present area supplied with electricity is only a small part of the city. There is no doubt that, when mains are laid in the residential districts, the load curve will be greatly improved. A good motor day-load is looked forward to in course of time, as there is no doubt respecting the several advantages of electric motors, more especially to small users of power, and where the power is required intermittently. Up to the present the question of street lighting has not been considered.

*Mode of Distribution.*—The system of distribution is what is known as the three-wire low-tension. The current is supplied to consumers at 110 or 220 volts pressure. The distributing mains are connected up in a network, and fed at seven points by feeders from the generating station. The feeders deliver the current at the feeding points of the distributing mains at a pressure of 220 volts. The drop in the feeders at full load is 10 per cent. The pressure between the middle wire, coloured black, and the positive or negative is 110 volts. Pilot wires, dotted black, are connected from the feeding points to voltmeters in the generating station, so that the switchboard attendant can always see what the pressure is at these points, and keep it constant by due regulation.

*Charges and Pressures.*—The charge for current for lighting is 7d. per Board of Trade unit, with discount ranging from 2½ to 17½ per cent. according to consumption; the maximum discount reduces the price to 5·77d. per unit. The charge for current for motors, heating, &c., in daylight hours, is 4d. per unit with the above discounts, of which the maximum reduces the price to 3·3d. per unit. Meters range upwards from 2s. 6d. per quarter, according to size. Installations containing over 50 lamps of 8 c.p. are wired either with single 220-volt lamps, or with pairs of 110-volt lamps in series, or on the three-wire system. Motors of over 1 H.P. are supplied with current at 220 volts. The meters in use are those of the Ferranti type.

*Station.**—The generating station is situated between Chapel-lane and Marquis-street, within 250 yards of Castle-place, which is practically the centre of the city; it is therefore a good position from which to distribute the supply. In the selection of the site the question of convenience for delivery of coal, removal of refuse, &c., had not to be considered. The buildings were designed by Mr. C. Stanley Peach, of London. The shape of the site is rather irregular, and the space available has been made use of to the best advantage.

* Abstract of a Paper read before the Institution of Mechanical Engineers, at Belfast.

* An illustrated description of the Belfast gas-engine station will be found in *The Electrician*, Vol. XXXV., p. 410.

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The engine room occupies the central and larger portion of the site, and measures 85ft. long by 33ft. wide at the east end, and 44ft. at the west end. A 6-ton overhead travelling crane is provided, all the motions of which are actuated from below by means of ropes. The switchboard platform is raised about 4ft. above the floor level, and runs the whole length of the west wall of the engine room. The battery room, measuring 28ft. square, is situated between the engine room and the offices, on the same level; it contains four rows of stands for the cells, and is provided with ample means of ventilation. The offices occupy the west end of the site, with frontage to Marquis-street. The meter-testing room and store room are above the offices on the first floor. A fitting shop and driver's room are placed at the east end of the building; and above them is the cooling tank, measuring 34½ft. by 12½ft. and 4ft. 2in. deep. Owing to the absence of anything like solid foundations to build upon, the whole site was piled with 480 piles of 35ft. length. A 3in. memel flooring was secured to the pile heads, and on this was placed concrete to a depth varying from 3ft. to 4ft., to form the engine beds and the foundation for the walls of the building.

*Engine Room.*—The plant in the engine room consists of the following engines and dynamos. Four 120 I.H.P. tandem double-acting horizontal gas engines, running at 160 revolutions per minute, and driving, through eight ⅞in. diameter cotton ropes, four 57·6 kilowatt dynamos of 240 amperes and 240 volts at a speed of 600 revolutions per minute. Two 60 I.H.P. single-cylinder double-acting horizontal gas engines, running at 160 revolutions per minute, and driving through eight ¾in. diameter cotton ropes two 26·4 kilowatt dynamos at 750 revolutions per minute. Two 150 I.H.P. four-cylinder single-acting high-speed vertical gas engines, running at 380 revolutions per minute, coupled direct to two 72 kilowatt dynamos of 300 amperes and 240 volts.

*Switchboard.*—The switchboard consists of five slates, each about 7ft. high; the centre one is 36in. wide, and the others 32in. All are bolted to an iron frame-work, fixed on the switchboard platform about 4ft. from the engine-room wall. The centre slate carries the feeder and omnibus-bar voltmeters, the battery instruments and regulating gear, and the middle-wire ammeter and connections. The other four slates carry the feeder and dynamo instruments, switches, &c.; the two on the left-hand are for the positive side of the system, and the two on the right-hand for the negative side.

The machine and feeder bars, which are the vertical bars on the outer slates, are fixed on the front; and each is provided with three holes, through which a plug can be inserted to make connection with any one of the three omnibus bars that are fixed horizontally at the back of the board. From the feeder-fuses to the point where they leave the station the feeders are brought in the form of bare solid copper rods supported on insulators, which are fixed behind the match-boarding at the south side of the engine room. The machine bars are side by side with the feeder bars, and the connections to the machine ammeters and automatic switches are at the back. The leads from the dynamos consist of insulated cables, which are brought along behind the match-boarding at the north side of the building. The automatic switches are arranged to break circuit, should the current from the machine fall below 10 amperes. The shunt change-over switch is shown above the automatic, and connected with it by an interlocking lever. An ampere-hour meter is connected in the circuit of each dynamo, and registers the work done during a run, the readings being taken at start and finish. The voltmeters are Kelvin multi-cellular electrostatic, and are provided with multiple-contact switches. The feeder voltmeters show the pressure at any feeding point between the middle wire and the positive and negative wires. The bar voltmeters show the pressure between the positive and negative omnibus bars, and also between the middle wire and any of the omnibus bars. The dynamo voltmeters are used for showing the voltage of the machines before putting them on to the circuit.

The batteries are connected through their ampere-hour meters, polarised ampere meters, and emergency switches, to the top omnibus bars. The usual practice at full load is to have all the machines and feeders plugged in parallel on this bar; but should it be necessary to run any particular pair of feeders at a different voltage, this can be done by plugging that pair of feeders and a machine on the bottom omnibus bar. As a matter of fact it has never been required to run a separate machine on a separate pair of feeders, as a very even drop all round is obtained. The starting resistances and the shunt resistances are fixed in the cellar beneath the switchboard. The shunt regulating switches are fixed on the handrail of the switchboard.

*Battery.*—The battery consists of 126 cells of the Electric Power and Storage Co.'s 34 K or heavy-discharge type: 63 cells for the positive side of the system and 63 cells for the negative. The capacity of each cell is 500 ampere-hours, at a discharge rate of 100 amperes; the battery will, however, give a much higher rate of discharge for short periods. The plates are contained in lead boxes, which are supported on wooden stands, being insulated from the latter by means of glass oil insulators. There are also eight hospital cells, which can either be used for assisting weak cells, or be put in series with the main battery. The connections from the battery to the regulator and switchboard consist of bare copper rods supported by oil insulators suspended from the roof. The method of regulating the battery is different from that usually practised, by cutting in or cutting out end cells. The regulation here is accomplished by putting the cells at the middle-wire end of the positive battery in parallel with those at the middle-wire end of the negative battery; the other ends of the batteries being connected through ammeters and emergency switches to their respective omnibus bars. The regulator is placed in the battery room, and is worked from a handwheel on the switchboard by means of a rack and pinion. A reversible ampere-hour meter, which registers both charge and discharge, is connected in each battery circuit.

*Dynamos.*—The dynamos are by Messrs. Siemens Brothers, double-pole with drum armature and shunt-wound. The rope-driven machines are provided with heavy flywheels, and the larger ones have three bearings. The two small 26·4-kilowatt machines have double-wound armatures, each winding connected to a separate commutator. By means of a plug-board the armatures can be put in series or parallel, so that the machines can be run at 110 to 120 volts for balancing, or at 220 to 240 volts across the system. The voltage can also be increased to 270, if required. The rope-driven machines are placed close up to the back end of the back cylinder, to save floor space; and backward driving has been adopted in order to get the slack of the ropes at top.

*Gas Engines.*—The six horizontal gas engines were manufactured by Messrs. Dick, Kerr and Co., Kilmarnock, under Hartley and Kerr's system. The four larger are double-cylinder double-acting with the cylinders working tandem and the two pistons on the same rod, which is connected through crosshead and connecting rod to the crank. The bore of the back cylinder is 13¾in., and of the front 13½in.; the stroke is 20in. The flywheel and driving wheel, one fixed on each end of the crank shaft, are each 8ft. 5in. diameter, and weigh 37cwt. and 29cwt. respectively; the driving wheel is grooved for eight ⅞in. ropes. These engines run at a speed of 160 revolutions per minute, and indicate 120 H.P.; the number of explosions per minute is 320 or two per revolution. The two smaller engines are single-cylinder double-acting; the cylinder is 13½in. diameter and 20in. stroke. They run at 160 revolutions per minute, and indicate 60 H.P. The number of explosions per minute is 160, or one per revolution. The flywheel and driving wheel are each 7ft. diameter, and each weighs 57cwt. The cyclical variation in the speed of the tandem engines is very small, owing to the number of explosions, their low initial pressure, and their even distribution, the number of explosions being as 4 to 1 in comparison with a single-cylinder, single-acting engine. The impulses occur in the following order: –

| | | | | | |
|---|---|---|---|---|---|
| 1st, Front cylinder, | Front end, | angle of crank | ..... | 0deg. |
| 2nd, „ | „ | Back „ | „ | ..... | 180 „ |
| 3rd, Back „ | Front „ | „ | ..... | 360 „ |
| 4th, „ | „ | Back „ | „ | ..... | 540 „ |

There are thus four complete Otto cycles in two revolutions; and this working is continued right through the whole range of the engine load.

*Governing.*—The method of governing is different from that usually adopted of missing an explosion. With these engines the impulses are continuous, and are graduated according to the load in the manner about to be explained. With the tandem engines it is at once seen that very steady working may be attained without running at a high speed. These engines were originally intended to work down to one-third of full load without missing an explosion; and it was thought that at lighter loads an explosion might be missed, and still sufficient steadiness be maintained. It was found, however, that the missing of an explosion at light loads affected the steadiness too much; and the adjustment of the engines was then taken in hand under the immediate personal supervision of Mr. Hartley, with the result of obtaining finely graduated impulses, such as the writer believes have previously been unknown in gas engines. The engines are now capable of working from 20 per cent. overload down to no load, without missing an explosion. At no load the initial pressure is 60lb. per square inch; the pressure when the piston is at half-stroke is 20lb.; and the terminal pressure is 3lb. The word "explosion" seems here somewhat misapplied when on considers the extremely low steady pressure all through the stroke.

*Graduation of Explosions.*—The difficulty to be overcome was the prompt ignition of the charge without initial shock, and under the difficult conditions of a rich charge varying down to an extremely poor one; and also to reduce the terminal pressure by more complete combustion in the cylinder. The quantity of air supplied to the cylinder is practically constant; the quantity of gas only is varied, and hence the difficulty of ignition. It is well known that a poor mixture of gas and air ignites slowly. The method adopted appears to indicate that stratification actually takes place in the gas-engine cylinder, and that for certain purposes it may be rendered of great use. The regularity of the ignition was attained by admitting gas to the cylinder later and later in the charging stroke;

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and even at full power a considerable quantity of air is drawn into the cylinder before gas is admitted. At light loads this results in the cylinder being almost full of air immediately following the piston, with only a small portion of rich and explosive mixture near the ignition chest. The ignition is controlled by a timing valve, which opens always at the same point of the stroke.

The gas charge is varied by a novel device, which is controlled by the governor. The gas valve is worked by an expanding cam, which may be described as an ordinary gas cam divided into three leaves in planes at right angles to the axis of the cam shaft. These three leaves are capable of being spread or closed by a sliding key, which slides in a keyway cut in the cam shaft, and is controlled by the governor. A helix upon the key engages the leading leaf of the cam ; and when the key is moved longitudinally along the shaft in either direction by the governor, the cam is spread or closed as the case may be. The third leaf is fixed on the shaft, the middle leaf being loose on the shaft and having a slot in which works a pin fixed on the leading leaf. The key and cam are held in position by a detent, during the opening of the gas valve ; but immediately it is fully opened the detent is released, leaving the cam again under the control of the governor. A Buss governor is employed, and the gas-valves are gridiron slide-valves ; all other valves are of the mushroom type.

*Ignition.*—The method of ignition is by hot tubes, which are of ordinary wrought iron, nickel steel, and porcelain. The economical life of the wrought-iron tubes is found to be rather short ; after about 15 hours the tube gets partially choked up, and gives late firing.

*Lubrication and Packing.*—The cylinders are provided with valve lubricators opening inwards ; the oil is drawn in during the charging stroke. Asbestos packing is used for the piston-rod glands, and no trouble has occurred with hot rods, notwithstanding the high temperatures to which they are exposed ; they are as bright and clean as those of a well-kept steam engine. The lubricant is ordinary gas-engine oil.

*Cooling Water.*—The cooling water from the overhead tank is circulated by means of small centrifugal pumps driven by belt from the crank-shaft of each engine. The evaporation is made up through a ball-cock valve connected with the tank, and supplied by the town water supply. The town water can also be mixed in any required proportion with the tank water. Separate connections are made to the cylinder covers and jackets ; and regulating cocks are supplied for the necessary adjustments. When returned to the tank the water is discharged into a long timber shoot provided with a number of holes, by which it is broken up into a shower, thus presenting a larger surface to the atmosphere, whereby the cooling is accelerated. This plan has been found of distinct advantage ; and on few occasions has water been required from the town supply, even when running four or five engines together. The capacity of the tank is 10,700 gallons at 4ft. depth.

*Gas Supply.*—The gas is supplied through an 8in. branch from the Corporation gas mains, brought into the station at the Chapel Lane end and connected to three 500-light dry meters ; the three are connected in parallel, and each is provided with a by-pass. The gas is conveyed from the meters through an 8in. main, which runs the whole length of the engine-room, supported by brackets on the columns. Each engine gets its supply from the main through a 3in. branch pipe, provided with a valve and gas bag. The ignition gas is supplied through a separate pipe and meters. The horizontal engines each deliver their exhaust gases through 6in. branch pipes into a common 18in. exhaust main. A silencer is connected between the main and the uptake.

*High-Speed Engines.*—The high-speed vertical engines, manufactured by the Acme Gas Engine Company, Glasgow, have four single-acting cylinders arranged in two lines of two in tandem, working on to opposite cranks. The pistons in the bottom cylinders form guides in the usual manner. The piston-rod, connecting the top and bottom pistons, passes through a water-jacketed cylinder, the packing being ordinary Ramsbottom rings on the rod. The gas valves and mixture valves are of the mushroom type, actuated by means of cams. The piston valves, which control the exhaust and time the ignition, are worked from a small crank shaft fixed on the same level, and are parallel to the main crank shaft, being geared from it in the ratio of 1 to 2 through steel spur and pinion. The cam shaft is also worked from this, through an upright shaft gearing with both.

These engines being of the closed-in type, the base forms an oil chamber in which the crank shaft works. The bottom pistons and the bottom piston valves are lubricated by the splash from the cranks. Lubricators are provided for the top cylinders only. The engine base is extended to take the dynamo, and the crank shaft is coupled direct to the armature shaft. A flywheel of 3ft. diameter is fixed on each end of the crank shaft, the one at the dynamo end weighing 28½cwt. and the other 24½cwt. Each cylinder is fitted with a stop valve, so that the engine can be run on one or more cylinders as desired. Each cylinder is provided with an ordinary pendulum type of governor ; and the usual method of governing, by missing an explosion, is employed. Ignition is obtained by means of the hot-tube. When the engine is running at full load, at its normal speed of 380 revolutions per minute and no explosions missed, 190 impulses per minute are obtained in each cylinder, or a total of 760 per minute in the engine. This, aided by the heavy flywheels, gives a very steady running.

The engines are provided with a separate silencer and exhaust pipe for each line of cylinders. The cooling arrangements are practically the same as with the horizontal engine. Tank water is circulated by means of a centrifugal pump, and there is also a direct connection from the town water mains. Cooling pipes are also fitted to the crank chamber. This kind of engine is specially

TABLE 1.—*Test of No. 6 Tandem Engine and Dynamo. Taken April 24, 1896.*

| No. of test | I. | II. | III. | IV. | V. | VI. |
|---|---|---|---|---|---|---|
| Duration of test .....min. | 30·0 | 30·0 | 30·0 | 30·0 | 30·0 | 15·0 |
| Load factor.....per cent. | 120·0 | 100·8 | 74·8 | 52·3 | 25·2 | exciting |
| Mean speed per min. ...revs. | 166·5 | 167·5 | 168·0 | 166·0 | 168·0 | 167·0 |
| Mean amperes ... ..... ..... | 285·7 | 241·5 | 179·4 | 125·2 | 60·2 | ... |
| Mean volts..... ..... | 240·9 | 240·2 | 240·0 | 240·1 | 240·0 | 240·0 |
| Mean kilowatts..... | 68·8 | 58·1 | 43·1 | 30·1 | 14·5 | ... |
| Mean E.H.P. ..... ... | 92·35 | 77·9 | 57·8 | 40·3 | 19·4 | ... |
| Mean I.H.P..... | 120·5 | 101·4 | 80·2 | 64·4 | 45·0 | ... |
| Kilowatt hours ..... | 34·4 | 29·0 | 21·7 | 15·01 | 7·25 | ... |
| E.H.P. hours ..... | 46·1 | 39·0 | 28·9 | 20·2 | 9·7 | ... |
| I.H.P. hours ..... | 60·25 | 50·70 | 40·10 | 32·20 | 22·50 | ... |
| E.H.P. ÷ I.H.P. ..... per cent. | 76·6 | 76·8 | 71·8 | 62·7 | 43·2 | ... |
| Gas used :— | | | | | | |
| Excl. ignition ...cubic feet | 1,247·0 | 1,115·0 | 1,010·0 | 955·0 | 874·0 | 394·0 |
| Incl. „ ... „ | 1,260·5 | 1,129·3 | 1,024·2 | 968·1 | 888·3 | 401·4 |
| Pressure ..... inch | 1 | 1 | ¾ | 1 | 1 | 1 |
| Total cubic feet.. ...per hr. | 2,521·0 | 2,258·6 | 2,048·4 | 1,936·2 | 1,776·6 | 1,605·6 |
| Excl. ignition...per k.w. hr. | 36·3 | 38·5 | 46·5 | 63·7 | 126·5 | ... |
| „ „ per E.H.P. hr. | 27·1 | 28·6 | 35·0 | 47·5 | 90·1 | ... |
| „ „ per I.H.P. hr. | 20·7 | 22·0 | 25·2 | 29·6 | 38·8 | ... |
| Incl. „ per k.w. hr. | 36·6 | 39·0 | 47·6 | 64·3 | 122·6 | ... |
| „ „ per E.H.P. hr. | 27·4 | 29·0 | 35·5 | 48·0 | 91·7 | ... |
| „ „ per I.H.P. hr. | 20·9 | 22·3 | 25·6 | 30·1 | 39·2 | ... |
| Water used, tank temp. ...F. | 85·5° | 84·5° | 84·0° | 86·0° | 83·5° | ... |
| Temp. of jacket-water leaving jacket ..... . .. F. | 119° | 108·4° | 131·7° | 105·0° | 112·0° | 95·5° |
| Water used ..... lbs. | 10,915 | 6,550·0 | 11,280 | 6,360·0 | 6,375·0 | 5,650·0 |
| „ „ lbs. per k.w. hr. | 317·5 | 226·0 | 520·0 | 423·0 | 850·0 | ... |
| „ „ lbs. per E.H.P. hr. | 237·0 | 168·0 | 391·0 | 314·0 | 657·0 | ... |
| „ „ lbs. per I.H.P. hr. | 181·0 | 129·0 | 282·0 | 197·0 | 283·0 | ... |

TABLE 2.—*Tests of No. 2 Single Cylinder Double-Acting Engine. Taken June 5 and 6, 1896.*

| No. of test ..... | I. | II. | III. | IV. | V. | VI. | VII |
|---|---|---|---|---|---|---|---|
| Duration of test..min. | 30·0 | 30·0 | 30·0 | 30·0 | 30·0 | 30·0 | 15·0 |
| Load factor...per cent. | 117·8 | 99·3 | 75·8 | 53·6 | 23·85 | 50·6 | 23·85 |
| Mean speed per min. revs. | 160·3 | 162·0 | 160·5 | 163·0 | 160·0 | 161·0 | 163·0 |
| Mean amperes ..... | 214·8 | 183·0 | 138·8 | 96·3 | 44·3 | 55·0 | 43·8 |
| Mean volts ..... | 144·7 | 143·0 | 143·7 | 147·0 | 141·8 | 242·4 | 144·4 |
| Mean kilowatts..... | 31·1 | 26·2 | 20·0 | 14·15 | 6·3 | 13·35 | 6·3 |
| Mean E.H.P. ..... | 41·7 | 35·1 | 26·8 | 19·0 | 8·45 | 17·9 | 8·45 |
| Mean I.H.P. ..... | 57·6 | 48·8 | 43·06 | 33·2 | 23·8 | 29·8 | 22·3 |
| Kilowatt hours ..... | 15·5 | 13·1 | 10·0 | 7·07 | 3·15 | 6·67 | 1·5 |
| E.H.P. hours ..... | 20·8 | 17·5 | 13·4 | 9·5 | 4·22 | 8·9 | 2·11 |
| I.H.P. hours ..... | 28·8 | 24·4 | 21·53 | 16·6 | 11·9 | 14·9 | 5·9 |
| E.H.P. ÷ I.H.P..per cent. | 72·2 | 71·8 | 62·3 | 57·3 | 35·5 | 60·1 | 37·9 |
| Gas used :— | | | | | | | |
| Excl. ignition..cub.ft. | 604·0 | 540·0 | 495·0 | 485·0 | 448·0 | 317·0 | 133·0 |
| Incl. „ ... „ | 610·6 | 546·5 | 501·2 | 491·7 | 454·3 | 323·9 | 136·9 |
| Total per hr.... „ | 1,221·2 | 1,093·0 | 1,002·4 | 983·4 | 908·6 | 647·8 | 547·6 |
| Excl. ignition.....per k.w. hr. | 38·9 | 41·2 | 49·5 | 68·5 | 142·0 | 47·5 | 84·5 |
| „ „ .....per E.H.P. hr. | 29·0 | 30·4 | 36·9 | 51·0 | 106·0 | 35·4 | 63·0 |
| „ „ .....per I.H.P. hr. | 21·0 | 22·1 | 23·0 | 29·2 | 37·6 | 21·27 | 23·9 |
| Incl. „ .....per k.w. hr. | 39·4 | 41·8 | 50·1 | 69·4 | 144·0 | 48·5 | 87·0 |
| „ „ .....per E.H.P. hr. | 29·4 | 31·2 | 37·4 | 51·7 | 107·0 | 36·2 | 64·8 |
| „ „ .....per I.H.P. hr. | 21·2 | 22·4 | 23·3 | 29·6 | 38·2 | 21·72 | 24·5 |
| Water used :— | | | | | | | |
| During test .. ...lbs. | ... | ... | 1,805·0 | 1,940·0 | ... | 1,940·0 | ... |
| Per hr. .....lbs. | ... | ... | 3,610·0 | 3,880·0 | ... | 3,880·0 | ... |
| Per k.w. hr. .....lbs. | ... | ... | 180·0 | 274·0 | ... | 290·0 | ... |
| Per E.H.P. hr. ...lbs. | ... | ... | 134·0 | 204·0 | ... | 217·0 | ... |
| Per I.H.P. hr.....lbs. | ... | ... | 84·0 | 117·0 | ... | 130·0 | ... |

NOTE.—In Tests I. to V. both ends of the cylinder were working, no explosions being missed. In Tests VI. and VII. one end only of the cylinder was working.

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suited for steady driving, high speed being attained without knocking, all parts being in constant thrust; this is obtained by having a high compression (about 90lb. per square inch) in one or other of the cylinders at every up stroke. When the bottom right cylinder is exhausting the top right is compressing, and *vice versâ*. The same operation occurs in the left line of cylinders; and by cushioning at the top of the piston valve cylinder, the piston valves are also kept in constant thrust. Where economy of floor space is a consideration, this kind of engine is very suitable. An engine of 150 I H.P. requires a floor area of 6½ft. by 5ft., or 32½ sq. ft. over flywheels; and the combined plant, engine and dynamo of 72 kilowatts, necessitate only an area of 62½ sq. ft.

*Starting Arrangements.*—The engines can be started either electrically or by compressed air. In the electrical starting the dynamo is run as a motor off the omnibus bars, pulling the engine round until it begins to explode. First, the machine is plugged on to the omnibus bar, the machine automatic switch being left open. A starting resistance is then plugged into the machine circuit, the resistance switch being on the off contact. The field of the machine is next excited from the omnibus bar by closing the shunt switch on the top or bar contact. An initial start is given to the engine by the driver, and the current is switched on gradually through the starting resistance. As soon as the dynamo is up to speed, the starting current is cut off. The voltage is then regulated by the shunt resistance, and the dynamo switched on to the circuit by closing the automatic switch. The closing of the automatic switch actuates the shunt switch, changing it over from the top to the bottom contact, and the dynamo then runs as a shunt machine. The electrical starting is worked from the switchboard by the engineer in charge. In starting by compressed air, the engine has first to be turned by hand by the driver into the correct starting position. The stop valve admitting the compressed air is then opened, and is again closed as soon as a few explosions have taken place. The dynamo is then run up to speed and its voltage regulated; and it is put on to the circuit in the ordinary way.

*Compressed-Air Starting Apparatus.*—The air compressor has two water-jacketed single-acting cylinders of 4½in. diameter and 8in. stroke. The pistons are driven by opposite cranks. The admission and delivery of air are regulated by slide-valves moved mechanically. The crank shaft carries on one end a flywheel, and on the other a mortice wheel, which gears with a steel pinion on the motor shaft. The power is supplied by a 6 H.P. electric motor, running at 800 revolutions per minute, and taking its current from the mains at 220 volts pressure. The air receiver is 12ft. long by 4ft. diameter, made for a working pressure of 100lb. per square inch, and tested up to 200lb.; it is provided with safety valve, pressure gauge, &c. A 4in. air main from the receiver runs the whole length of the engine room, with a 2in. branch pipe to each engine.

In the tandem engines the connection is made to the back end of the back cylinder. The compressed air is admitted during the impulse stroke of that end—by a valve actuated by a cam, thus giving an impulse every second revolution. The gas is cut off from the back cylinder while starting. As soon as an explosion occurs in the front cylinder the compressed air is shut off, the starting cam put out of action, and the gas turned on, letting the back cylinder take up its part of the work. In the single-cylinder double-acting engines the arrangement is the same, with only the difference in working that the gas is admitted to the front end of the cylinder, while starting, but not to the back end. In the high-speed four-cylinder engines the compressed-air connection is made to the bottom right-hand cylinder, which for starting purposes is specially provided, firstly with a valve to close the mixture-admission port, secondly with an exhaust passage and a valve to close it, and thirdly with an inlet for the compressed air. The valve of this inlet is worked by a double-throw cam, thus giving an impulse for every revolution in this cylinder. The speed increases quickly; and as soon as the explosions take place in the other cylinders, the compressed air is shut off, the starting cam thrown out of action, and the gas turned on to this cylinder.

*Mains, Feeders, and Distributors.*—These are mostly bare copper strip in concrete culverts. The strip is simply supported on earthenware insulators placed 6ft. apart, which are held in place by a pitch setting. The strip is laid in before the cover flags are put down; and extra copper can be drawn in at any time without raising the flags. Everywhere the culvert is placed beneath the footway. The lengths average 25 yards, and are built with a fall towards the junction boxes, in order to allow any water that may get in to drain off. The average depth of the copper below the surface is 20in. The space required for a three-way culvert for a distributing main is 27in. wide, with a minimum depth of 18in. below the surface. For a five-way culvert, which takes the distributing mains and a pair of feeders, the space required is 34in. wide with a depth of 18in.

*Culverts.*—These are built of cement concrete in the proportion of five of gravel and broken stones to one of Portland cement. The side walls are 6in. thick, and the bottom 4in., all faced inside with cement. The covering slabs are 2in. Kilrush and Caithness flags. The culvert when dry is itself a fair insulator, which is a great advantage where there is a possibility of sometimes getting a sag of the strip between the insulators, as may occur through the carelessness of workmen. At street crossings, and under narrow footways where there is no room for a culvert, insulated cables in cast-iron pipes are used. Connections between the lengths of strip, or between cable and strip, are made in the street boxes by means of gun-metal grip-boxes, which clamp the ends together. The copper strip is 1in. wide and 0·2in. thick, giving 0·2sq. in. section. This is the section used in all the distributing mains, both for middle and outer wires. When the lamp density—that is, the number of lamps per yard—increases, the section of the outer wires can be increased by putting in another strip on the top of the present. The section of the feeders varies from 0·4 sq. in. to 0·8 sq. in., according to the length; the longest feeder at present is 520 yards. The distributing mains are all in parallel, and are connected at as many points as possible in order to equalise the pressure. They are brought back to the station to supply current for the lighting, &c. The middle wire is brought back from four different points of the network. The pilot wires are in the form of three separately insulated conductors, twisted together and cased in lead; some have paper insulation and others impregnated jute. The joints are protected, either by a lead sleeve soldered to the lead covering and filled with insulating oil, or by being placed in a special joint-box, which is filled with insulating material run in hot. The pilot wires are drawn into cast-iron pipes laid along one side of the culvert.

On account of the wet nature of the ground and the comparatively low level of the city, special precautions had to be taken against water getting into the culverts or accumulating in them; and the aim has been to make the whole watertight. The street boxes are built of brick, faced inside with cement, and the bottoms are concreted. They are provided with a cast-iron frame and cover, the latter being filled with concrete. A water-tight joint is made between cover and frame by the use of House's slow-setting cement. Junction-boxes placed in the roadway are provided with specially heavy frames and covers, the latter being filled in with wood blocks. The covers are provided with inspection plugs, which allow of a rapid examination of the system being made without lifting the covers. Any accumulation of water can be removed through the inspection-plug hole by means of a small hand-pump. A record is kept of the condition of the boxes, and of the dates of their having been pumped out. The covers are also lifted periodically for the ventilation of the culverts. No trouble has been experienced from gas accumulating in the culverts. At the laying of the mains all defective gas services were renewed; and those that ran close to the culvert were coated with a mixture of pitch and tar. The service mains are rubber-covered cables drawn into wrought-iron pipes, which are laid from the nearest street-box. They are connected to the Corporation-main fuses immediately inside the building. The connections to the distributing mains are clamped in the case of bare copper strip; and insulated T joints are employed for connecting to cable.

Throughout the system the positive and negative mains have certain relative positions under the footway; namely, the negative main or feeder is everywhere next the kerb, and the positive next the houses. In the street boxes the positives are coloured blue, the negatives red, and the middle wire black; the service cables are coloured in the same way.

*General Remarks.*—From the experience here gained the author is of opinion that a gas-engine station necessitates more attention than a steam-driven station; and more drivers of a better class are required for a given power than in the latter station. A couple of men are always required for the electrical starting of an engine. Without their help the strain on the armature would be too great, if the current were switched on when the machine was standing.

The following statement shows the cost of current sold from January 23rd to December 31, 1895:—

| | |
|---|---|
| Number of units sold | 82,771 |
| ,, lamps connected (equivalent in 8 c.p.s.) | 10,500 |
| Revenue from sale of current | £2,186 |
| Average price obtained per unit | 6·34d. |

| | Cost of production. | Per unit sold. |
|---|---|---|
| | £ s. d. | d. |
| Fuel (gas) | £01 3 0 | 1·450 |
| Oil, waste, water, and stores, including ignition tubes | 80 4 3 | 0·233 |
| Salaries and wages at generating station | 444 17 4 | 1·290 |
| Repairs and maintenance of buildings, engines, dynamos and accumulators | 93 16 8 | 0·272 |
| Repairs and maintenance of mains | 76 4 6 | 0·221 |
| Rents, rates, and taxes | 236 0 0 | 0·684 |
| Management expenses, &c. | 415 9 11 | 1·200 |
| Insurance | 23 2 0 | 0·07 |
| Total | £1,868 17 8 | 5·42 |



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A machine can be started up and got on circuit in about two minutes, the stand-by units being kept plugged-up on the switchboard and the ignition tubes kept hot. For the sake of efficiency the machines are run as near to full load as possible, but, as far as governing is concerned, they can be run at any part of their load. The cost of fuel (gas) per Board of Trade unit sold for the year ending December 31, 1895, worked out at 1·45d. This, with gas at 2s. 3d. per 1,000 cubic feet, is equivalent to 53·6 cubic feet per unit sold, or 59 feet per unit generated. The total efficiency of units sold to generated is 91 per cent. This is equal to an average consumption during the year of 44 cubic feet of gas per E.H.P. hour. The cost of engine-room stores, including oil, waste, water, and ignition tubes, amounts to 0·23d. per unit sold, which compares favourably with steam-driven stations. Ignition tubes form a heavy item of the cost. Good results are now being obtained with porcelain tubes, which require only a short time to heat up. The cost of cooling water works out at a low figure, and this is due to the use of a tank of large capacity, which has special cooling arrangements.

The station started to supply current on January 23, 1895, with 2,300 8-c.p. lamps; there are now 13,500 lamps of 8 c.p. connected with the mains. The following statement shows the quantity of units of electricity generated, sold, &c., from January 23, 1895 to December 31, 1895:—

| Quantity sold:— | Units. | Units. |
|---|---|---|
| Public lamps | — | |
| Private consumers by meter, at 4d. per unit. | 574 | |
| Private consumers by meter, at 7d. per unit. | 82,197 | |
| | | 82,771 |
| Quantity used on works | 3,822 | |
| Do. lost in battery | 6,304 | |
| | | 10,126 |
| Total quantity accounted for | | 92,897 |
| Quantity not accounted for | | 2,229 |
| Total units generated | | 95,126 |

From this it will be seen that:—

| | Per cent. |
|---|---|
| Total efficiency | = 91·0 |
| Loss in batteries | = 6·7 |
| Loss in main | = 2·3 |
| | 100·0 |

The total maximum supply demand was 159,000 watts, which is equivalent to 5,300 30-watt lamps.

DISCUSSION.

Mr. E. R. DOLBY said that, in examining the tables, he saw that the gas used per electrical horse-power was 27·1 cubic ft., or 27·4 cubic ft. including the ignition. The engine was then giving off the full load of 120 H.P. Returning to Table II., the smaller engines were giving about 57·6 H.P., and that was obtained from 29 cubic ft. per electrical horse-power, or 29·4 including ignition. He was in hopes that Mr. McCowen would have been able to add the results of the tests upon the new high-speed engines, but it appeared that he was not able to do so yet, although tests were made at the works before they were delivered. There was one very important point to which attention should be given. He had not been able to see in the Paper any analyses as to gas. Now, there was considerable difference in the gas in Glasgow and in Belfast, and it was an important matter in preparing specifications for gas engines to know what were the exact qualities of the gas to be used, or they might get tests in the works of one main with gas which appeared to be eminently satisfactory, but when they came to test them with gas in another place where the gas was not of the same quality, they would not get the same results up to specification standard: and it would be a very valuable addition if the analyses were given. It was always very interesting to compare the light which could have been obtained from gas by using it in an ordinary way in burners, and then pointing out how much more candle-power they had been able to obtain by using this gas in producing electricity. If the point were put before the ordinary consumers of the gas it would be an incentive to them to use electricity in preference to gas, putting aside the question of injury to decorations, &c.

Mr. B. DONKIN said he would like to know whether there was any trouble with the gas engines in regard to internal deposit, or how often they required to be cleaned. With regard to the experiments in the Paper, he noticed they were only of 30 minutes' duration, and even one or two were rather lower than that. He supposed that was sufficient, but he should like to have the author's opinion as to whether they would have been altered if they had been a little longer.

Mr. B. T. O'BRIEN asked what induced the Belfast Corporation to put down gas instead of steam plant. It had always struck him that gas was a more expensive way of generating power than steam. Gas engines at first worked very efficiently to an average of about 20 cubic ft. per indicated horse-power per hour, but afterwards they began to use a little more gas. Taking the price of gas indicated in the Paper, 2s. 3d. per thousand cubic feet, it ran to about two-thirds of a penny per horse-power per hour. Steam engines would work it with far greater efficiency at, say, two pounds of coal per indicated horse-power per hour than gas engines would give.

Prof. GOODMAN (Yorkshire College) pointed out the extremely high consumption of gas in Belfast. They had a gas engine at Leeds, which, when they were working it at full power, just used under 20 cubic ft. of gas per electrical horse-power per hour. Taking a week's run, light and heavy loads, they gave out somewhere about 25ft. of gas per horse-power, and the cost of gas in Leeds was considerably under 1d. per electrical horse-power per hour, which was nearly half the cost in the Belfast installation. Considering that it was a private installation at Leeds, on a comparatively small scale, he thought that either they were doing remarkably good results, or that in Belfast they were doing remarkably bad results. He did not like to criticise work carried on by such an eminent engineer as Prof. Kennedy, but he thought there must be something radically wrong when the engines were using such an enormous amount of gas as this.

Sir EDWARD CARBUTT, Bart., asked whether the effect of the engines working was to cause vibration in adjoining buildings in Belfast. In the St. James's district, London, they had had complaints from the clubs of the vibration which was set up in this way. It must have been at a time, of course, when all the engines were going.

Mr. J. H. GREENHILL said the question had been asked, Why had gas plant been adopted in Belfast? That question was probably put from an economical point of view; but when it was taken into consideration that one of the ostensible reasons for the establishment of a central electrical station in Belfast was to relieve the gas works, the question became of double significance. He supposed the advising engineer to the Corporation had very good reason for so doing. Mr. McCowen was not responsible for the adoption of gas engines in Belfast. He drew attention to the want of economy in these engines. A good many had passed through his hands as an expert, and the results obtained in Belfast were not very favourable. In these very large engines they had got 20·9 cubic feet per indicated horse power, but he had known personally that engines one quarter the size had done very much better than that. He had got as low as 18½ and even less than that.

Mr. McCOWEN, in reply, said that with reference to the tests, he considered the time sufficient, and every care was taken to have the tests fairly reliable. Electric ignition had not been tried up to the present. In regard to Mr. O'Brien's question as to the reasons for a gas engine station, he was afraid he could not answer that. Prof. Goodman referred to the high gas consumption, and said they had got down to 20ft. per electrical horse-power at Leeds. Gas was evidently very good there, and they seemed to have very efficient gas engines. As to running steady with flywheels, he had run a number of gas engines with flywheels, belt driving, and, as far as he saw, it was all right where they were running one engine on a load; but running parallel engines he found great difficulty, and never knew what load an engine was taking. There was no doubt about a belt being better than rope for a single-impulse engine, but for their engine in Belfast he thought rope was quite as good. There was not a bit more swing in the ropes when working than with a steam engine. They had had no complaints from neighbours as to vibration or nuisance. As to the governing, they had no passing of gases.

## BELFAST CORPORATION AND ELECTRIC LIGHTING.

At the monthly meeting of the Belfast Corporation on Saturday, the Electric Committee reported that they had had under consideration the probable necessity of increasing the present gas plant in the central station, as that now available would in all likelihood be fully utilised before the extension of the system, as proposed, could be taken in hand. It was, however, satisfactory to know that the engineer's report showed a fair surplus over the working expenses.

Councillor ANDREWS (Chairman of the Electric Committee), in moving the adoption of the report, said the Committee had had under consideration the necessity of increasing the present gas plant at the electric station, as that now available would be fully utilised before the extension of the system as proposed. Although the Committee had not yet arrived at any definite conclusion as to the amount of plant that would be required, they roughly put it down as equivalent to 7,000 more lamps, bringing up the possibilities of wiring to a little over 20,000 lamps. At the moment their safe limit, allowing the ordinary light by engines—that was one large engine and one small—was almost fully occupied. They had about a free margin of 1,000 8 c.p. lamps. Therefore, it was necessary for the Committee to take this matter of increased generating power in hand within a short time. The makers of the last engines, which had been going fairly satisfactorily, said they now saw where the difficulties referred to existed, and that they could overcome them, and deliver an engine, or a couple of engines, in a very short time. But the difficulty was in getting dynamos from the makers, as all the manufacturers of electric lamps were, of course, very busy at this time of the year in preparing for the coming winter season. The Committee would probably report to the Council next month that they had entered into negotiations for the erection of further plant, so that consumers need not be anxious about being short in supply in the winter. With regard to the larger scheme, which had been already reported to the Council, it was rather early to bring it forward yet. The outlay would be so large that it would have to be included in the report of the Finance Committee for next year. It would amount, he might say, roughly, to about £100,000, and that would give them a sufficient supply to enable fully six times the present number of lamps being wired, a number which should be sufficient for the city for a number of years to come.

Councillor WOODSIDE asked whether gas engines were most economical for working the electric light. He had heard it stated that the gas engines were not satisfactory; and why go to the expense of having further gas plant if it had not been satisfactory in the past? The Chairman of the Electric Committee told them that some of the engines were working

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fairly satisfactorily. What did that mean? Apparently there was something that the members of that Corporation, and especially those who were not members of the Electric Committee, knew nothing about. Were the makers of those engines responsible for their unsatisfactory state, and would they bear the expense of making them right?

Councillor YOUNG said that if the statement went forth that the Electric Committee were making a very large profit, the ratepayers would come to the conclusion that they were paying too much for the light. But it was misleading, because really they had no surplus at all. They had borrowed £30,000, and the interest on that was not provided for, nor was there anything for a sinking fund. If they took these into consideration their surplus would not only disappear, but they would see that they were to the bad. If it was not that they had borrowed money from the Gas Committee they could not go on at all. He protested against any increase of power at the central station, which was next door to a chapel; and if they increased the power they would be in for a very serious action for injury to surrounding property. The sooner they got away from the present building and on the banks of the Lagan the better. It would also, in his opinion, be an improvement to have steam instead of gas engines.

Councillor HARRISON said the Vice-Chairman of the Gas Committee (Councillor Young) had furnished them with an excellent reason why the price of gas should be reduced. He had told them that because the Electric Committee was working at a small profit, therefore the public would demand a reduction of price.

Councillor BARKLIE said that Councillor Young had been finding fault with the Electric Committee for constructing this station on its present site; but this station, he would point out, was not initiated by the members of the present Electric Committee, but by the Gas Committee; so that the Gas Committee were really the persons who were to blame. It was a mistake to introduce gas engines at all for driving purposes. He had no doubt that when they got steam they would be able to supply electricity at a cheaper rate.

Councillor ANDREWS, in reply, said they were at present paying about three times as much for fuel as they would with a steam-driving station. At the same time, the Electric Committee could not accept the responsibility for the position. All they could do was the very best possible with the plant in their hands. The plant was now working fairly satisfactorily, taken all round. With regard to the last two engines, the makers were bearing all the expense of making them efficient, and he had reasonable grounds for stating that they would be more efficient than the original engines, which were of a different type. The first engines never gave satisfaction, but the present type would be as satisfactory as large-power gas engines could be made. As to the question of profit, with the high cost of fuel they could not make any very great show in the way of earning a profit. At the same time, if electric light went on as it had gone up to the present in Belfast, there was no doubt that they would be able in time to show a surplus at least sufficient to pay interest.

## ELECTRICITY IN AMERICAN COAL MINES.*

An interesting electrically operated coal property is that of the Youghiogheny River Coal Company at Scott Haven, Pa. The mines in which the different machines driven by electric power are installed are scattered over a large extent of territory. The power house is located on the east side of the Youghiogheny river, contiguous to the line of the B. and O. Railroad. The engine room is 74ft. long by 54ft. wide. The engine installation consists of three automatic engines, each 15 by 16 inches, with 72-in. fly wheels, running at 240 revolutions. Each engine is belted to a four-pole 650 revolution, 100 kilowatt general electric generator, wound for 500 volts, and over-compounded for 10 per cent. loss in the line. The engines and dynamos are erected on brick foundations, and current from the generators is carried under the floor to the switchboard by heavily insulated cables hung on porcelain insulators.

The switchboard is of the skeleton type, divided into two parts, one for the generators and one for the feeders, on a plan similar to that used in electric railway stations. The generator board carries three automatic circuit breakers, three circular dial Weston ammeters, three main double-pole, double-throw switches and three field rheostats. The voltmeter is carried on a bracket on the side. Two sets of circuits are run, one of which is grounded, for haulage work, and the other insulated, for the fans, coal cutters, &c. Any machine may be run on either the insulated or the grounded circuit. The feeder switchboard carries an automatic circuit breaker for each of the haulage circuits, a double-pole switch for each pump circuit, fan circuit and the coal cutter circuit, and a double-pole switch for throwing the metallic and grounded bus bars into multiple. Lightning arresters protecting the generators are placed behind the switchboard. From the power house the circuits for No. 1 mine are run on poles to the pit's mouth. This mine is about 900ft. from the power house, and the circuit is used to drive fans, pumps, locomotives and coal cutters. The fan is a Capell exhaust fan, 8ft. by 3½ft. in diameter, running at 280 revolutions per minute, driven by a belted 25 H.P. multipolar motor, running at 650 revolutions.

All the coal cutting is being done in No. 1 mine by five Jeffrey chain coal undercutters, operated a mile and three-quarters from the power house. The circuit for the coal cutters is insulated, the other circuits all having earth return. This mine is also provided with a Knowles triplex pump, 6½in. by 8in., driven by a 7½ H.P. multipolar motor. The pump, motor and rheostat are mounted on an iron truck, and may be run over the track from place to place in the mine.

The electric locomotive operated in this mine has a length of haul a little over a mile and a quarter. The grades vary from 1 per cent. against loads, to 25 per cent. in their favour. The track is laid on thirty-pound rails, with a gauge of 43½in. The overhead construction is of the regular mining type. The pump and haulage circuits are all grounded for the return.

The fact that the various mines are separated from each other by water introduces a novel feature into the installation, and illustrates the flexibility of electric power transmission. For each of the other mines in the Youghiogheny Company's system, current has to be carried under the Youghiogheny river by heavily insulated and armoured cables, to a small cable house forming the centre of distribution for the lines running to the mines on the west side of the river. In No. 4 and in the south-west mines electricity is applied to pumping purposes only. The pumps are triplex pumps, similar to those in No. 1 mine, and are driven by two multipolar slow-speed motors of 10 H.P. and 7½ H.P. respectively. These pumps are about 8,000ft. away from the power house. In the Pacific mine the haulage is effected by a locomotive having a drawbar pull of 2,500lb., with a length of haul of about 5,000ft. underground and 800ft. in the open. This mine also contains a pump, similar in size to that in No. 1 mine, driven by a 7½ H.P. motor, located about 16,000ft. from the power house. A 30 H.P. motor fan is erected about 1,000ft. beyond the pump. The installation of the electrical apparatus in No. 5 mine is not yet completed.

In the new steel tipple of No. 1 mine a 7½ H.P. motor drives a revolving screen and runs an emery wheel for sharpening bits, &c. The installation of electricity in this mine has proved of considerable benefit from every point of view. A fair idea can be obtained of the economical value of electric haulage from the statement that the two locomotives have displaced 18 mules and their drivers; and the four pumps, which take only a small share of the attention of three separate men, are doing the work with which ten men, four mules, two steam boilers and two steam pumps formerly found it difficult to cope.

* Abstract from the *Electrical Engineer* of New York.

## TRACTION QUANTITIES AND COEFFICIENTS.

A number of useful data have been determined by Messrs. H. P. Curtiss and H. O. Pond, of Cornell, during some tests of motor cars on a length of the Buffalo and Niagara Falls Electric Railway. This line is equipped with 78lb. girder rail laid on ties 2ft. between centres and rock-ballasted. The testing car had a 28ft. body mounted on double trucks; and it was in length 38ft. over all, and 8ft. wide. There was a motor on each of the four axles, thus giving eight driving wheels and no idlers or trailers. The total weight of the car was 30,515lb. In starting, the motors were connected two in series and two in parallel; when the normal speed was reached the motors were all connected in parallel. Tests were made as to the following quantities: (1) Friction of car; (2) acceleration; (3) performance of car and of individual motors. The curves giving the results of these tests are published in the *Street Railway Review*, of Chicago, for July 15, 1896. A novel and ingenious method of determining the average friction was adopted, and consisted in measuring the distance along a level track at which the car came to rest from a known speed, no current being on the motors. The only objection to this method is that it does not measure the friction at a specific velocity, but averages it between the initial velocity and zero. During the first run, on this method, the coefficient of tractive resistance proved to be 6·66lb. per 1,000lb. gross weight; in the second and third runs it was 6·86lb., and 6·88lb. per 1,000lb. respectively. The results of the complete series of tests are summed up in the following averages:—

| | |
|---|---|
| Average friction of car, equivalent draw-bar pull | 208·5lbs. |
| Average traction coefficient, pounds per 1,000 | 6·86lbs. |
| Average acceleration horse-power (this is not the actual electric horse-power expended) | 16·02 |
| Average mechanical efficiency of car on straight level track at constant speed | 63·37 per cent. |
| Average voltage on line from several runs | 513·10 |
| Average current taken on trip over entire line | 63·4 amperes |
| Average electrical horse-power of car over entire line | 40·44 |
| Average speed in miles per hour | 23 |
| Maximum current taken by car during tests | 188 amperes |
| Maximum pressure at car during tests | 583 volts |
| Maximum electrical horse-power of car during tests | 143 |
| Maximum speed in miles per hour on regular run | 36 |
| Maximum speed attained in miles per hour | 42 |



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## RECTIFIERS.

When an alternate-current supply station is to be used for running public arc lamps, a choice between several methods is open. The lamps may be run singly or in batches off transformers fed from the ordinary mains; or they may be provided with a separate generating plant, producing continuous current; or they may be supplied with rectified current, the power being generated in the ordinary supply sets. From the fact that all these methods have been adopted in modern stations, it is evidently not an easy matter to choose between them. Each possesses its peculiar merits. The first and last of the three methods have the advantage that the arc lamp load is put on the ordinary supply generators, and thus furnishes these with steady work, in addition to their fluctuating ordinary load. The second method involves the cost of erecting and running special generating plant, but it confers all the well-ascertained advantages of the continuous-current arc—a result which is, of course, also practically attained by the use of rectifiers. As between the first and last methods, the use of transformers with arcs in batches has the advantage of simplicity, while the rectifier enables the lamps to give a better light. But the rectifier is, comparatively speaking, a new thing, and doubtless engineers have not been quite easy in their minds about it. It introduces a somewhat complicated apparatus into the circuit, and its two essential parts are not unnaturally looked upon as the source of two possible additions to the annual expenditure. It has been said that the transformer part of the rectifier—the part which converts the power at constant pressure into power at constant current—has a low power factor and involves considerable loss; and as to the com-

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mutator part of the apparatus, where the real rectification is done, we have heard it said that this requires a deal of attention, and consumes brushes at an alarming rate. Against these adverse opinions, however, there is the weight of considerable practical experience telling in favour of rectifiers. No one who has visited Portsmouth by night can fail to have noticed the fine illumination given by the rectified currents used there; and we understand that the rectifiers are run with very little cost for attendance, one boy being sufficient to manage the whole battery of rectifiers, the consumption of brushes, moreover, being reasonably low. We have a shrewd suspicion that success or failure in the use of rectifiers is very largely a matter of intelligent management, assuming that a well-designed type, such as that of Messrs. FERRANTI and Co., is used. In earlier forms of rectifiers troubles with the brushes were persistent; but in modern forms of the apparatus the violent sparking which takes place is almost entirely electrostatic discharge, and of a kind not calculated to burn the brushes or the commutator, if these are properly adjusted.

In a Paper read before the Northern Society of Electrical Engineers last session, an abstract of which we publish this week, Mr. HESKETH relates his experiences and conclusions in regard to "The Use and Economies of Rectifiers for Arc Lighting." The Paper is a very fair and extensive survey of the subject, and there does not appear to be any important phase of the question which the author has left untouched. Mr. HESKETH first points out the paramount advantage which the use of rectifiers affords in allowing the arc load to be placed on the same generators as the ordinary load, and towards the end of his Paper he enters into detail as to the saving in size of plant and floor space which results. He next considers the question of efficiency, both apparent and real. The apparent efficiency, he thinks, is almost as important as the real efficiency. In other words, a high real efficiency does not completely atone for a low apparent efficiency arising from a low-power factor. For, when the power factor is low, the rectifier reduces the plant efficiency of the alternator on which it is run, since this is practically determined by the maximum current the alternator will develop, and is independent of whether that current is or is not largely idle. Fortunately for rectifiers, Mr. HESKETH is able to pronounce favourably in regard to both efficiencies. He has found the real efficiency to be as high as 95 per cent., between one-tenth and full load, in the FERRANTI rectifiers used at Blackpool; while an apparent efficiency of 90 per cent. has been realised. Public arc lighting does not require the load at any time to fall to anything so small as one-tenth of its full value; indeed, it rarely falls to half. The charge of inefficiency is thus satisfactorily disposed of. The effect of rectified currents on the mechanism of the lamps is next discussed. As would naturally be expected, the inductance in the coils is lower with a current of this form than with an alternating current. Self-induction splits a rectified alternate current into a continuous-current component and a pulsating-current component, a fact which makes it necessary to alter the winding and adjustments of a lamp when it is to be placed on a rectifier circuit. Finally, Mr. HESKETH has a few words to say about the maintenance of a rectifier. He has not found any trouble in regard to the consumption of brushes and commutator; and he states that, with care, the commutators will last quite as long as those of arc-light dynamos. In fact, Mr. HESKETH regards the rectifier system as being by far the best solution of the problem of public arc lighting. It remains to be seen whether future experience will justify this somewhat sweeping dictum.

## OBITUARY.

### SIR WILLIAM GROVE.

We regret to announce the death, at the ripe age of 86, of Sir William Grove, eminent alike as a natural philosopher and as a lawyer.

William Robert Grove was born at Swansea on July 11, 1811. He never went to any of our great public schools, but after private tuition proceeded at an early age to Brasenose College, Oxford, where, in 1830, he took an ordinary degree. In 1835 Mr. Grove was called to the Bar, but instead of immediately actively practising became absorbed in electrical research work, devising in 1839 the zinc-platinum element which bears his name. Mr. Grove first made known his discovery through the medium of the *Philosophical Magazine* of February, 1839, and subsequently through the British Association, which met that year in Birmingham. The British Association communication was entitled "On a Small Voltaic Battery of Extraordinary Energy." The Paper was accompanied by a specimen battery, "hastily constructed," consisting of an outer case of wood, height 5½in., breadth 5in., width 3in., which the author remarked should be of glazed earthenware, "similar to the Wollaston troughs," separated into four compartments by glass divisions. Into these compartments were placed four flat porous vessels, the interior dimensions of which were 5 by 2½in. by $\frac{3}{10}$in., the thickness of the "parois" being $\frac{1}{8}$in.; they contained each three measured ounces. The metals (four pair) exposed each a surface of 16 sq. in., and the battery gave, by decomposition of acidulated water, 9 cub. in. of mixed gases per minute. Charcoal points burned brilliantly, and the battery heated 6in. of platinum wire $\frac{1}{40}$th of an inch diameter, and its effect upon the magnet, when arranged as a single pair, was "proportionately energetic." The battery was stated to be constant for about an hour without any fresh supply of acids, and the porous vessels were described as being "identical in their constitution with the common tobacco pipe." The discoverer then goes on to explain "the rationale of the action of this combination," and concludes with the following remark: "As far as my experiments go, its power with reference to Mr. Daniell's battery is, *cæteris paribus*, as 16 to 1; but the relative proportions vary somewhat with the series. The cost of the whole apparatus is £2. 2s."

In 1840, the year following this brilliant invention, Mr. Grove was appointed Professor of Experimental Philosophy at the London Institution, a chair which he filled for some five years. It was mainly during his tenure of this office that he built up the reputation he enjoyed among physicists all over the world. In the latter part of 1846 Mr. Grove published his famous essay "On the Correlation of Physical Forces," containing the substance of a course of lectures delivered at the London Institution in 1843. And right well does this sterling contribution to physical science deserve its renown. Apart from the grand generalisation modestly put forward in the "Correlation of Physical Forces," the lucidity of the style; the cogency, clearness and orderly marshalling of the arguments; the admirable conciseness, and the pregnant remarks on this subject and on that subject, which are scattered here and there throughout the essay, make it a model scientific memoir.

The essay commences with a modest plea for attention. The claim is not grounded upon the assumption that the author is an intellectual giant, but that he is a dwarf, who, being raised upon the high edifice erected by the labours of others, may possibly be able to see a little further than the original builders; "for no theory can be more immature, none is likely to be so incorrect, as that which is formed at the first flush of a new discovery; and though time exalts the authority of those from whom it emanates, time can never give to the illustrious dead such means of analysing and correcting erroneous views as subsequent discoveries confer." The author then proceeds to define his standpoint in the following terms:—"The position which I seek to establish in this Essay is, that the various imponderable agencies,

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or the affections of matter which constitute the main objects of experimental physics, viz., Heat, Light, Electricity, Magnetism, Chemical Affinity, and Motion, are all correlative, or have a reciprocal dependence. That neither, taken abstractedly, can be said to be the essential or proximate cause of the others, but that either may, as a force, produce, or be convertible into the other; thus, heat may mediately or immediately produce electricity, electricity may produce heat; and so of the rest," the term force in reference to the five "affections of matter," other than Motion, being defined "as that active principle inseparable from matter which induces its various changes." The six "affections of matter" are then treated of seriatim, and the convertibility of any one "affection" into any other is demonstrated. As an instance of the author's method we cannot do better than quote the following:—"A prepared Daguerreotype plate is enclosed in a box filled with water, having a glass front, with a shutter over it; between this glass and the plate is a gridiron of silver wire; the plate is connected with one extremity of a galvanometer coil, and the gridiron of wire with one extremity of a Bréguet's helix; the other extremities of the galvanometer and helix are connected by a wire, and the needles brought to zero. As soon as a beam of either daylight or the oxyhydrogen light is, by raising the shutter, permitted to impinge upon the plate, the needles are deflected; thus, Light being the initiating force, we get *chemical action* on the plate, *electricity* circulating through the wires, *magnetism* in the coil, *heat* in the helix, and *motion* in the needles." The concluding pages of this memorable essay are devoted to a strong defence of the doctrine of the "non-annihilation of force." In several places in the course of this monograph the author gives vigorous expression to his dislike of hypothesis spinning and to his lawyer-like fondness for severe precision of phraseology. For instance, he condemns the "latent heat" hypothesis as "a dangerous one. . . . something like the old principle of Phlogiston. . . . a mere subtle mental conception. . . . only to be received on the ground of absolute necessity." Again, further on he has hard words for the etherial hypothesis. "The advocates of the etherial hypothesis," he remarks, "certainly have this advantage: that the ether, being hypothetical, can have its characters modified or changed without any possibility of disproof, either of its existence or modifications. . . . To account for the phenomena we assume the ether, and to prove the existence of the ether we cite the phenomena." Precision of language is characterised as "the safest guard to knowledge, from the absence of which physical science has materially suffered."

Mr. Grove was now a Fellow of the Royal Society, and took an active part in its proceedings, obtaining, in 1847, a Royal medal for his Bakerian lecture of November, 1846, "On Certain Phenomena of Voltaic Ignition and the Decomposition of Water into its Constituent Gases by Heat," a contribution occupying some sixteen pages of the *Philosophical Transactions*. To show Mr. Grove's scientific activity at this period in his career we cannot do better than cite some of his more important Papers. In the *Comptes Rendus* for 1839 there is a "Note sur l'incapabilité de l'eau pour conduire les courants voltaïques sans être decomposée;" and in the same year the *Philosophical Magazine* contains Papers "On Voltaic Series and the Combination of Gases by Platinum," and "On the Inaction of Amalgamated Zinc in Acidulated Water;" and to Sturgeon's *Annals of Electricity* for the same year was contributed an article on "Voltaic Reaction, or the Phenomenon usually termed Polarisation." In 1840 a Paper "On some Phenomena of the Voltaic Disruptive Discharge" was contributed to the *Philosophical Magazine*, where in 1841 and 1842 respectively also appeared articles "On some Electro-Nitrogurets" and "On a Gaseous Voltaic Battery." In 1845 there were contributions "On Grotthus's Theory of Molecular Decomposition and Recomposition" (*Phil. Mag.*), on the "Voltaic Action of Phosphorus, Sulphur, and Hydrocarbons" (*Phil. Trans.*). In 1847, in addition to the Bakerian lecture previously mentioned, the British Association Report contains a Paper "On the Quantity of Electrolysis as Affected by the Extent of the Sectional Area of the Electrolyte," the same report for 1848 also containing a Paper "On the Peculiar Cooling Effects of Hydrogen and its Compounds in Cases of Voltaic Ignition." Subsequently there were Papers "On the Transmission of Electricity by Flames and Gases" (*Roy. Inst. Proc.*, 1851-54), "On the Electro-chemical Polarity of Gases, including the Striæ in Electrical Discharges" (*Phil. Trans.*, 1852), "On the Influence of Light on the Polarised Electrode" (*Phil. Mag.*, 1858), "On the Reflection and Inflection of Light by Incandescent Surfaces" (*Phil. Mag.*, 1859), and "On the Transmission of Electrolysis across Glass (*Phil. Mag.*, 1860).

In 1866 Mr. Grove was President of the British Association, which met that year at Nottingham, the subject of his Presidential Address being the "Continuity of Natural Phenomena;" and in 1871 he was created a Judge of the Common Pleas. He retired from the Bench in 1887.

Sir William Grove's interest in science research was ever keen, even during the sixteen years of his occupancy of the Bench, and on his retirement he at once returned to his old pursuit as far as his age permitted him. In February, 1888, he delivered a lecture at the Royal Institution on "Antagonism, or the Conflict of the Various Forces by which the Equilibrium of Nature is Maintained;" and in March, 1891, he made a memorable speech at the Chemical Society's jubilee, reproaching himself for not having discovered the spectroscope, a discovery to which he went tantalisingly near.

Whether Law gained as much as Science lost by Sir William Grove's increasing success in and final absorption by his legal work, it is not for us to say; but whatever the gain to Law, Science lost a mind of a rare type.

## THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 417.*)

*Fall of Potential Methods.*

The principle of these methods is delightfully simple. A galvanometer is required whose deflections are proportional to the current through it, the instrument being used to measure relative differences of potential. Its resistance must be high compared with the resistances of the fault, testing wires and cable; if it is not, a resistance must be placed in series with it to fulfil this condition. Connections are made as in Fig. 24. Between A and earth is a current generator, either a dynamo or a primary or secondary battery. The last-named is the best suitable for the purpose, as the current flowing must remain absolutely constant during the test.

A B represents a known resistance R; B D represents the faulty section of cable, C being the position of the fault; $x$ stands for the resistance of B C.

On connecting the points 1 and 2 together there will be a galvanometer reading $d_1$ proportional to the difference of potential between A and B.

On connecting the points 2 and 3 together there will be a deflection $d_2$ proportional to the difference of potential between B and D, *i.e.*, between B and C, as C D is not in the main circuit.

Then
$$x = R\frac{d_2}{d_1}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

We will now consider the practical application of this.

*Method* 3.—A B is a section of good cable, in series with B D, the faulty section. Testing wires or spare cables of good insulation are available to connect D and B respectively to the testing station A. There must be a resistance box in series with the galvanometer. This resistance is adjusted until both the deflections $d_1$ and $d_2$ are readable on the scale of the instrument, and are conveniently large.

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Let $b$ be the distance required, viz., that from B to the point C; and let $a$ be the length of cable between A and B. If A B be of the same sectional area as the faulty cable

$$b = a\frac{d_2}{d_1}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

If, by adjusting the resistance in series with the galvanometer, the reading $d_1$ be made exactly $a$, $d_2$ will give directly the required length $b$. In practice, however, this adjustment is not worth the trouble.

If the cables A B and B C are made up of several pieces of cable of different sectional areas, the "equivalent lengths" of the pieces (as explained in describing the loop tests) must be taken for $a$ and $b$ in equation 25. Thus, in the simple case in which A B has throughout a sectional area $s_1$, and B C throughout a sectional area $s_2$,

$$b = a'\frac{s_2}{s_1} \cdot \frac{d_2}{d_1}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

where $a'$ is the actual length of the piece A B, $a'\frac{s_2}{s_1}$ being its equivalent length—*i.e.*, the length of a cable of sectional area $s_2$, which would have the same resistance as the piece A B.

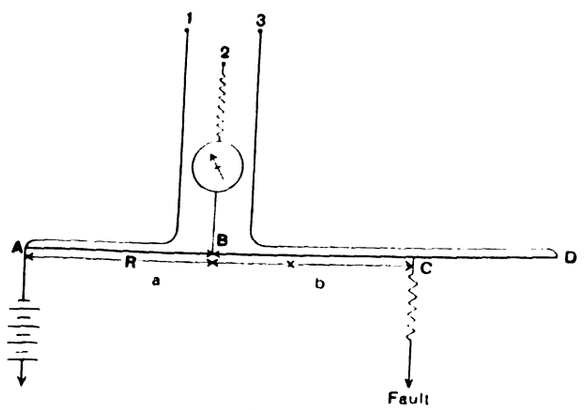


Fig. 24.

*Method* 4.—When the conditions are such that the piece of good cable A B, with the testing-wire from B back to station, are not obtainable, A B must be a piece of cable in the testing-station itself, B D being, as before, a length of cable containing the fault. Then the one testing-wire, from the far end of the cable to the testing-station, is all that is required in the way of external circuit. But now it is usually necessary to make a correction for the difference in temperature between the two pieces of cable; this correction is especially important if the testing point is the engine-room of the station itself. In calculating the equivalent length of the piece of cable in the station, 0·22 per cent. must be added for every degree Fahrenheit its temperature is above the estimated temperature of the cable in the ground. The length and size of the piece of cable A B in the station should be chosen so that its equivalent length, and, therefore, its resistance, is about the same as that expected from the station to the fault, so that the deflections $d_1$ and $d_2$ may not be too different.

Thus, if the fault be in a cable of 37/14 gauge, running to the station, and it is expected that the fault is about 100 yards distant, the piece A B may be taken of 7/14 cable, and its length $\frac{100 \times 7}{37}$ yards = 56ft. 9in. Then if the temperature error is negligable its equivalent length is 100 yards. If this piece of cable is in the engine room, whose temperature is 15deg. higher than the estimated temperature underground, $15 \times 0{\cdot}22 = 3{\cdot}3$ per cent. must be added to obtain its correct equivalent length, which then becomes 103·3. Suppose the deflections obtained were $d_1 = 241$ and $d_2 = 218$, the distance of the fault from the station would be $a = \frac{218}{241} \times 103{\cdot}3 = 98$ yards.

The size of the cable A B and the current sent through the circuit A B C. . . must be so chosen that there is no appreciable heating of either of the cables. This is very important, and applies also to method 3. The connection between the two cables at B must be a very good one. A good plan is to sweat both ends together, or to sweat each into a connecting-lug and bolt them up tightly, the lugs being first polished clean with emery cloth.

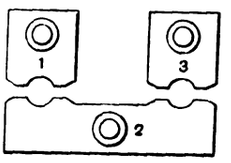


Fig. 25.

The difficulty in carrying out these fall of potential methods is that the current through the main circuit A B C must be kept *absolutely constant* during the test. This would be easy enough if it were an ordinary circuit, but it includes the fault,

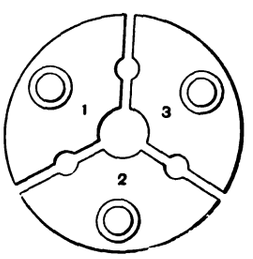


Fig. 26.

which is a thing of constantly varying resistance. In carrying out the test, the resistance of the galvanometer circuit is adjusted so that the deflections $d_1$ and $d_2$ are of convenient size, as above explained. If necessary the E.M.F. of the

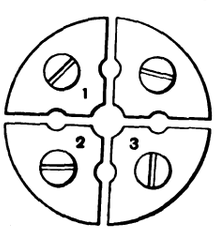


Fig. 27.

dynamo or battery must also be adjusted, and a resistance inserted between the battery and A. A plug switch is the best to use to make the contacts 1, 2 and 2, 3. One of the pattern shown in Fig. 25 is to be preferred to the

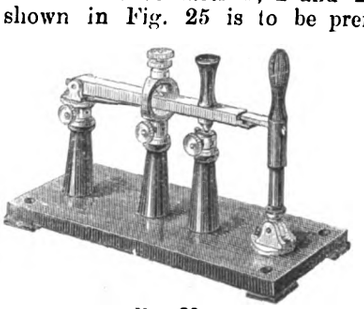

Fig. 28A.

usual type of three-way plug switch shown in Fig. 26. An ordinary reversing plug switch, Fig. 27, may be used, in which case one segment is left free, and one plug only is used. Or else a Webb key may be employed, Figs. 28A

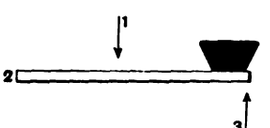


Fig. 28B.

and 28B. The current in the main circuit A B C should be switched on about five minutes before the final test is made, so that the resistance of the fault has time first to assume a steady value; the current must be maintained constant, and

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must not be switched off until the test is completed. First the connection 2, 1 is made. The deflection is watched until it appears quite steady, neither increasing nor decreasing. Then 2, 1 is disconnected, and the connection 2, 3 is made. The deflection $d_2$ is read as quickly as possible, and then 2, 3 is disconnected, and 2, 1 made as at first. If it is now found that $d_1$ has not altered, the readings $d_1$ and $d_2$ can be taken as correct. But if $d_1$ is now considerably different, one must take more readings until they seem satisfactorily constant. Changing the connections and reading the deflections must be done as quickly as possible, from the first change onwards. The following is an example of the kind of readings one may get:—

| $d_1$ | $d_2$ |
|---|---|
| 216 | |
| | 186 |
| 225 | |
| | 197 |
| 230 | |
| | 198 |
| 231 | |
| | 198 |

In this case the readings 230 and 198 may be taken for the calculation of the position of the fault. If the readings are very irregular a number of them must be taken, and $\frac{d_2}{d_1}$ must be calculated from their sums. In the example above, if $d_1$ and $d_2$ be taken as 230 and 198 respectively, $\frac{d_2}{d_1} = 0{\cdot}861$. The sum of all the readings of $d_2$ is 779, the sum of the readings $d_1$ is 902, and $\frac{779}{902} = 0{\cdot}864$, so that there is a difference of about a-third per cent.

It is always advisable to have an ammeter in the battery circuit, to see that too much current is not allowed to pass. This may be replaced by a galvanometer of the d'Arsonval pattern, if one is available, in addition to the instrument which is actually required for the test. It should be connected in the cable circuit between the battery and A, and should be shunted with a resistance of such a value that a conveniently large reading on the galvanometer scale is obtained. An adjustable resistance of some sort, capable of standing the main current, should also be included in the circuit. This is shown in Fig. 29. The latter resistance is to be continually adjusted so as to keep the deflection of the d'Arsonval galvanometer constant, and thus to compensate for the variations in the resistance of the fault. If this be done it is necessary to have two observers, one watching the d'Arsonval galvanometer and maintaining the current constant, the other carrying out the localisation test with the other galvanometer. A d'Arsonval galvanometer is recommended, as it is almost absolutely dead-beat.

*General Conclusions.*—The loop tests are to be preferred wherever they can be used, as they are easier to carry out than the fall of potential methods, they are "null" methods, and they are not influenced by variations in the resistance of the fault. Another great advantage of the loop methods is that exactly the same apparatus and methods of procedure can be employed whatever the resistance of the fault or sectional area of the cable. The fall of potential method requires to be adjusted to circumstances in each case. This is an important consideration. When a fault appears in a network, especially if this is a rare occurrence, the engineer is sure to feel more or less "worried"; but if he knows exactly what is to be done and in what order to do it, without having to waste too much time thinking and considering, things will go much easier. It is well to have ready worked out, once for all, the equivalent lengths of the various loops that would be most likely to be required, and to have one or two pairs of leads of known length specially reserved for such tests.

However great the hurry, the time necessary to make good tight connections must not be grudged. Murray's method (method 1) can be made absolutely direct-reading as already explained, and it can be carried out without the use of a resistance box, the only expensive piece of apparatus required being the galvanometer. This has often been replaced by a telephone, a contact-breaker being placed in the battery circuit. The modification is, however, not to be recommended. In the first place, it takes longer to adjust the bridge to balance, as the hum or click in the telephone is of the same character whether the slide has to be moved to the right or to the left, or whether *more* or *less* resistance is required in the adjustable arm of a resistance box bridge. Secondly, the use of interrupted or alternating currents for the bridge may give errors owing to the different capacities and self-inductions of the different parts of the loops.

It may happen that the only return circuit that can be obtained is a testing-wire, whose equivalent length in terms of the main cable would be very large indeed. In such a case a fall of potential method must be used.

Varley's method (method 2) cannot be employed when the resistance of the loop is very low, as for instance in the first example given to illustrate method 1. The reason of this is that the value of $d$ (Fig. 19 and equation 22) would have to be so small that it could not be adjusted accurately with the coils of an ordinary resistance-box pattern bridge. The method is a great favourite in cable factories, as the connections of the bridge for copper resistance measurements have hardly to be changed for the test. But in cable factory

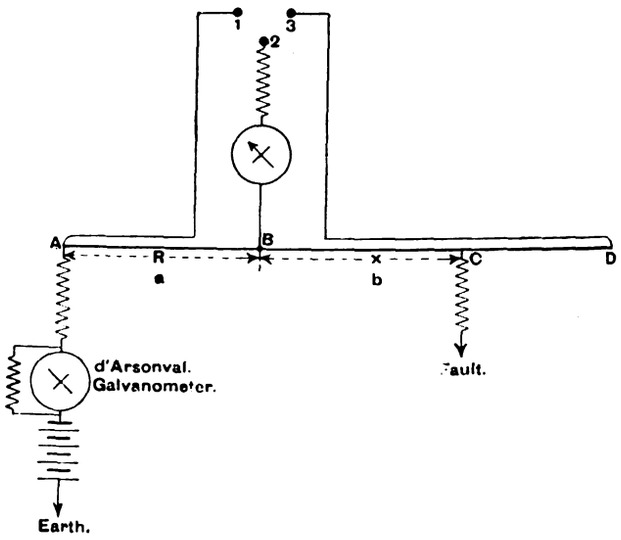


FIG. 29.

testing-rooms the conditions are different. The bridge often has coils from $\frac{1}{10}$th of an ohm upwards as well as a sensitive galvanometer, so that $d$ can be determined to $\frac{1}{100}$th of an ohm by taking comparative deflections. Then the connections are only changed over to Murray's method in the case of very low resistance cables. A testing-room electrician prefers a slightly longer calculation to disturbing the connections on his instrument table.

*(To be continued.)*

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**Electric Driving of Machine Tools.**—At the present time, says Mr. Horace L. Arnold, in his series of articles on "Modern Machine Shop Economics," now running through the *Engineering Magazine*, "electric driving of machine tools is in a transition stage of development, which may end in complete systems of individual motor driving, or in mixed systems where separate motor units of not very large capacity drive short lines of shafting. There seems at present a strong probability in favour of a final verdict for the individual system, where each tool is driven by its own independent electric motor. There is every reason to hope that all overhead shafting, pulleys, and belting may disappear from the machine shops, as these hitherto indispensable elements of power transmission are dirty and expensive light-obscuring annoyances; the sooner they go, the better for all concerned."

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## NOTES ON SOME AMERICAN ALTERNATING-CURRENT MACHINERY.*

(*Concluded from page 149.*)

Of the many topics bearing upon the best methods of alternating-current practice none, perhaps, has brought forth more discussion than the question of frequency; and as the conclusions arrived at by different writers have been more or less conflicting, it will prove of interest, we trust, to learn why the standard of 60 cycles per second has been adopted by the General Electric Company. The tendency, and, in fact, the general practice abroad, has resulted in the employment of frequencies in this neighbourhood, showing that whatever may be the advantages of very high frequencies, those to be gained by the use of lower are paramount.

*Frequency.*—All of the old single-phase generators were designed for 125 cycles per second; but the latest types are designed for 60 cycles, as has been previously stated. There is no reason why motors cannot be operated on circuits of any frequency; but in order to get them comparatively small, and at the same time adapted to low speeds, frequencies lower than 125 must be adopted. The drop in the line is another factor of great importance. The reactance voltage, that is, the drop due to self-induction of the line, is directly proportional to the frequency, and, consequently, if we have twice the frequency we get twice the reactive drop. The total drop, that is, the impedance drop, is the square root of the square of the ohmic drop plus the square of the reactive drop, and consequently the total drop in the line is greatly increased as the reactive drop increases. As an example, we will consider a No. 0000 B. and S. wire, which has an ohmic resistance of 0·26 ohm per mile. The reactance at 60 cycles is 0·65 ohm per mile, and the reactance at 125 cycles is 1·34 ohms, consequently the impedance of the line at 60 cycles is 0·7 ohm, and at 125 cycles 1·37 ohms. With a power factor as high as 95 per cent. this gives an apparent resistance to the line at 60 cycles of 0·44 ohm and at 125 cycles 0·66 ohm, or the apparent resistance is increased 50 per cent., with about 100 per cent. increase in frequency. It is to be noticed that at 60 cycles per second the reactance is about two and one-half times as large as the resistance for this particular wire; in sizes of wire most commonly used, that is, from No. 1 to No. 6, at 60 cycles, the reactance is very small, and in most cases practically negligible, while still very considerable at 125 cycles.

From what has just been said it would appear that low frequencies are preferable, but transformers used on low-frequency circuits are necessarily larger for the same output than those required when higher frequencies are employed. Consequently a mean between the two must be chosen, the higher frequencies being avoided, owing to the greater drop in the line and the necessarily high speed of generators and motors, while it is practically impossible to operate incandescent lights below 25 to 30 cycles per second, and arc lights below 40 to 45 cycles, owing to the perceptible flickering. It is chiefly for these reasons that the General Electric Company has adopted 60 cycles as a standard.

In special cases, as, for instance, in transforming alternating currents to continuous currents, it is advisable to use still lower frequencies, as otherwise the peripheral speed and the number of poles of the rotary transformers have to be high. The rotary transformers operating the plant of the Pittsburg Reduction Company are running at 25 cycles, and the Portland and Lowell transformers at 30 cycles. For very large units it might be advantageous to go even still lower.

*Alternating-Current Transformers.*—Constant improvements have taken place in the manufacture of alternating-current transformers built by the General Electric Company, and the old forms of type B. and E. transformers have been replaced by the type of more modern design, and in the latter constant improvements have been made without change in appearance and size by the use of better iron and consequent increase in efficiency, until at present the iron used in these transformers has a hysteretic coefficient as low as 0·0025, while in the older types frequently two and three times this quantity were unavoidable. The result of this reduced core loss has been an increased efficiency, which shows up especially in an increased all-day efficiency.

The type F transformer consists of primary and secondary coils laid close together, interwound in the larger sizes, and surrounded by a divided magnetic circuit giving the least magnetic length for a given magnetic cross-section. The losses in an alternating-current transformer consist of the $C^2R$ loss in the copper of the primary and secondary coils, and the hysteresis loss in the iron. Of these the latter is by far the more important factor in the all-day efficiency of the system, since it takes place continuously, whether the transformer is loaded or not, while the loss in the copper is noticeable only under load and practically disappears when the transformer is but lightly loaded. It is therefore of the greatest importance to keep the hysteresis loss in the transformer as low as possible. For instance, if in a transformer having an efficiency of 96 per cent. at full load, the $C^2R$ loss being 1 per cent. and the hysteresis loss 3 per cent., we assume that the full load is on during two hours of each day, running at no load the remaining 22 hours, it follows that the total loss in the transformer for the two hours will be 4 per cent. of the rated output, and that for the remaining 22 hours 3 per cent., giving a total of $\frac{4\times2+3\times22}{2}=37$ per cent. of the true output, which is an all-day efficiency of 63 per cent. If now the transformer be redesigned, so as to give a $C^2R$ loss of 2 per cent. and a hysteresis loss of but 2 per cent., then with the same full load efficiency of 96 per cent., the all-day loss would be, under the previous condition of load, $\frac{4\times2+2\times22}{2}=26$ per cent., that is, the all-day efficiency would be 74 per cent., which is considerably higher than in the first case. In reality, transformers used for lighting very seldom run at full load, and most of the time operate practically at no load. This shows the exceeding importance of having hysteresis loss as small as possible, while the $C^2R$ loss which takes place only under load, that is where the efficiency is high, is of less importance. With the advent of the new low-frequency work at 60 cycles, it was found desirable to design a new line of transformers, giving the same high efficiency at 60 cycles as the type F transformers give at 135 cycles. While the type F transformers can be used at 60 cycles as well as at 125 cycles, the efficiency, and especially the all-day efficiency, is necessarily lower at the lower frequency, and, therefore, for high economy work a special line of low-frequency transformers became desirable. These have been called type G transformers, and have essentially the same features as those of type F, except that the secondary voltages of 115 and 230 volts, the latter being designed for the three-wire system, have been used, corresponding to a ratio of transformation of 1 to 9 or multiples thereof, while in the type F transformers the ratio of transformation of 1 to 10 is used with secondary voltages of 52 and 104. The higher secondary voltage in the type G transformer is to be preferred, since in low-frequency systems it is more economical, and at the same time offers the desirable opportunity of employing secondary mains, utilising the increased secondary voltage with the attendant increased efficiency. For this reason the same secondary voltage was adopted as that commonly used in continuous low-tension distributing systems.

The exciting current of the transformers, that is, the current passing through the primary coil at no load, frequently but erroneously called the leakage current, is of comparatively small importance for the efficiency of operation, since it is essentially a lagging or idle current and does not represent power consumed. This means that the current reaches its maximum when the volts have decreased, and that the maximum value of the volts occurs at the moment when the current is still very small, so that the product of volts and amperes or the total power is considerably less than the product of average volts and average amperes. That part of the exciting current which represents energy, is, however, of great importance. Since it is the energy consumed due to hysteresis it is called the hysteretic energy current, or in other words, in a transformer having a 2 per cent. hysteresis loss, the energy part of the exciting current is 2 per cent., while the total exciting current may be 3 or 4 per cent., or even more according to the construction of the transformer.

Type F and type G transformers are built in sizes from 300 volts up to 30,000 volts, and from 6 lights to 600 lights. In the larger sizes the primary and secondary coils are interwound with each other so as to give low self-induction, and thereby close regulation, or a small drop of voltage from no load to full load. If the distance between the primary and secondary coils in a transformer is considerable, or the coils are thick, a large percentage of the magnetic flux passes between the coils when the transformer is loaded, owing to the counter magneto-motive force due to the secondary coil. The result is therefore that if the total magnetic flux passes around the secondary coil when the latter becomes loaded the voltage drops off. To avoid this the primary and secondary coils are brought very close together, so as to leave no room for magnetic flux to pass between them. All the transformers are tested for insulation at a voltage many times exceeding their rated voltage.

The transformers of type F and type G are mounted in cast-iron boxes which can be filled with oil or they may be used without oil.

Large transformers of from 30 kilowatts to about 800 kilowatts output are usually of the air-blast type; that is, both the copper and the iron are thoroughly separated, and an air blast produced by a small blower driven by a motor is blown through the passage between the coils as well as the iron. The general type is the same as in the F and G transformers, representing the transformer with external exciting magnetic circuit. The coils stand vertically, and consist of a large number of small primary and secondary coils alternating with each other and having air spaces for artificial cooling left between them. The iron is not built up solid, but numerous spaces

* Abstract from the *Electrical World* of New York. We are indebted to our New York contemporary for the blocks illustrating this article, which gives a useful insight into American methods.



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are left as ventilating ducts. In some of these transformers, instead of air a flow of oil is used for cooling, and, the whole transformer being immersed in an oil tank, the construction being in other respects the same as in the air-blast type, the oil merely replacing the air for carrying off the heat. Such transformers have been built and are in operation in sizes up to 830 kilowatts and potential up to 12,000 volts. The efficiency of these large transformers is extremely high, reaching 98·3 per cent. in the 830 kilowatts oil-cooled transformer built for the carborundum plant at Niagara Falls and operating at 25 cycles. This transformer is also of interest, inasmuch as its magnetic circuit probably represents the largest alternating magnetic flux ever produced, being over 42,000,000 lines.

Two distinct types of potential regulators are now being built by the General Electric Company, one of unitooth construction, and designated as M. R., and the second of multi-tooth construction, and designated as I. R. The M. R. regulators consist of two stationary coils placed at right angles to each other and fitted into four large slots in an exterior stationary magnetic iron circuit. Within the coils is an iron core which is capable of being turned in relation to the stationary field, so that by moving this core 90deg. the flux set up by one of the coils, which is the primary, may be shifted in its direction so that more or less lines of induction interlink with the secondary coil, and thus produce an increase or decrease of the secondary potential. The primary coil is in parallel with the mains, while the secondary is in series, and therefore the difference of potential on the mains may be raised or lowered.

These M. R. regulators are built in the following standard styles :—The 1 kilowatt 60 cycle, wound for either 1,000 or 2,000 volts primary, and permitting of 2½ per cent. or 5 per cent. boosting. The secondary current capacity is from 20 to 40 amperes on those adapted to 1,000 volts, and from 10 to 20 amperes for those built for 2,000 volts. The second size is of 1¼ kilowatt capacity, 125 cycles, and wound for the same voltages as the previous. The third size is a 3 kilowatt 60-cycle regulator, wound for either 1,000 or 2,000 volts, and either 2½ or 5 per cent. boosting—that is, with a capacity of 30 to 60 amperes secondary for the regulator having a 2,000-volt primary, and from 60 to 120 amperes for the coil having 1,000 volts primary. The fourth size is of 3·75 kilowatt capacity, for 125 cycles, and has the same winding as the preceding. A fifth type is designed for 6 kilowatt 60 cycles and wound for the same voltages and percentages of boosting, and is built suitable for a 2,000-volt circuit with 60 or 120 amperes, or 1,000-volt circuit with 120 and 240 amperes respectively. The sixth type is of 7·5 kilowatt capacity, designed for 125 cycles, the same voltages and percentage of boosting, 75 or 150 amperes in the 2,000-volt circuit, and 150 to 300 amperes in the 1,000-volt circuit.

In special cases regulators are built of ratios different from those given above, as, for instance, a great number of 1 kilowatt regulators which are now being built in which the primary is designed for 100 volts and 8 volts boosting.

The I. R. regulators are built upon practically the same lines as the induction motor; that is to say, the movable and stationary members have distributive windings. These I. R. regulators are built in larger sizes, where the unitooth construction of the M. R. regulators would offer too high self-induction, while for smaller sizes the M. R. type is to be preferred. The principle of these I. R. regulators is that the mutual induction between the primary and secondary is varied by moving the armature of the regulator in relation to the field so that in a particular position the secondary potential is practically added to the primary, while if the armature is moved through the distance between the two poles it is subtracted therefrom, and consequently the terminal voltage, which is the resultant of the effect of the primary on the secondary, is changed.

A large size regulator used in the carborundum plant at Niagara is described in the *Transactions* of the American Institute of Electrical Engineers, September, 1895, from which we have taken a few extracts. This regulator, diagrammatically shown in Figs. 33 to 35, is used on the Niagara power circuit in connection with a stationary transformer, by means of which latter the voltage generated at the power house is reduced from 2,200 volts to 185 volts, and supplied to regulator at this voltage. By varying the position of the armature in relation to the field of the regulator the difference of potential at the secondary, that is, at the carborundum furnace, can be varied accordingly.

When the furnace is started, that is, when the resistance of the furnace is very high, the position of the armature in relation to the field is such that the secondary voltage is 250 and the secondary current 3,000 amperes. As the furnace heats up the resistance decreases, and consequently the voltage has to be reduced. If the armature is in the middle position between the two extremes, the voltage is 185, and the current is 4,500 amperes. In this position, therefore, the regulator neither boosts nor lowers the voltage. When the furnace is going full blast the voltage is still more decreased and the current increased to give the same output, so that we then have 100 volts and 7,500 amperes. The position of the armature and the field are shown plainly in Figs. 33 to 35. This regulator is designed so that the armature can be moved either by hand or by motor. At present the hand regulation is being used.

*Alternating-Current Fan Motor.*—Although a number of fan motors have been placed upon the market of practically the same design as that made by the General Electric Company, yet perhaps few have taken the trouble to inform themselves of the principles employed in its action. The motor has a laminated field in one type of eight poles, and is designed for 125 cycles; while in the second type it is designed for 60 cycles, and has four poles. Both types run at about 1,800 revolutions per minute. The armature is of the squirrel cage pattern—that is, there is no wire wound upon the armature, but it is simply a solid mass of iron and copper.

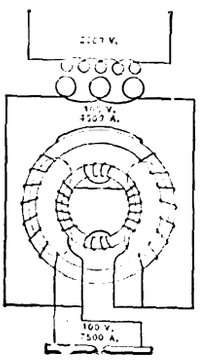


FIG. 33.

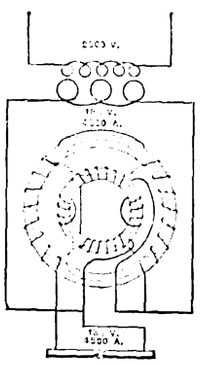


FIG. 34.

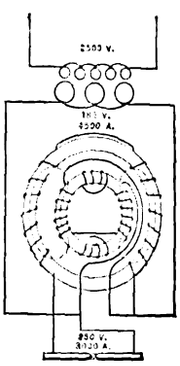
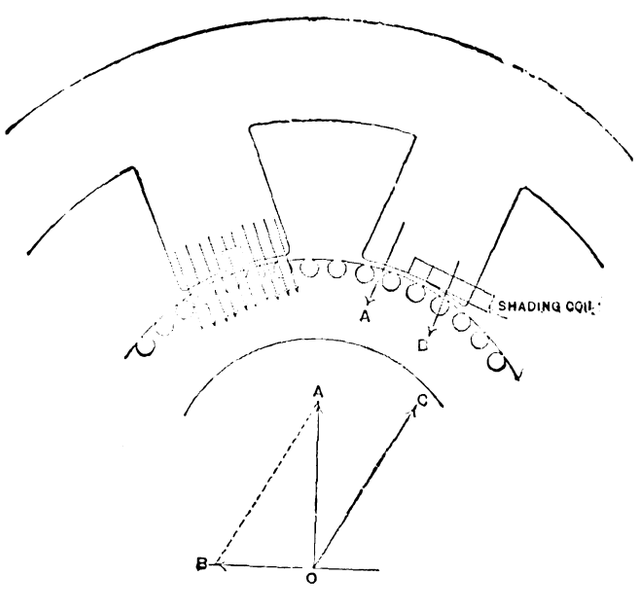


FIG. 35.

Partly covering each field spool is a shading coil (Fig. 36) which consists of a copper ring passing through the middle of the pole, and covering half of it. The object of these shading coils is to displace the magnetism between the armature and the field, so that the pull, instead of being in the line connecting the centre of the armature with the centre of the field, in which direction, of course, there would be no turning moment, is displaced sideways, thereby causing a continuous pull in a definite direction between the surface of the armature and the field.

If we consider a certain instant, when the current through the field spools is a maximum, and consequently the magnetism going through the pole is a maximum, part of this magnetism, as seen in the sketch, passes through the short-circuited shading coil, and




FIGS. 36 and 37.

consequently causes a current to flow in this coil. Let O A, Fig. 37, be the resultant magnetism of the field excitation and the current in the shading coil; O B is then the secondary current, which is 90deg. ahead of the magnetism; consequently O C represents the phase relation of the primary current and the magnetism. Since O C represents the magnetism corresponding to the primary current, and consequently is in the direction of the middle of the pole and the centre of the armature, O A, which is the resultant magnetism, is displaced therefrom, and produces consequently a turning moment on the armature.

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*Insulators.*—With the installation of high-potential plants it has been necessary to improve upon the insulators employed upon the lines carrying high voltages, and after a great deal of experimenting the General Electric Company has now adopted a double-petticoat porcelain insulator for voltages up to 15,000 or 20,000. Before these insulators leave the factory they are subjected to a very careful test at 30,000 volts. It is found that not 1 per cent. of the insulators crack at this potential, but practically all of them stand at least 40,000, even when supported on wet wooden pins and covered with snow or moisture. Since it might be of interest to know how these tests are carried out, we will briefly mention the methods employed.

A ring-shaped transformer made of regular armature punchings is surrounded by a number of wooden spools wound with the primary and secondary coils. By coupling in series or parallel all the primary coils, and likewise all the secondary coils, practically any desired ratio of transformation can be given to the transformers, and in this way any desired voltage or current may be obtained.

The transformers used in testing these insulators are so proportioned as to cause about one ampere to flow in the high potential circuit. To do this the transformer has to have a great deal of self-induction, therefore if there is any possibility of resonance it will be likely to show itself.

If what has been previously stated in this article is recalled, it will be remembered that the conditions for resonance depend upon the product of the capacity and the self-induction; therefore, although the capacity is very small in this circuit, since the self-induction is large, resonance may occur. It is necessary, therefore, to shunt the transformers by means of spark gaps, so that when resonance occurs, due to a change in the shape of the wave, the sparks will jump across the needle points in the shunted gap and thus save the transformer. It has been found that under certain conditions with the same generator and with different kinds of external loads the ratio of transformation, or rather the potential, judging from the ratio of transformation of the transformer, has varied 100 per cent. These high-potential insulators have been used in several places, for instance, Folsom, Cal.; Guadalahara, Mex.; Regla, Mex., and the circuits upon which

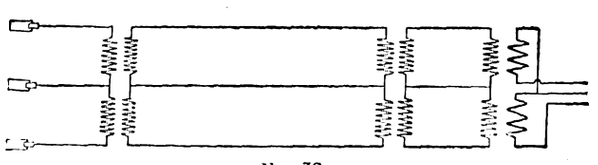

Fig. 38.

they are employed are from 10,000 to 12,000 volts. There is at present in operation at the Schenectady works a high-potential experimental line transmitting power from the power-house to the punching shop at the potential of 21,000 volts. The difference of potential in the power-house at the terminals of a monocyclic generator is 1,000 volts. In a special transformer-house this potential is raised by means of two 30-kilowatt oil insulated transformers to practically 20,000 volts. The ratio of transformation of each transformer is 575 to 11,500. By the connections given in Fig. 38 approximately 21,000 volts will be obtained at the terminals. The power is supplied at this potential, and by means of step-down transformers, identical in construction to the step-up transformers, reduced to 1,000 volts and further to 110 volts inside the punching shop, where the power is utilised for driving all the punching presses for arc lighting and incandescent lighting. This line has been in continuous and successful operation for about three months.

## CORRESPONDENCE.

### THE DUODECIMAL SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The article which you reprint on page 418 (July 24, 1896) seems to me to be replete with common sense. The first sentence exposes the tactics of the opponent of the metric system, and the two sentences beginning the last paragraph are equally judicious.

There is, however, one rather serious matter referred to in the middle of the article, which is not, in my opinion, thoroughly examined. I refer to the matter of names. I take it for granted that the so-called metric system, on a decimal basis, will be adopted in this country, and probably before very long, even though, owing to the enormous quantity of old-fashioned weights and measures in constant use by the multitude, the change must involve inconvenience for a time. It is a far more difficult matter than the rationalisation of the electrical units, yet it will be done. But what I do not like about the metric system is the names. The principle is to have a word, say metre, and then develop others from it, centimetre, millimetre, and so on. This is scientific, and is simple in a certain sense. But it is not, I think, suitable for popular use. I think that besides this scientific system, the various sub-units should have popular names, short names, monosyllabic and widely differentiated, just as are the old names, mile, league, yard, foot, inch, acre, perch, pole, and so on *ad inf.* The *names* are capital, for popular use. No ordinary person need know them all (I refer to the same done in the metric system), but only those he is concerned with. The question is, whether we should employ the old names (which the writer in *Engineering* objects to), say, call the metre a yard, or, for distinctness and transitionally, a new yard, the kilogramme a new pound, and so on—or a fresh lot should be invented. I am inclined to think the man in the street will do it himself if it is not done for him, or else stick to the old names. He won't stand Latin and Greek combinations and polysyllables; pint, quart, and so on, is the sort of thing he wants. If decimetre is forced upon him he is likely to call it a dessy. New monosyllabic words can be turned out in large number, quite easily. But their meanings would have to be learnt. This would be rather harder than giving a new meaning (in size) to an old word, without altering its type, though probably more satisfactory in the long run.—Yours, &c.,

July 31, 1896. Oliver Heaviside.

### NEGATIVE ACCURACY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Prof. Silvanus Thompson's "logical processes of thought" consist in a *petitio principii.* He assumes that resistance is a positive scalar quantity, and then deduces that it cannot be a directed quantity. *If* resistance be conveniently *defined* to be a positive scalar quantity, it cannot then be logically assumed to have directed properties; but that is one of the questions at issue. Is it or is it not convenient to define resistance as a positive scalar quantity? There is no authoritative statement on the subject, so far as I am aware. Nothing in the definition of the legal ohm states that it is a positive scalar quantity.

As to the ratio of two vectors being necessarily scalar, Prof. Thompson had better study the subject a little more, when he will find that, in general, the ratio of two vectors is not all scalar. No doubt the ratio of two parallel vectors is scalar; but there is nothing in the nature of scalar quantities, as such, to prevent the ratio of two such vectors being a negative scalar. Besides all this, an alternating voltage is not a vector at all; so that $\frac{dV}{dA}$, when V and A are alternating voltages and currents, is not the ratio of two vectors.

Prof. Silvanus Thompson says (see *The Electrician*, July 24th, p. 421) there "might be other criteria" between a "distributed adjuvant electromotive force" and a negative resistance. I am sure we would all feel very much obliged if he would suggest some way of distinguishing between ordinary resistance and Lord Rayleigh's suggested opposing electromotive cause of the resistance of alloys. Perhaps the same method might enable us to distinguish between adjuvant electromotive forces and negative resistances.

In conclusion, I entirely disclaim any desire to decide whether or no a negative resistance exists in any particular case; but I do claim that the only sound objection to the use of the term "negative resistance" is founded on the clearness and convenience of using the term "resistance" only for cases in which work is irreversibly turned into heat, and not for a reversed heat operation. But this is to add something to existing definitions of electrical resistance.—Yours, &c.,

Geo. Fras. FitzGerald.

Trinity College, Dublin, July 25, 1896.

### THE SALARY OF SCIENCE DEMONSTRATORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your impression of the 24th ult., p. 398, you refer to a protest by a correspondent of *Nature* against what he



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considers the scandalously low salary of £70 per annum for a demonstrator of chemistry. It appears to me difficult to understand what else can be expected. There is nothing now so cheap or so easily obtained as what is called education. Being cheaply obtained, it is gradually becoming of smaller value. The country is beginning to see that that which is ordinarily called education must be supplemented by that which is the most important education, though not called education—namely, personal practical experience. That which is only book-and-lip education must become a drug in the labour market; everyone can get it; one person can teach twenty—three-fourths of it is of no convertible value—the recipient, in fact, has nothing to sell or a very limited market. We are multiplying at an enormous rate the number of those who have what is, after all, a superficial technical knowledge of things; and are losing sight of the superior value, as a marketable commodity, of much dearly-bought practical experience, tacked on to a moderate quantity of that which is commonly called education.—Yours, &c.,

London, August 4, 1896. WYBROW.

## JOHNSON AND PHILLIPS' ARC LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We regret to observe in your last issue an unauthorised statement to the effect that Brockie-Pell Arc Lamp (Limited) has been formed for the purpose of taking over part of our business. We must ask you to kindly contradict this, as the Company referred to leaves our business alone, taking over from us only Messrs. Brockie and Pell, in whom we cannot claim to have proprietary rights. The Company, we understand, has been formed for the exploitation of certain of Mr. Brockie's patents for which we did not see our way to make an offer; but our name did not appear in the prospectus, we have no interest in the concern, nor do we consider that our business in arc lamps will be *adversely* affected by it. We shall continue to manufacture our lamps as before, bestowing upon them that care in make and finish to which their great success in the past has been due. It may be difficult for experts to detect the difference between our lamp and that known up to the present as the "Brockie-Pell;" but to our customers the difference will be apparent, inasmuch as the price of ours will now be reduced by the amount hitherto paid in royalties.—Yours, &c., JOHNSON AND PHILLIPS.

Old Charlton, Kent, August 4, 1896.

## *RE* OZONE: A PROTEST.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is very hard for me to have to reply to an article published by a paper of such a high scientific repute as *The Electrician*—to say to the not very competent man who wrote it, that he was utterly wrong when stating that my apparatus is of two types: "in one of which rows of points are opposed with *no intervening dielectric, save air*; while in the other an electrode is enclosed in a vacuous glass envelope, which is surrounded by concentric rings with radial points looking inwards towards the axis of the glass tube encircled by the rings. This annular structure constitutes the other electrode, and is made of aluminium."

Whoever may be the author of the above lines, he had no right to write them, because his statement is absolutely wrong.

I never constructed any apparatus *with no intervening dielectric*; there are strong objections to the construction of such an ozoniser, and I cannot make out how your contributor discovered that I *produce ozone without a dielectric*. I must strongly protest against this most unscientific and unfair criticism of your representative, who insists in saying that there is no dielectric between my electrodes, and takes advantage of this erroneous description of my apparatuses to run them down just at the moment when, after six years of work, I have succeeded in constructing what may be safely called a commercial ozoniser.

I will take the liberty to tell him that the apparatus which he recommends "in the form of two concentric glass tubes with conducting coatings on their remote surfaces, and entirely out of contact with the ozone, which is confined to passage through the annular space defined by the concentric glass tubes" is merely a toy. He is sweet and short when he condemns my electrodes, which, as a matter of fact, in spite of what he says, are separated by an absolute dielectric septum of glass.

"As to the apparatus, we may be allowed to speak. It is not necessary to do more than remind our readers that the best type of ozoniser used by chemists for the preparation of ozone in the greatest quantity and highest attainable concentration has an absolute dielectric septum (of glass) between the two coated surfaces."

The construction of my ozonisers allows me to utilise the two sides of my electrodes, and the ozonising surface is twice greater than in the existing ozone generators. This, therefore, enables me to obtain a larger yield of ozone.

In the existing ozonisers there is a metal sheet on a glass plate or tube, then a second metal sheet on another glass plate or tube, and so on, so that there is only one space where the silent discharge takes place, since one side only of the electrodes is working. In my apparatus there are successively a metallic electrode, a dielectric separator facing, on one side, the active surfaces of the first electrode, and, on the other, one active surface of the other electrode, and so on; and, therefore, each dielectric separator is between two flows of silent discharge. Thus, with 12 electrodes (assuming that the two end surfaces of the first and last electrodes do not work) there are 11 dielectric separators, and on each side of these 11 separators, I have the effluvia, *i.e.*, 22 surfaces of electrifying glow, as on each side of the dielectric, the silent discharge ozonises the stream of air, gas or mixture of gases forced through the apparatus by a blower. In a 1 H.P. generator or ozoniser, I have, therefore, 12 electrodes, 1 sq. ft. each, and utilise 22 sq. ft. of ozonising surface. Is it not wonderful that this absolutely original and efficient arrangement did not strike my supercilious critic, who does not appear to have noticed that I double the ozonising surface, and that I use 11 dielectric separators each 14in. square?

Who said that the use of points is non essential or injurious? My apparatus is based on this principle, that the electric tension is weak on all the plane parts of a conducting surface. In the theory of induction it is assumed that the particles of dielectrics between two conducting electrodes are in a certain state of tension, which rise higher and higher either by closer approximation of the inducing electrodes, increase of the charge, or by variation of the form.

The tension of the particles of the dielectric is excessively increased when conductors terminate in mere points or small surfaces; in fact, all the lines of induction force may be supposed to concentrate upon a pointed conducting body. The tension does not vary sensibly near the centre of a flat electrode, but it augments rapidly in approaching the edges, corners, or extremities. Thus the tension is sensibly uniform on a plate; on the contrary, the tension is greater on the surfaces which present a small curve. At the spot where the conductor ends by a point the tension is almost infinite, and the resistance of the surrounding air cannot prevent the continuous escape of electricity. The utilisation for the production of ozone of this property of points, edges, corners, &c., of increasing electric tension, and thus enabling the electricity with which an electrode is charged to overcome resistance and escape through the air or other non-conductor, is one of the characteristic features of the construction of my apparatuses, in which I produce ozone by the silent discharge, which means that between my electrodes there must be a dielectric.

I daresay each of my electrodes bears at least 10,000 points per square foot, and there is no exaggeration in stating that the production of ozone is much greater on such point bearing electrodes than on plain metal.

It really looks as if the article had been written by a biassed party. The only possible excuse would be that the so-called electrician who sneers at my work, of which I may be allowed to be proud, has not seen my apparatuses at all; but this is not an excuse.

I had nothing to do with the Exhibition mentioned in the "Production and Utilisation of Ozone." I never went to see it. Our offices and works are at 5, New Union-street, E.C.

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What interests me most is the application of ozone to industrial purposes, and therefore to the construction of ozonisers which present the essential qualities of cheapness, solidity, durability and efficiency. We have recently sent some 1 H.P. ozone generators to Paris in a factory, where next week we will send six more; then we will have some in Sweden for purifying substances used in the manufacture of yeast; and next month we shall have ten 1 H.P. generators in Scotland for the oxidation of oils and linoleum. (The ozone is produced in each ozoniser by means of 10,000 volts transformers.) Within a few weeks we shall probably have ready an installation for the sterilisation of water by ozone. I very seldom speak of my own work; but how can I, when attacked, avoid speaking for my generators which allow me to produce ozone on a manufacturing scale?

I must refer your contributor to my article in this week's *l'Electricien*, p. 54, on "L'Ozone Industriel," where he will very likely find something instructive and to the point for him.

In the meantime, we shall be glad to show him, when he likes, my small and large apparatus at work at 5, New Union-street, Moorgate Station; and in conclusion I will say that if he tells me how many grammes of ozone the apparatus he patronises gives per horse-power and per day, I will give him my figures, and I can assure him that he will not find any ozoniser which, with a given output of electrical energy, will give better results than my point-bearing ozonisers, which can work day and night in a continuous manner.

People who do not know ought not to be allowed to give their opinion; they only do mischief. In this case, I must complain of the serious prejudice caused by an outside man who says, as if he were competent, "until such proof is forthcoming, discussion is supererogatory." I can give the proof he wants, and I can discuss the question; and I shall feel very thankful if you send to New Union-street one of your staff who will see my ozonisers at work, and who, if he desires, will make an analysis, and determine how many grammes of ozone we produce per horse-power hour. At the same time, he will be able to ascertain that if my ozonisers are not constructed according to what my anonymous critic calls so pretentiously the accepted "canons," they are none the worse for it; on the contrary.

I should be very sorry, indeed very humiliated and ashamed of myself, if I had ever distorted and misrepresented the true facts in such a wilful manner. I do not want apologies; I do not care for them. If some one can prove that my apparatus is badly constructed and not efficient, I will accept his criticisms, but I will never submit to unfair treatment; and this is why I protest against the article on "The Production and Utilisation of Ozone."—Yours, &c., E. ANDREOLI.

[We freely acknowledge an error of description in the case of the apparatus having rows of opposed points. Our criticism is, however, unaffected. All existing experience indicates that the coated surfaces acting as electrodes should be out of contact with the gas to be ozonised. In Mr. Andreoli's apparatus this requirement is not fulfilled, and it rests with him to prove that his departure from recognised practice is of advantage.—ED. *E.*]

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THE ENGINEERING MAGAZINE.—The August number of this magazine is now ready, and contains the following articles:—"The Relations of Finance to Industrial Success," by Henry Clews; "The Fallacy of Municipal Ownership of Franchises," by Frank M. Loomis; "First Principles in Railroad Signalling," by George H. Paine; "The Era of Extravagance in the Electrical Business," by Burton E. Greene; "The Architecture of Bridge Building," by E. C. Gardner; "Are the Cyanid Patents Valid?" by J. S. C. Wells; "Natural Wealth and Industrial Possibilities of Cuba," by Raimundo Cabrera; "Modern Machine-Shop Economics," by Horace L. Arnold; "The Important Future of Producer-Gas," by A. Humboldt Sexton; and "British Railway Stocks as Desirable Investments," by W. J. Stevens. The issue also contains the usual exhaustive review of the World's Press. This number, as well as all the back numbers, may be obtained at the offices of the European Edition, 1, 2, and 3, Salisbury-court, Fleet-street, London, E.C.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied. price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application,

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

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TENDERS INVITED.—The Electric Lighting Committee of the Bath Corporation invites tenders for (*a*) boiler-house plant—boiler and fittings, feed pump, &c.; (*b*) engine-house plant—steam alternators, oil filter, fittings, &c., steam, exhaust, feed, blow-off and sundry pipes, valves, &c.; (*c*) mains; (*d*) crane; and (*f*) arc lamps and posts. Plans, specifications, &c., may be obtained after the 13th inst. from the consulting engineer (Mr. Robert Hammond), Ormond House, Great Trinity-lane, London, E.C.; and tenders must be sent in to the Clerk (Mr. F. H. Moger), 3, Wood-street, Bath, on or before Monday, the 31st inst. Further particulars are given in our advertisement columns.

——— The St. Pancras Vestry invites tenders for supplying and erecting 80 arc-lamp columns. Further particulars may be obtained at the offices of the Electricity Department, 57, Pratt-street, Camden Town, N.W. Tenders should be sent to the Vestry Clerk (Mr. C. H. F. Barrett), Vestry Hall, Pancras-road, London, N.W., by noon on Monday, the 24th inst. Our advertisement columns contain some additional information.

——— The Oldham Electric Light Committee invites tenders for an electrically-driven feed pump, capable of delivering 2,000 gallons of water per hour against 125lbs. steam pressure. Specifications, &c., may be obtained from Mr. Arthur Andrew, Gas and Water Offices, Oldham, to whom tenders should be sent by Tuesday, the 18th inst. Further particulars appear in our advertisement pages.

——— The Dundee Gas Commissioners invite tenders for the supply of india-rubber covered electric light cables. Quantities, &c., may be obtained from the electrical engineer, Dudhope-crescent, Dundee, and tenders should be sent to Mr. Thos. Thornton, Clerk to the Commissioners, City Chambers, Dundee, by the 19th inst. Further information appears in our advertisement pages.

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TENDERS INVITED.—The Radcliffe District Council requires tenders for the supply and erection of a gas engine and dynamo, and for wiring and fitting up the Technical School for the electric light. Tenders to the Clerk (Mr. J. Sharples) by the 17th inst.

——— The Islington Vestry invites tenders for the enlargement of its electricity supply station at Eden Grove. Tenders to the Vestry Clerk (Mr. Wm. F. Dewey), Vestry Hall, Upper-street, Islington, London, N., by the 21st inst.

——— The Lighting Committee of the Copenhagen Municipal Council invites tenders for the supply of 20,000 incandescent lamps. Tenders to the Directeuren for Belyskingsraesen, Copenhagen, by the 22nd inst.

——— The Spanish Government is inviting tenders for the construction and working of a telephone system in Mayagüez, in Porto Rico, and some particulars may be seen at the Commercial Department of the Foreign Office between 11 and 6 daily. Tenders should be sent in to the Minister of Public Works, Madrid, by October 8th.

——— The Dortmund Municipal Council invites tenders for the supply and erection of boilers, steam engines and dynamos at its electricity supply station. Conditions from the Bureau des Stadtischen Elektricitäts Werkes. Tenders to the Direction des Stadt. Elektricitäts Werkes, Dortmund, by September 1st.

TENDERS ACCEPTED.—The Leyton District Council has decided to accept the tender of Messrs. S. Z. de Ferranti (Limited) for the supply of 10-ampere electricity meters at £6 10s. each (less 15 per cent.) for use by private consumers.

——— The tender of Messrs. Laing, Wharton and Down has been accepted by the Bath City Council for the electric wiring of the pump room extension at £273.

——— The St. George's Vestry has decided to accept the tender of Messrs. Ridout and Co. for wiring and fitting up the Pimlico-road offices for the electric light at £39. 15s., subject to an alternative price being obtained for utilising the existing fittings.

——— The Leeds City Council has definitely accepted the tender of Messrs. Laing, Wharton and Down for the supply of trolley wire and attachments for the Roundhay and Kirkstall tramway, at the sum of £5,740.

——— The Cheltenham Town Council has decided to accept the tender of Messrs. Siemens Bros. and Co. for the supply of an alternator and a Belliss engine, at £1,590. It has also been decided to accept the tenders of Messrs. Chas. Malvern and Son for the extension of the electricity station buildings, at £1,183; and the tender of the St. Pancras Iron Company for lamp standards for Bath-road, at £1. 17s. 6d. each.

——— The Bray Town Commissioners have accepted the tender of Mr. W. Beckett, Dublin, for building a chimney at the electric light works for £546.

APPOINTMENTS.—Mr. H. C. Bishop has been appointed resident engineer at the Leyton Electricity Works, at a salary of £156 per annum. There were 56 applications for the position. Mr. Bishop has been engaged for some time past as an assistant at Bristol.

——— The Dundee Town Council has appointed Mr. W. H. Tittensor borough electrical engineer, in place of Mr. W. H. Brownlee, who recently resigned, at a salary of £200 per annum. The Council has decided not to appoint an assistant electrical engineer, but the Convener of the Gas Committee and the engineer have been requested to adjust and increase the subordinate staff.

APPOINTMENTS VACANT.—A clerk of works is required by the Leeds Corporation for the construction of the electric tramway from Roundhay to Kirkstall. Applications to the Town Clerk (Mr. Jno. Harrison), Town Hall, Leeds, by the 22nd inst. Some further particulars appear in our advertisement columns.

——— The Bristol Corporation Electrical Committee invites applications for the position of a charge engineer at a salary of £2 per week. Applications to the City Electrical Engineer (Mr. H. Faraday Proctor), Temple Back, Bristol, by Tuesday, the 11th inst. Some additional information is given in our advertisement columns.

——— There is a vacancy for an assistant at the City and Guilds Central Technical College. Commencing salary £150 per annum. Applications to Prof. Ayrton, Central Technical College, Exhibition-road, S.W. Additional particulars appear in our advertisement columns.

——— A teacher of advanced physics, mechanics and mathematics, is required at the Carpenters' Company's Technical School, Jupp-road, Stratford, E. Salary £130 per annum. Applications to the Principal.

REMOVALS.—The offices of the Dynamo Brush Company, formerly the Boudreaux Dynamo Brush Company, have been removed from Gresham-street to Chiswell House, Finsbury Pavement, E.C.

——— The London offices of Messrs. Robey and Co. (Limited), of Globe Works, Lincoln, have been removed from 117, Cannon-street to 79, Queen Victoria-street, E.C.

PARTNERSHIP CHANGES.—We are informed that Mr. C. Barry Hayes and Mr. John Wood, who have for many years taken a leading part in the management of the business of Messrs. Mosses and Mitchell, have been admitted as partners in the firm.

LIQUIDATION.—At a meeting of the proprietors of Callender's Bitumen, Telegraph and Waterproof Company (Limited), on July 8th, it was resolved that for the purposes of reconstruction it was desirable to wind up the Company voluntarily. Messrs. H. Drake and D. P. McEwen were accordingly appointed liquidators. Particulars of the registration of the new company (Callender's Cable and Construction Company, Limited) are given in our present issue.

"BROCKIE-PELL" ARC LAMPS.—Mr. Bennett Pell, Managing Director of the Brockie-Pell Arc Lamp (Limited), informs us that orders for Brockie-Pell lamps should now be addressed to the offices of the Company, 14, Gracechurch-street, London, E.C. Mr. Pell has, we learn, resigned his position with Messrs. Johnson and Phillips.

"D. P." BATTERY.—The D. P. Battery Company announce that, in view of the profits that have resulted from the sale of this well-known battery during the past year, a reduction in the price will be made to electric lighting contractors and others.

CASSIER'S MAGAZINE.—The contents of the August number of this magazine include articles on "The Storage Battery for Central Stations," by Arthur E. Childs; "Electric Fire Pumps," by C. L. Newcomb; "The Future of Power Development," by George E. Strong; "Automatic Coal-Weighing Machines for Power Stations," by F. H. Richards; "The World's Desire for Rapid Transit," by G. E. Walsh; "Some Unusual Forms of Locomotives," "Brains in Modern Steam Engine Building," "Flywheel Novelties," "Five-Crank Marine Engines," "Elevator Cables," "Sand-Blast Apparatus for Cleaning Castings," "Conveying Belts and their Use," "Some Fuel Problems," and "The Use of Power Hammers." The number also contains a biographical sketch of Charles F. Brush, with portrait, and discussions of current topics of engineering interest.

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BOLTON.—The General Purposes Committee has decided to give notice to the lessees of the tramways for the appointment of an arbitrator upon the question of introducing mechanical traction. The motive power suggested is electricity, powers for the adoption of which are being sought by the Town Council.

CAIRO.—The Cairo electric tramways were formally opened on Saturday last, the trial trip taking place in the presence of the Minister of Public Works (Fakhry Pacha) and a large concourse of spectators. The overhead trolley system is employed.

CHELTENHAM.—On the recommendation of the borough electrical engineer (Mr. Hamilton Kilgour), the Town Council has decided to carry out some extensions of the electric light mains in the Suffolk-square district.—St. James's Church and the Cambray Chapel, Cheltenham, are to be wired for the electric light. Current is to be taken from the Corporation's mains.

CORK.—Before deciding upon the question whether the Corporation should itself carry out the conditions of the Cork Provisional Order, it has been decided to obtain terms from electrical firms for establishing an electricity supply station for supplying current for public and private lighting.

CROYDON.—Several applications for electric current have been received from residents in the London-road, a district outside the compulsory area, and the Town Council has decided to take steps for providing a supply, subject to a guarantee by the applicants to take a supply of energy for three years of such an aggregate amount as will produce annually a sum equal to 10 per cent. upon the expense of laying down the necessary works. It has also been decided to borrow an additional sum of £2,000 for the purpose.

DERBY.—The Local Government Board has sanctioned the application of the Town Council for power to borrow £11,134 for electric lighting purposes.

DUNDEE.—A report on the condition of the electricity works has been prepared by the borough electrical engineer. The plant was originally intended for the supply of 10,000 lamps, but there are at present 17,000 lamps connected. The Wellgate, Overgate and Whitehall-street mains were overloaded; and applications for a supply of current had been received from Dock-street and South Tay-street, in neither of which streets were mains laid, although they were both within the area of supply. It has been decided to make additions to the mains in these districts at a cost of £1,047. The engineer was also instructed to prepare a report on the electric lighting of High-street, and to make inquiries as to public street lighting by electricity in other towns.

ELECTRIC TRACTION IN SOUTH AFRICA.—The Pretoria Tramway Company has obtained the sanction of the Government to substitute electric for horse traction, provided the residents approve the proposed change. The necessary plant has already been ordered

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from England, and work is expected to be commenced early next month. The cost of construction is put at about £8,500 per mile, and the Company is of opinion that by electrical power the trams can be worked much more economically and satisfactorily than by horses. The capital of the Company is £65,000, in £1 shares.

EPSOM.—The Urban District Council has decided to apply for a Provisional Order.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from July 29th to August 5th, with the ports of destination :—

*Australasia*—Launceston, £240 ; Melbourne, £634 (including £325 telegraph material) ; Perth, £28 ; Sydney, £858 ; Wellington, £67. *Belgium*—Antwerp, £38 ; Brussels, £519 ; Ostend, £83. *Ceylon*—Colombo, £145 (telegraph material). *China*—Shanghai, £1,247. *Denmark*—Copenhagen, £24 (telegraph wire). *Egypt*—Alexandria, £700. *France*—Boulogne, £15 ; Calais, 5 tons of telephone wire. *Germany*—Hamburg, £90. *Holland*—Amsterdam, £11. *Hong Kong*, £1,539 (telegraph apparatus). *India*—Bombay, £10 ; Madras, £80. *Italy*—Genoa, £220 (electric launch). *Japan*—Nagasaki, £32. *South Africa*—Cape Town, £589 ; Durban, £705 ; East London, £246 ; Port Elizabeth, £197. *Spain*—Pasages, £45. *Straits Settlements*—Penang, £331 ; Singapore, £180. *Sweden*—Gothenburg, £253 (including £225 telegraph wire and cable) ; Stockholm, £195.

GATESHEAD-ON-TYNE.—The following suggestive paragraph is taken from the report of the Parliamentary Committee presented at the last meeting of the Town Council :—"The Newcastle and District Electric Lighting Company recently intimated that they had abandoned the idea of obtaining a Provisional Order for the supply of the electric light in Gateshead ; and as no notice has been received from any other company, no application can be made this year to the Board of Trade for a Provisional Order except by the Corporation. Under these circumstances we recommend that for the present no action should be taken by the Council to obtain the necessary Order." Having freed themselves for a time from the attentions of electric light companies, the Council naturally decided to do nothing, and adopted the Committee's recommendation with alacrity.

HULL.—The Finance Committee has now endorsed the recommendation to apply to the Local Government Board for sanction to borrow £42,000 for electric lighting purposes.

JOHANNESBURG.—In the annual report of the manager of the Lighting Department of the Sanitary Board it is stated that the demand for electric current is far in excess of the capacity of the station, and considerable extensions will have to be carried out immediately. It has just been decided to light the railway stations and goods yards electrically.

LIVERPOOL.—Sir A. B. Forwood has resigned his position as Chairman of the Lighting Committee, and Mr. Charles Petrie has been elected to the vacant position. The Committee have instructed the electrical engineer, Mr. A. Bromley Holmes, to carry on the manufacture, sale and fixing up of fittings as before ; but applications for fixing fittings outside the area of the city or port of Liverpool or the borough of Bootle should be referred to the Committee.

MANCHESTER.—On the recommendation of the Gas Committee the City Council has decided to make a further reduction in the charge for electric current to large consumers. The charge to such consumers has hitherto been 4s. per quarter per lamp and 2d. per unit, and under the new regulations the charge will be 3s. per quarter per lamp and 1½d. per unit. This is equivalent to a reduction of 25 per cent., and it is hoped that the result will be a great increase in consumption, particularly during the day hours.

MILE END (LONDON).—The County of London and Brush Provincial Company has notified the Vestry of its intention to apply for a Provisional Order for the district of Mile End Old Town.

MILL LIGHTING.—Considerable extensions of the electric lighting installation at Daubhill Mills have been decided upon by the proprietors, Messrs. Tootal, Broadhurst, and Lees. Messrs. Drake and Gorham have obtained the contract, and the work is being carried out by their Manchester branch to the specification of Mr. W. Druce.

PLYMOUTH.—The borough electrical engineer (Mr. J. H. Rider) has presented an exhaustive report on the question of the erection of an electricity supply station. Mr. Rider recommends (1) that the station should be erected on the site of the Prince Rock cottages, on the shores of the Cattewater ; (2) that it should be so designed that the waste heat from the refuse destructor could be utilised if found desirable or feasible ; and (3) that electricity for traction purposes should be supplied from the same station. It is proposed to employ the alternating-current system. Mr. Rider suggests that the plant at the station should consist of three Lancashire boilers, with mechanical stokers and coal-conveying plant ; two direct-coupled steam alternators, of 200 kilowatts each ; and two direct-coupled steam alternators of 100 kilowatts each ; with the necessary switchboards, pumps, condensers, and other apparatus. The 100-kilowatt sets would be special combinations, which could be used either for tramway work alone, lighting alone, or tramway and lighting at the same time. Vertical compound condensing engines of the enclosed type are recommended. It is proposed to work all auxiliary machinery, such as pumps, mechanical stokers, coal conveyers, &c., by means of electric motors, and to erect a battery of accumulators in connection with the electric traction plant. The latter would be charged during the hours of light load, and would help to meet the sudden demands for current on starting the tramcars, and would also take the whole of the car-load if required during a few hours each day. This plant would give an effective output of 400 kilowatts, leaving 200 kilowatts as spare, and would enable the equivalent of between 7,000 and 8,000 8 c.p., lamps to be supplied at one time (equal to about 12,000 8 c.p. lamps connected), besides the arc lighting and the one section of the tramways. The total capital expenditure is put at £46,000, and the annual expenses at £3,815. The annual income is estimated as follows :—public lighting £1,184 (74 arcs at £16 each), private lighting £3,000, and tramways £2,143 (147,000 units at 3½d.), a total of £6,327, or a profit of £2,512. Mr. Rider recommends the adoption of the Brighton system of charging for current. The Electric Lighting Committee has approved Mr. Rider's scheme, and have decided to recommend the Council to apply to the Local Government Board for sanction to borrow £46,000 for the purpose of carrying it out.

RANGOON.—The question of the erection of an electricity station for supplying current for public and private lighting is at present being considered by the Municipal Council. A sub-committee is preparing a report on the subject.

REIGATE.—The Town Council have decided to apply for a Provisional Order. This resolution has been come to owing to the receipt of a notice from the Guildford Electricity Supply Company of intention to apply for an Order.

THE TELEPHONE IN FIFESHIRE.—At the last meeting of the Telephone Committee the Chairman was authorised to obtain estimates for the construction and erection of a telephone system for the service of the county, and to insist upon the Government conforming to the conditions under which the National Company work as to wayleaves. It was agreed to demand £75 annually from the National Telephone Company for wayleaves for the system they still own in Fifeshire.

WILLESDEN.—The District Council intends to oppose the application of the Willesden Green Electric Supply Company for a Provisional Order.

WOLVERHAMPTON.—The Town Council has accepted the tender of Messrs. Thomas Parker (Limited) for rewinding four armatures, and other electrical work, at £955. 10s. Permission to borrow this amount, and an additional sum of £600 already sanctioned by the Council, is being sought from the Local Government Board.

WORKS LIGHTING.—We learn that the contract for the electric lighting of Strine's Printing Company's Works in Derbyshire has been placed with Messrs. Drake and Gorham.

## COMPANIES' MEETINGS AND REPORTS.

### Edison and Swan United Electric Light Company (Limited).

The thirteenth ordinary general meeting of the shareholders was held at Cannon-street Hotel on the 31st ult., under the presidency of Mr. J. S. Forbes.

The SECRETARY (Mr. H. Charles Gover) having read the notice calling the meeting,

The CHAIRMAN, in moving the adoption of the report and accounts, reminded them that at their last meeting he pointed out the necessity for a good deal of reticence in their business, owing to the severity of the competition they had to meet. It would also be necessary for him to be extremely reticent that day, for by going into details they would only be arming their opponents. Their business was progressing in bulk, although under the necessity of competition there was a diminution on the profit of many things. The year's working had given them a credit balance of £27,526, and after providing the interest on the debentures they recommended a dividend of 5 per cent. on the "A" capital and the carrying forward of a considerable balance. The amount carried forward would enable them to pay more than 5 per cent. if it were thought prudent to do so ; but it was not. They thought that 5 per cent. was a very good dividend to pay until they saw that it was prudent to declare more. He had said that they had to meet very severe competition, and that was the case, although it was a little less serious now than it had been. The Ediswan lamp had a certain reputation, and a great many were committed to its use, and liked it. A great many who had tried other lamps which had been offered to them had given them up, and were returning to the Company ; but there was still competition in prices. Nevertheless, the bulk of their business had increased ; but the cost of

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materials had gone rather against them, platinum, brass, and things of that sort having been much higher in price. They had a strike in the early part of the year, and this disarranged their affairs for some time, and rather adversely affected the results of the year's working. The strike, however, opened their eyes to methods of making themselves independent of the class of people who struck; but they suffered during the strike and for some time afterwards. From the sale of lamps, fittings, royalty on holders, &c., they had derived £128,101, which exceeded the amount obtained in the previous year by £14,000. Although they had had a larger revenue, the profit had been less by about £2,000 than it was in the previous year. Nevertheless, they were able to recommend a dividend of 5 per cent. for the year, and to carry forward £5,352, compared with £3,700 a year ago. He believed they were now in a much sounder position than they were ever previously in, and they fully believed that the Company might be made more prosperous in the future. The stock on hand on the 1st July, 1895, amounted to £95,983; but on June 30th last the stock was £93,700, that being its estimated value after a good deal of revision and some considerable writings-down in value. After calling attention to the chief items in the accounts he expressed a hope that sooner or later the "B" shareholders would get something. It would not, however, be until after the "A" shareholders had received 7 per cent., when the "B" shareholders would come in for one-fourth of the balance.

Mr. J. W. SWAN, F.R.S., seconded the motion, which was carried unanimously.

After a few remarks from a SHAREHOLDER (to which the CHAIRMAN replied) a resolution was passed approving the dividend; and the retiring Directors and auditors were subsequently re-elected.

A vote of thanks to the Chairman and Directors then terminated the proceedings.

## Waterloo and City Railway Company.

The fifth half-yearly general meeting of the shareholders of this Company was held at the Waterloo Station yesterday (Thursday); Mr. Wyndham S. Portal presiding.

The SECRETARY (Mr. Fred. J. Macaulay) read the notice calling the meeting; the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN intimated that there were now 586 shareholders of the Company. The Directors had only to report a steady and continuous progress. The description of the work during the last six months, as shown by the engineers' report, was interesting and very instructive. Through the kindness of those gentlemen he had received another statement giving a summarised history of this exceptional railway undertaking up to the present time. The plan adopted for the construction of the railway was to erect a stage in the river Thames above Blackfriars Bridge, where 21 shafts were sunk 42ft. below the bed of the river. At the bottom of these shafts four shields were erected two in each shaft, and a driving tunnel, 12ft. in diameter, was commenced—two Citywards and two towards Waterloo. At the date of the last general meeting the City tunnels were under Queen Victoria-street, and they have now reached the western end of the City Station, where two tunnels, each 23ft. in diameter, have to be constructed to give the necessary space for the up and down platforms. Towards Waterloo the progress has not been quite so rapid, because the Waterloo tunnels have been for some months past driven through gravel charged with water, necessitating the use of compressed air to prevent the influx of water into the workings. Steady progress, however, had been made, and the northernmost, or up-tunnel, was now within 10 yards of the South-Eastern viaduct; and in the course of a few days the shield which was lowered into the bed of the river at Blackfriars, will see daylight near Waterloo. The southernmost or down-Waterloo tunnel has now reached a forward point in Stamford-street. The total length of single tunnel constructed during the past six months has been 1,100 yards. The shareholders' attention should be called to the fact that a work of such magnitude and importance had been carried out without any interference with the traffic of the important streets in the City and on the south side of the river under which the tunnel passes. Neither had there been a trace of what was going on below. It was very satisfactory to state that, although a night watchman lost his life last May by falling into one of the shafts at the South Eastern Railway, the works had been carried out without mishap to any of the contractors' workmen. I told them at the last meeting that arrangements were made with the South Western Railway Company with respect to the terminus at Waterloo station. With regard to the City terminus, suitable arrangements had been made with the Central London Railway Company for the accommodation of their traffic. He concluded by moving the adoption of the report and accounts.

The resolution was agreed to unanimously, and a vote of thanks to the Chairman and his colleagues brought the proceedings to an end.

## Electric Construction Company (Limited).

The report of the Directors of this Company, to be submitted to the shareholders at the third annual general meeting, to be held on Thursday, the 27th inst., at Winchester House, Old Broad-street, E.C., at 2:30 p.m., is as follows:—

The net profit of the year, after paying interest and general expenses, providing for the full maintenance of buildings and plant, and appropriating £5,000 to depreciation account, is £16,450. 9s. 11d. Adding to this amount the credit balance of £10,134. 15s. 10d. from last year, the sum available for dividend is £26,585. 5s. 9d., whereof the Directors recommend that £2,288. 0s. 5d. be applied in payment of the dividend on the Preference shares on September 1st next, and £11,000 in payment of a dividend of 5 per cent. (free of income-tax) on the Ordinary shares, one half on September 1st next, and the other half on March 1, 1897, and that the balance, £13,297. 5s. 4d., be carried forward to the credit of next year. The gross manufacturing profit has increased from £31,814. 12s. 7d. in 1895 to £41,353. 1s. in 1896. The output of the works shows a considerable increase on that of the previous year, and the Company's high reputation for excellence in design and quality of workmanship has been fully maintained. The factories are now full of orders at fairly remunerative prices.

To meet the demands of a growing business a considerable addition has been made to the buildings and plant at Bushbury; and these extensions, which have recently been completed, will not only facilitate prompt execution of orders, but also tend to economy in production. Among the more important works completed during the year, or now in progress, may be mentioned orders from the War Office and Crown Agents for the Colonies, and contracts for the supply of plant for various central stations, including Shoreditch, Clerkenwell, Leyton, Durban, and the Hartlepools Electric Tramways.

The retiring Directors, Sir Henry Mance and Mr. Philip Edward Beachcroft, offer themselves for re-election, as do the auditors, Messrs. James Meston and Co.

## Central London Railway Company.

The following is the report of the Directors of this Company for the half-year ended June 30th, to be submitted to the general meeting of shareholders, to be held at the Cannon-street Hotel, E.C., on Tuesday, the 11th inst., at 3 o'clock p.m.:—

The expenditure during the half-year has amounted to £273,812. 14s. 9d., which, added to the amount previously expended, makes a total outlay of £442,998. 0s. 11d. The further payments for property and works required during the next few months has rendered a call upon the shareholders necessary, and accordingly a call of £2 per share, payable on the 1st September next, has been made. Representations having been made that it would be a convenience to proprietors to be allowed to pay up in full the uncalled capital on their shares in advance of calls, the Directors have decided, until further notice, to accept such payments in advance.

Satisfactory progress has been made with the works. Possession has been obtained of the station sites at Shepherd's Bush, Holland-park, Notting-hill-gate, Westbourne, Marble-arch, Oxford-circus, Tottenham-court-road, British Museum, and Chancery-lane. It has been considered expedient to enlarge the Post Office station in Newgate-street, and the acquisition of the additional property required for that purpose will involve some delay. The Great Eastern Company has approved the plans for the station at Liverpool-street, and it is hoped that an agreement satisfactory to all parties may soon be completed. The North London Company has also approved plans providing for a public access from Broad-street station to the Liverpool-street station of the company.

## Liverpool Overhead Railway Company.

The report of the Directors of this Company for the half-year ended June 30th, to be presented at the general meeting of shareholders to be held at the Law Association Rooms, 14, Cook-street, Liverpool, on Tuesday next, states that the gross revenue receipts for the period amounted to £31,285. 3s. 3d., and the working expenses to £19,694. 2s. 5d. The number of passengers carried during the last two years is as follows:—

| | Half-year ending December 31, 1894. | Half-year ending June, 20, 1895. | Half-year ending December 31, 1895. | Half year ending June, 30, 1896. |
|---|---|---|---|---|
| First class .. ..... | 352,179 ... | 400,260 ... | 441,762 ... | 455,561 |
| Second class ..... | 2,228,224 ... | 2,114,462 ... | 2,374,794 ... | 2,284,823 |
| Workmen (special return tickets) ..... | 1,050,976 ... | 945,338 ... | 950,819 ... | 999,191 |
| Total ..... | 3,641,379 ... | 3,460,060 ... | 3,780,375 ... | 3,739,575 |

The works at the Southern Extension have been somewhat delayed; but it is hoped that the line will be opened in the late autumn.

The total receipts from passenger traffic and miscellaneous items amount to £31,285. 3s. 3d., and after deducting working expenses and debenture interest there remains a balance of £9,092. 0s. 10d. With the sum of £2,074. 6s. 7d., balance from last half-year, there is a sum of £11,165. 7s. 5d. available for dividend. The Directors recommend the declaration of dividends at the rate of 5 per cent. per annum on the Preference shares, and 2¾ per cent. per annum on the Ordinary shares, less tax, payable on the 15th inst., leaving a balance of £2,897. 12s. 5d. to be carried forward.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**BROCKIE-PELL ARC LAMP (LIMITED).**—This Company was registered on July 22nd, with a capital of £80,000, in £1 shares, to enter into an agreement with William Shrimpton, The Associated Underwriters (Limited), James Brockie and Bennett Pell, to manufacture, sell and supply electric arc lamps, electric incandescent lamps and electrical apparatus generally, to carry on the business of an electric lighting company in all or any of its branches, and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, &c. The first subscribers, with one share each, are: J. A. Fuller, A. T. Bucknall, A. W. Lawson, E. Wyatt, W. H. May, A. Eldridge, and E. T. Church.

**CALLENDER'S CABLE AND CONSTRUCTION COMPANY (LIMITED).**—This Company was registered on July 24th, with a capital of £100,000, in £5 shares, to acquire and take over as a going concern the business of contractors and manufacturers of electric cables, and bitumen and waterproofing materials carried on by Callender's Bitumen Telegraph and Water-

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proof Company (Limited), at Belvedere, Erith, Kent; and to carry on the business of electrical engineers, electricians, engineers, contractors, manufacturers of and dealers in railway, tramway, electrical and other apparatus, mechanical and chemical engineers, &c. The first subscribers, with one share each, are:—G. Carr, G. M. Callender (engineer), W. D. Reid (engineer), S. C. Lambert (secretary), C. W. Clarke, T. Petersen (engineer), and E. Thomson. The first Directors are:—H. Drake, W. O. Callender, D. P. McEuen, G. A. Elliott, W. M. Mackenzie and T. O. Callender. Registered office, 20, Cannon-street, London, E.C.

**EDWIN DANKS AND CO. (OLDBURY), LIMITED.**—This Company has been registered with a capital of £100,000, in £5 shares, to acquire the business of a boiler manufacturer, engineer, &c., hitherto carried on by Edwin Danks, at Oldbury, Worcestershire, and to carry on the businesses of boiler makers, mechanical, electrical and hydraulic engineers, electricians, &c.

**GLORIA ELECTROLYTIC INCANDESCENT LIGHT COMPANY (LIMITED)** This Company was registered on July 15th, with a capital of £20,000, in £1 shares, to work and deal with any inventions or patent rights relating to electric or gas lighting.

**IMPROVED INCANDESCENT ELECTRIC LAMP SYNDICATE (LIMITED).**—This Company was registered on July 22nd, with a capital of £700, in £1 shares, to carry on business as electricians and engineers, suppliers of electricity, and manufacturers of electrical apparatus. The first subscribers (with one share each) are:—S. P. Eastick, engineer; E. Sayer, engineer; J. Bates, engineer; S. C. Phillips, A. E. Tighe, and C. O. Bastian, electrical engineer. The first Directors are S. C. Phillips, C. O. Bastian, S. P. Eastick, and E Sayer.

**NEWTON ELECTRICAL WORKS (LIMITED).**—This Company was registered on July 25th, with a capital of £80,000 in £10 shares, to acquire and take over as a going concern the business carried on at Taunton, under the style of The Newton Electrical Works, to enter into an agreement with Francis M. Newton, and to carry on the business of electricians, engineers, electrical apparatus manufacturers, and dealers, &c. The first subscribers are:—Francis M. Newton (80 shares), H. N. Hickley (9 shares), A. E. Newton (10 shares), H. C. Sweet (1 share), A. W. Edgell (100 shares), Lionel C. H. Palairet (250 shares), and R. C. N. Palairet (250 shares). The first Directors are:—F. M. Newton, H. N. Hickley, and Lionel C. H. Palairet.

**TAVERNIER SAFETY MOTOR SYNDICATE (LIMITED).**—This Company was registered on July 25th, with a capital of £3,000, in £50 shares, to carry into effect an agreement with Alphonse E. Tavernier, electrician, for the acquisition of certain patent rights, and to carry on the business of electricians, mechanical engineers, motor manufacturers, founders, &c.

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**BOURNEMOUTH AND DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return of this Company to June 16th has just been filed. The capital is £500,000, in £5 shares, and 5,725 of these have been subscribed for. The full amount per share has been called, and £28,625 has been received.

**CHATHAM, ROCHESTER, AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).**—The annual return of this Company to July 14th has been filed. The capital is £50,000, in £5 shares, and 3,390 of these have been taken up. 1,863 have been considered as paid, and the full amount has been called on 2,000, and £2 per share on the remaining 27.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31⅜d. per oz. (Aug. 6th). Consols (2¾ per cent.) 113⅛—113⅜ for money, 113⅛—113⅜ for account; 2½ per cent. 108—108⅛ (Aug. 6th). Stock Exchange Settling Days: Consols, Sept. 1st; Stocks and Shares Continuation Days, Aug. 11th and 26th; Ticket Days, Aug. 12th and 27th; Pay Day, Aug. 13th; Mining Share Carry-over Days, Aug. 10th and 23rd.

**BELFAST STREET TRAMWAYS COMPANY (LIMITED).**—In their half-yearly report to June 30th the Directors of this Company express their regret that up to the present they have not been able to come to terms with the Corporation for working their tramways by electric traction. The Company's Bill authorising the use of electricity has been passed, but subject to the sanction of the Corporation being first obtained.

**BIRMINGHAM CENTRAL TRAMWAYS COMPANY (LIMITED).**—A special meeting of the shareholders of this Company was held on Wednesday, for the purpose of confirming the resolution passed on the 20th ult., agreeing upon a voluntary liquidation with the view of transferring the business of the Company to the Canadian Syndicate or to a new company to be formed by them. The Chairman (Mr. Neale) moved the confirmation of the resolution, and this was unanimously agreed to.

**BROCKIE-PELL ARC LAMP (LIMITED).**—Letters of allotment and regret for the recent issue of capital by this Company have been posted.

**CALLENDER'S CABLE AND CONSTRUCTION COMPANY (LIMITED).**—Letters of allotment and regret for the recent issue of debenture stock of this Company have been posted.

**CAPE TOWN AND SUBURBAN ELECTRIC LIGHTING SYNDICATE (LIMITED).**—The annual meeting of this Syndicate was recently held at Cape Town. The Chairman (Mr. R. S. Solomon), in moving the adoption of the report and accounts, congratulated the shareholders on the satisfactory increase in the business during the past year. Applications for electric current were coming in freely, and the prospects of the Syndicate were exceedingly encouraging. The year's revenue amounted to £4,898. 2s., and of this sum £2,695. 16s. 3d. was for private and £2,202. 5s. 9d. for street lighting. The working expenses amounted to £2,300. 15s., and after providing for depreciation there was a balance of £1,900 available for distribution, out of which it was decided to pay a dividend at the rate of 7 per cent. per annum. Owing to the necessity to provide additional funds for expenditure already incurred on new works, and also for contemplated extensions, the Directors recommended that the capital of the Syndicate should be increased to £50,000 by the creation of 25,000 additional shares of £1 each, and this proposal was duly agreed to.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The traffic returns of this Company for the week ended August 2nd were £1,036, against £804 in the corresponding period of last year, an increase of £232. The total receipts for the half-year amount to £4,524, against £4,224 in the corresponding period of 1895, an increase of £300.

**CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company recommend the payment of a dividend on the Ordinary shares at the rate of 8 per cent. per annum, free of income tax, for the half-year ended June 30th.

**DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for July are £1,950.

**D. P. BATTERY COMPANY (LIMITED).**—At the recent general meeting of this Company a dividend at the rate of 19 per cent. was declared for the past year.

**ELECTRICAL DEVELOPMENT AND FINANCE CORPORATION (LIMITED).** A prospectus has been issued inviting applications for 250,000 shares of £1 each in this Corporation, payable 5s. per share on application, 5s. on allotment, 5s. on November 2nd, and 5s. on January 1st, 1897. The Corporation, which has an authorised capital of £500,000, in £1 shares, has been formed to promote and develop undertakings for utilising electrical power in all its industrial applications. The business of the Corporation will not be confined to the British Isles, and it is proposed to extend operations to the Colonies and foreign countries. The Directors anticipate a considerable revenue from the promotion and development of electric tramway undertakings, and from schemes for the transmission of electrical energy for mining and other purposes. The prospectus states that the Corporation intends commencing operations at once, and has under consideration (1) the exploitation of an improved system of electric traction, (2) the electric lighting of an important and rapidly-growing district, (3) an interest in a new self-starting alternating-current motor, and (4) the construction of a system of electric-generating stations and the transmission of power in a mining district in South Africa. The Company will have ample working capital, as except for a small percentage for flotation expenses, the whole of the subscribed funds will be at the disposal of the directors for exploiting electrical enterprise at home and abroad. The Company is, we learn, unencumbered with costly patents. The Directors are the Duke of Newcastle, Mr. W. Claude Johnson, M.I.C.E., M.I.E.E. (of Messrs. Johnson and Phillips), and Prof. William Crookes, F.R.S., Chairman of the Notting Hill Electric Lighting Company. Mr. F. Hastings Medhurst, B.Sc., M.I.E.E., is consulting engineer, and Mr. James Meadowcroft is secretary (*pro tem.*). Copies of the prospectus may be obtained from the London and County Banking Company, Lombard-street, E.C., and branches; the brokers, Messrs. Marcus and Peczenik, 2, Drapers'-gardens, E.C.; the solicitors, Messrs. Renshaw, Kekewich and Smith, 2, Suffolk-lane, E.C.; or at the Company's offices (*pro tem.*), 24, Coleman-street, E.C. The list of applications opened on Wednesday, and close to-day (Friday) for town, and to-morrow (Saturday) for the country.

**GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).**—In our report of the proceedings of the general meeting of this Company in our last issue, it was stated at the conclusion of the Chairman's opening speech that the dividend for the year on the Ordinary shares was 4 per cent. This should have been 4½ per cent.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company in July last were £24,000, and the total receipts between January 1st and July 31st were £163,600, against £155,400 and £174,800 in the corresponding months of 1894 and 1895 respectively.

**IMPERIAL TRAMWAYS COMPANY (LIMITED).**—The report of this Company for the half-year ended June 30th states that the Directors have had in preparation for some time past proposals for the conversion of the Reading Tramways into electric lines and concurrently extending the system. As soon as these proposals are matured they will be submitted to the Town Council for approval. The report also states that a deposit of £30,000 has been received from the Dublin United Tramways Company (Limited), the purchasers of the Company's interest in the Dublin Southern District Tramways Company, and the balance (£76,000) is payable on or before December 31st. The gross revenue, omitting all credit on Dublin account, amounts to £1,892, and the net profit to £1,595, so that with the balance brought forward £2,349 is available for distribution. The Directors recommend an ordinary dividend at the rate of 2½ per cent. per annum, carrying £42 forward.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 2nd inst. amounted to £1,357. The amount for the corresponding week last year was £1,355; increase, £2.

**NATIONAL TELEPHONE COMPANY (LIMITED).**—The Right Hon. Sir James Fergusson, Bart, G.C.S.I., M.P., has been elected a Director of this Company, to fill the vacancy caused by the death of Sir Henry George Calcraft, K.C.B.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended July 31st, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,603.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half-month ended July 31st are £1,920, against £1,865 in the corresponding period of 1895. The March receipts, estimated at £5,754, realised £5,735.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, July 29. | | Price Wednesday, August 5. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending August 1. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 51 | 52 | 52 | 54 | 4 12 7 | Jan., Apr., July, Oct. | 52½ | 52 |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 96½ | 97½ | 97½ | 98½ | 5 1 6 | " " | 98 | 95½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 | 9½ | 9 | 9½ | .. | .. | 9½ | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 | 104 | 100 | 104 | 3 17 2 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ | 9½ | 8½ | 9½ | .. | .. | .. | .. |
| £30,000 | £10 | 3/0 | Brazilian Submarine | 15½ | 15½ | 15½ | 15⅝ | 4 8 11 | Mar., June, Oct., Dec. | 16½ | 15½ |
| £75,000 | £100 | 7% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 | 116 | 112 | 116 | 4 6 7 | June and December | 115½ | .. |
| 10,000,000 | $100 | 8/0 | Commercial Cable Capital Stock | 160 | 170 | 160 | 170 | 4 2 4 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 10% | Cuba Submarine | 12½ | 13½ | 12½ | 13½ | 5 18 6 | February and August | .. | .. |
| 6,000 | 10 | 2/0 | Do. Preference 10 per Cent. | 20 | 21 | 20 | 21 | 4 5 3 | " " | .. | .. |
| 12,931 | 5 | 10% | Direct Spanish (fully paid) | 3½ | 4½ | 3½ | 4½ | 5 0 0 | April and October | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 | 10½ | 10 | 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each xd | 107⅞ | 110⅞ | 107⅞ | 110⅞ | 4 2 1 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 xd | 9½ | 10½ | 9½ | 10½ | 4 3 0 | Jan., Apr., July, Oct. | 10⅞ | 9½ |
| 400,000 | 10 | 5/6 | Eastern xd | 17½ | 18½ | 17½ | 18½ | 3 11 2 | " " | 18½ | 17⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference xd | 18½ | 19 | 18½ | 19½ | 3 1 6 | " " | 18½ | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock xd | 131 | 134 | 131 | 134 | 3 0 2 | May and November | 133 | 131 |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 xd | 106 | 109 | 104 | 107 | 4 13 6 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension xd | 17⅜ | 18½ | 18 | 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅜ | 18 |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock xd | 132 | 135 | 130 | 133 | 3 0 2 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900 | 100 | 104 | 100 | 104 | 3 17 4 | January and July | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 100 | 104 | 100 | 104 | 3 17 4 | " " | 107 | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) xd | 103 | 109 | 105 | 108 | 3 14 1 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) xd | 111⅞ | 114⅞ | 111⅞ | 114⅞ | 3 10 10 | May and November | 11⅜ | 11⅜ |
| 180,227 | 10 | 3/9 | Globe Telegraph and Trust xd | 11½ | 11⅝ | 11½ | 11⅝ | 3 13 7 | Jan., Apr., July, Oct. | 18½ | 17⅜ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference xd | 17⅜ | 18½ | 17⅜ | 18½ | 3 5 9 | " " | 24½ | 21 |
| 150,000 | 10 | 5/0 | Great Northern | 23½ | 24½ | 23⅝ | 24½ | 4 1 8 | Jan., April, and July | 106 | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 Issue | 105 | 108 | 105 | 108 | 4 14 4 | March & September | 54 | .. |
| 17,000 | 25 | 37/6 | Indo-European | 53 | 55 | 53 | 55 | 4 10 11 | May and November | .. | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | .. | .. | .. | .. | .. | .. | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 111 | 114 | 111 | 114 | 5 7 7 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 | 111 | 103 | 111 | 3 12 4 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 7 | 8 | 7 | 8 | 5 0 0 | April and October | .. | .. |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 140 | 145 | 140 | 145 | 4 2 9 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 | 6 | 5 | 6 | 5 0 0 | January and July | .. | .. |
| £233,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 104 | 107 | 104 | 107 | 4 15 3 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 | 2 | 1 | 2 | .. | January and July | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 99 | 101 | 99 | 101 | 7 15 0 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1⅛ | 1⅜ | 1⅛ | 1⅜ | .. | .. | 1⅛ | .. |
| 84,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11⅝ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ | 10½ | 9½ | 10½ | 5 14 3 | " " | 10⅛ | 1⅛ |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 103 | 111 | 108 | 111 | 4 10 6 | June and December | .. | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8½ | 9½ | 8½ | 9½ | 4 17 7 | May and November | 9½ | 9 |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 7 | 7½ | 7 | 7½ | 5 0 0 | " " | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ | 2⅝ | 2½ | 2⅝ | .. | .. | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 xd | 105 | 109 | 103 | 107 | 5 12 2 | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 xd | 105 | 109 | 103 | 107 | 5 12 2 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 | 115 | 110 | 115 | 6 3 7 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 104 | 107 | 104 | 107 | 5 14 10 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| | | | Chili Telephone (fully paid) | 3½ | 4 | 3½ | 4 | .. | .. | .. | .. |
| 44,000 | 5 | 2/6 | Consolidated Telephone Const. & Manufacturing | 1/16 | 1/8 | 1/16 | 1/8 | .. | May and November | .. | .. |
| 224,850 | 10/0 | 1½d. | Oriental Telephone and Electric (fully paid) | 3/16 | 3/8 | 3/16 | 3/8 | 5 14 3 | Yearly | 7⅛ | 7 |
| 171,504 | £1 | 1/0 | National | 7⅞ | 7⅞ | 7⅞ | 8 | 3 8 9 | June and December | .. | .. |
| 484,597 | 5 | 3/0 | Do. 6 per Cent. Cumulative 1st Pref. | 17 | 19 | 17 | 19 | 3 3 2 | " " | 17½ | 17⅛ |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 16½ | 17½ | 17 | 18 | 3 8 7 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 3rd Pref. | 6⅞ | 7⅛ | 6⅞ | 7⅛ | 3 10 2 | January and July | 108½ | 108 |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 107 | 110 | 107 | 110 | 3 3 9 | July | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 3¾ | 4¼ | 3¾ | 4¼ | 4 14 2 | January and July | .. | .. |
| 58,000 | 5 | 4/0 | United River Plate | 101 | 103 | 101 | 103 | 4 14 9 | | | |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | | | | | | | | |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| | | | City of London Electric Lighting (fully paid) | 14½ | 15½ | 15 | 16 | 3 2 6 | February & August | 15½ | 15 |
| 40,000 | £10 | 10/0 | Do. 6% Cumulative Pref. (fully paid) | 16¼ | 17⅞ | 16½ | 17½ | 3 8 7 | January and July | 17½ | .. |
| 40,000 | 10 | 6/0 | * Do. 5% Debenture Stock (red.) | 133 | 137 | 133 | 137 | 3 13 3 | June and December | 134½ | .. |
| £100,000 | Stock | 5% | Electricity Supply Co. for Spain | .. | .. | .. | .. | .. | .. | .. | .. |
| 19,900 | £5 | .. | Charing Cross & Strand Electricity Supply Corp. | 8½ | 8⅞ | 8½ | 8⅞ | .. | .. | 8⅞ | 8½ |
| £30,000 | £5 | 3/0 | Do. 5 per Cent. Debentures, 1900 | .. | .. | .. | .. | .. | .. | .. | .. |
| £57,400 | £100 | 5% | County of London & Brush Prov. Ord. (fully paid) | 8 | 9 | 8 | 9 | .. | .. | 8½ | .. |
| 22,475 | £8 | .. | Do. Pref. (fully paid) | 13½ | 14 | 13½ | 14 | 4 5 9 | .. | 13⅝ | 13½ |
| £10,000 | £10 | 5/4½ | House-to-House Electric | .. | .. | .. | .. | .. | .. | .. | .. |
| 8,322 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 15,000 | £5 | .. | Do. 1st Pref. Cumulative (fully paid) | .. | .. | .. | .. | .. | January and July | .. | .. |
| 10,000 | £5 | 6% | Liverpool Electric Supply (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 45,000 | £5 | .. | London Electric Supply | .. | .. | .. | .. | .. | .. | .. | .. |
| 111,000 | 5 | .. | Metropolitan Electric Supply (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 49,900 | £10 | 5/0 | * Do. 4½% Debs. | ¾ | 1¼ | ¾ | 1¼ | 2 18 2 | June and December | 13⅝ | 13½ |
| £150,000 | Stock | 4½% | Notting Hill Electric | 13½ | 13⅝ | 13½ | 13⅝ | 3 9 4 | " " | 12 | .. |
| 6,452 | £10 | 4/0 | Rand Electric xd | 119 | 123 | 119 | 123 | .. | .. | .. | .. |
| .. | .. | .. | St. James and Pall Mall xd | 11 | 12 | 11 | 11½ | .. | .. | .. | .. |
| 19,930 | £5 | 2 6 | Do. 7 per Cent. Preference | 1⅜ | 1½ prem. | 1⅜ | 1⅞ prem. | .. | .. | .. | .. |
| 20,000 | £5 | 7% | Westminster Electric Supply (fully paid) | 12 | 13 | 12½ | 13½ | 2 17 5 | .. | .. | .. |
| 59,900 | 5 | 4/6 | | 9½ | 10½ | 10 | 11 | 3 6 8 | .. | .. | .. |
| | | | | 11 | 12 | 11 | 12 | 2 18 4 | .. | 11¾ | 11½ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| | | | Brush Electrical Engineering | 1 | 1¼ | 1 | 1¼ | .. | .. | .. | .. |
| 90,000 | 3 | 1/8 | Do. 6 per Cent. Pref. Non-Cumulative | 1⅜ | 1⅝ | 1¼ | 1½ | .. | .. | 1⅞ | 1⅛ |
| 90,000 | 2 | 6% | Do. 4½ per Cent. Debentures | 112 | 115 | 112 | 115 | 3 19 10 | March & September | 113½ | .. |
| £125,000 | Stock | 4½% | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 | 2¼ | 2 | 2¼ | .. | January and July | .. | .. |
| 28,180 | 5 | 3/0 | Edison and Swan United ("A" Swan) (£3 paid) | 1⅞ | 2⅛ | 1⅞ | 2⅛ | 6 13 4 | February & August | .. | .. |
| 89,261 | 5 | 1/6 | Do. 4½% Mortgage Debenture Stock | 103 | 106 | 103 | 106 | 4 5 2 | January and July | .. | .. |
| £100,000 | Stock | 4½% | Electric and General Invest. Ordinary (£1 paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| £20,000 | £5 | .. | Electric Construction | 1¾ | 1⅞ | 1½ | 1⅞ | .. | .. | 1½ | .. |
| 110,000 | 2 | .. | Do. 7 per Cent. Cumulative Pref. | 2½ | 3 | 2⅜ | 3 | 4 13 4 | September | .. | .. |
| 12,845 | 2 | 2 9/5 | Elmore's Patent Copper Depositing | ⅞ | ⅞ | ⅝ | ⅞ | .. | .. | .. | .. |
| 91,195 | 2 | 10/0 | Fowler-Waring Cables (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 20,000 | 5 | .. | India Rubber, Gutta Percha, &c., Works | 21 | 23 | 22 | 23 | 4 6 11 | February & August | 23 | 22 |
| 50,000 | 10 | 5/0 | * Do. 4 per Cent. Debentures | 105 | 109 | 105 | 109 | 3 13 5 | March & September | 108½ | 107½ |
| £200,000 | 100 | .. | International Okonite Ordinary | .. | .. | .. | .. | .. | .. | .. | .. |
| 15,995 | £10 | .. | Do. 8 per Cent. Preference | .. | .. | .. | .. | .. | December and June | .. | .. |
| 16,000 | £10 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ½ | ¾ | ½ | ¾ | .. | .. | .. | .. |
| 20,000 | £5 | .. | Telegraph Construction and Maintenance | 39 | 42 | 39 | 42 | 4 5 9 | March and July | 49½ | 39 |
| 37,350 | 12 | 12/0 | * Do. 5 per Cent. Bonds | 102 | 105 | 102 | 105 | 4 15 8 | January and July | .. | .. |
| £150,000 | 100 | 5% | Woodhouse and Rawson Ordinary (£3 15s. paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 37,514 | £5 | .. | Do. Preference (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 41,098 | £5 | .. | W. T. Henley's Telegraph Works Ordinary | 17½ | 18½ | 17½ | 18½ | 4 10 1 | March & September | 18½ | .. |
| £100,000 | 10 | 10/0 | Do. 7 per Cent. Preference | 17½ | 18½ | 17½ | 18½ | 3 15 8 | February & August | .. | .. |
| £30,000 | 10 | 7/0 | Do. 4½% Mortgage Debenture Stock | 109 | 114 | 109 | 114 | 4 0 4 | | | |
| £50,000 | Stock | 4½% | | | | | | | | | |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | | | |
| | | | City and South London Railway Con. Ordy. xd | 45 | 47 | 45 | 47 | 2 13 2 | January and July | 15⅞ | .. |
| £630,000 | Stock | 1⅞% | Do. 5% Perpetual Preference xd | 14½ | 15½ | 14½ | 15 | 3 6 8 | May and November | 137 | .. |
| 7,650 | 10 | 5% | Do. 4% Perpetual Debenture | 135 | 137 | 136 | 138 | 2 18 0 | " " | .. | .. |
| £10,171 | Stock | 4% | Liverpool Overhead Railway | 13½ | 13⅝ | 13⅝ | 13⅞ | 2 3 0 | " " | .. | .. |
| 37,500 | £10 | 3½% | Do. 5% Preference | 17½ | 17⅝ | 17⅝ | 17⅝ | 2 17 7 | " " | .. | .. |
| 10,000 | 10 | 5% | Do. 4% Debenture | 112½ | 114½ | 112½ | 114½ | 3 9 10 | January and July | .. | .. |
| 125,000 | Stock | 4% | | | | | | | | | |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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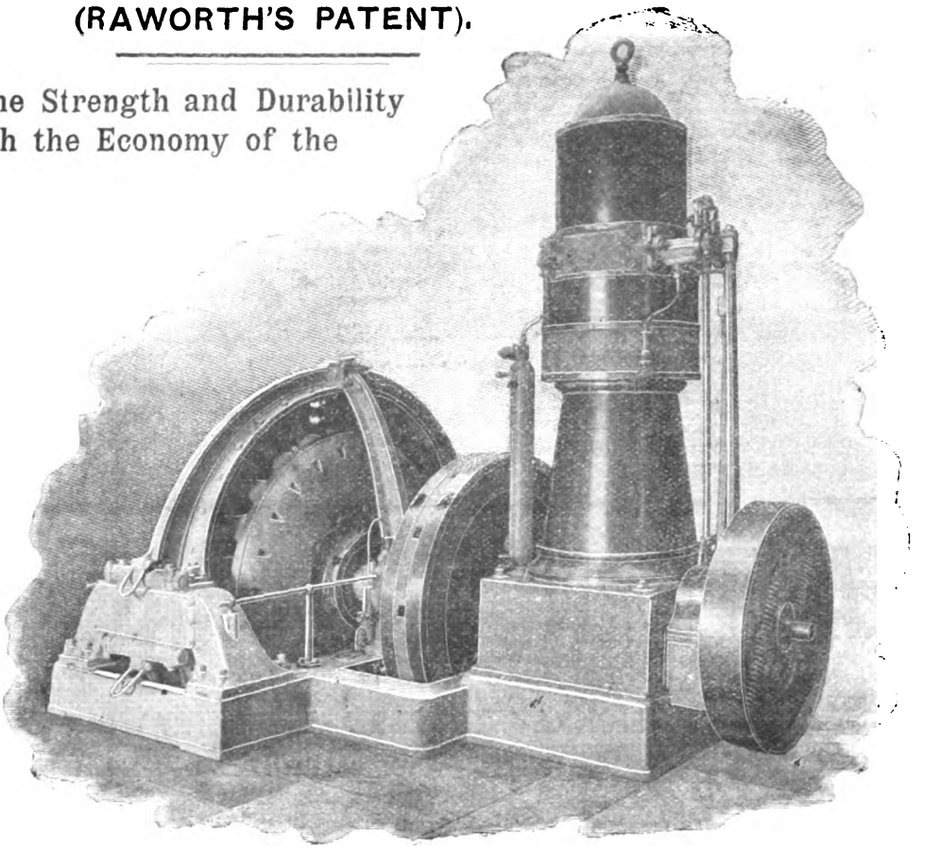
# THE UNIVERSAL ENGINE

(RAWORTH'S PATENT).



This Engine combines the Strength and Durability of the Corliss Engine with the Economy of the High Speed Engine.

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***Small Space,***
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***Perfect***
***Governing.***

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MANUFACTURERS OF

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**"AETNA" Insulators and Hangers.**

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TROLLEYS, LIGHTNING ARRESTERS, SPECIAL TOOLS, &c. EVERY REQUISITE FOR OVERHEAD LINE CONSTRUCTION.

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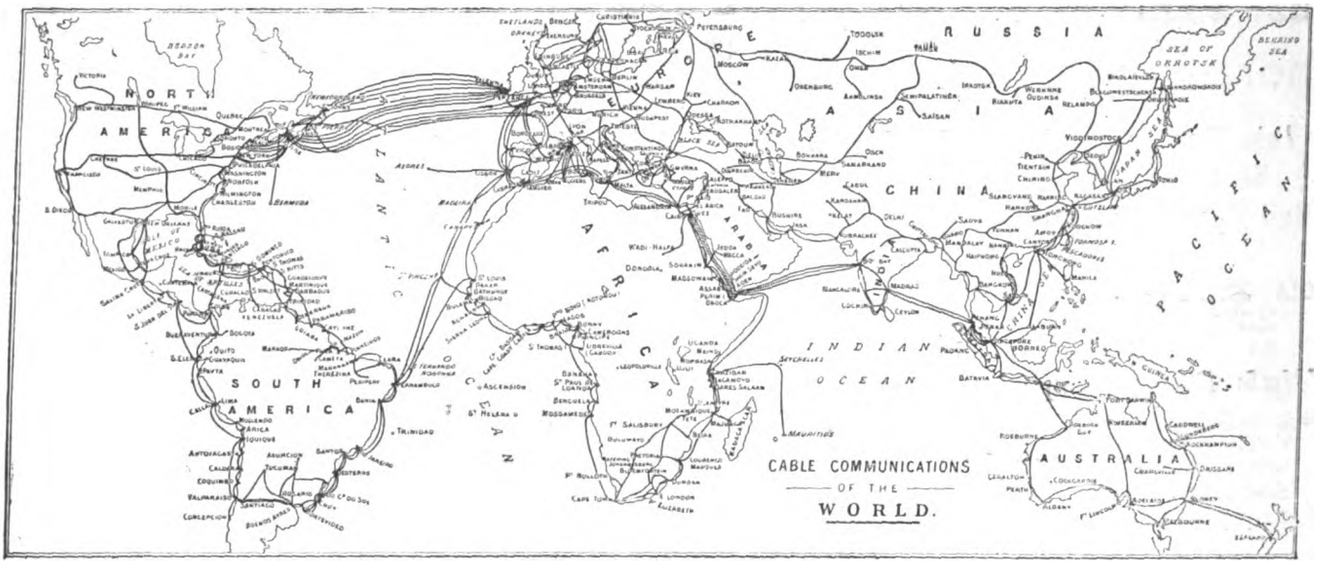
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

# EASTERN TELEGRAPH COMPANY

IN CONNECTION WITH THE (LIMITED),

EASTERN EXTENSION (AUSTRALASIA AND CHINA), BRAZILIAN SUBMARINE, EASTERN AND SOUTH AFRICAN, EUROPE AND AZORES, WEST AFRICAN AND AFRICAN DIRECT TELEGRAPH COMPANIES.

By DIRECT TRIPLICATE CABLES, to Spain, Portugal, Gibraltar, Malta, Egypt, Aden, and India.

By DIRECT DUPLICATE CABLE ROUTES to Madeira, St. Vincent, Brazil, Argentine Republic, Uruguay, also to Peru, Chili, and other parts of South America; and to Suakin, Perim, Penang, Malacca, Singapore, Labuan, Java, Australia, New Zealand, Tasmania, New Caledonia, Bangkok, Cambodia, Saigon, Tonquin, Hainan, China.

By ALTERNATIVE CABLES to Zanzibar, Mombasa, Mozambique (duplicate) Lourenço Marques (Delagoa Bay), Durban and Capetown; Bathurst, Sierra Leone, Accra, Lagos, Bonny, Bolama, Bissao, Cameroons, St. Thome, Principe, Loanda, Benguella, Mossamedes, Conakry, Grand Bassam, and Gaboon.

By SINGLE CABLE to the Azores, Tangier, Tripoli, Cyprus, Seychelles, Mauritius, and Manila.

Telegrams should be sent from the Company's Stations—

**LONDON**—11, OLD BROAD STREET, E.C.; 8, LEADENHALL STREET; 3, GREAT TOWER STREET; 42, PARLIAMENT STREET, S.W.; 206a, WINCHESTER HOUSE, E.C.; 37, HOLBORN VIADUCT, E.C.; FOREIGN AUCTION HALL, COVENT GARDEN MARKET, W.C., and 449, STRAND, W.C.

**MANCHESTER**—20, Brown Street. **LIVERPOOL**—K13, Exchange Buildings.

**GLASGOW**—141, BUCHANAN STREET.

COMPANY'S LEVANT SYSTEM:

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The Company's Cables are worked by Muirhead's DUPLEX principle upon all its Main Sections.

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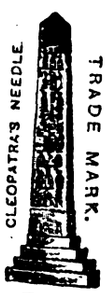


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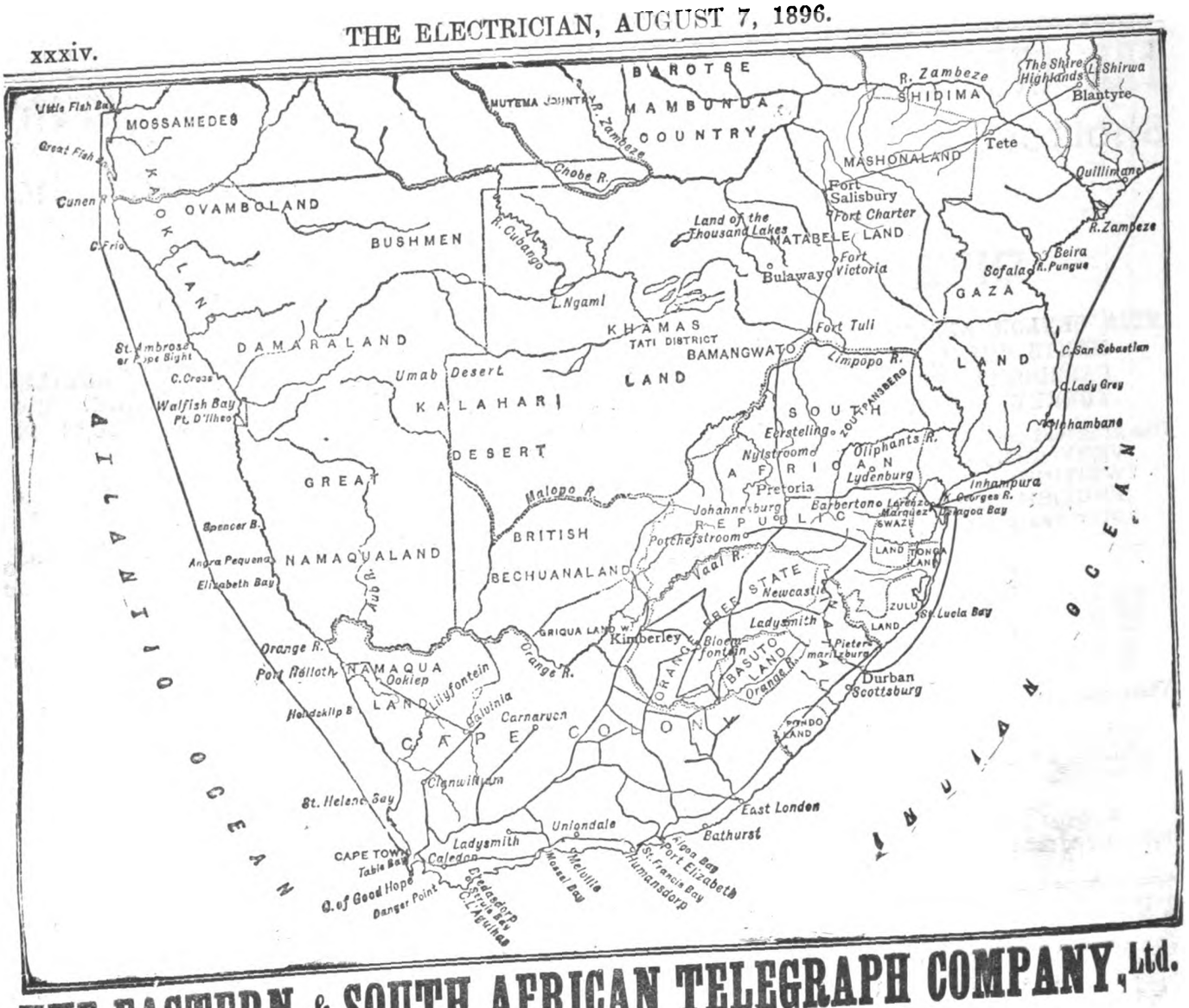


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|---|---|---|
| BATHURST (Gambia). | BISSAO. | CONAKRY. |
| SIERRA LEONE. | BOLAMA. | GRAND BASSAM. |
| ACCRA. | PRINCIPÉ. | KOTONOU (Porto Novo) |
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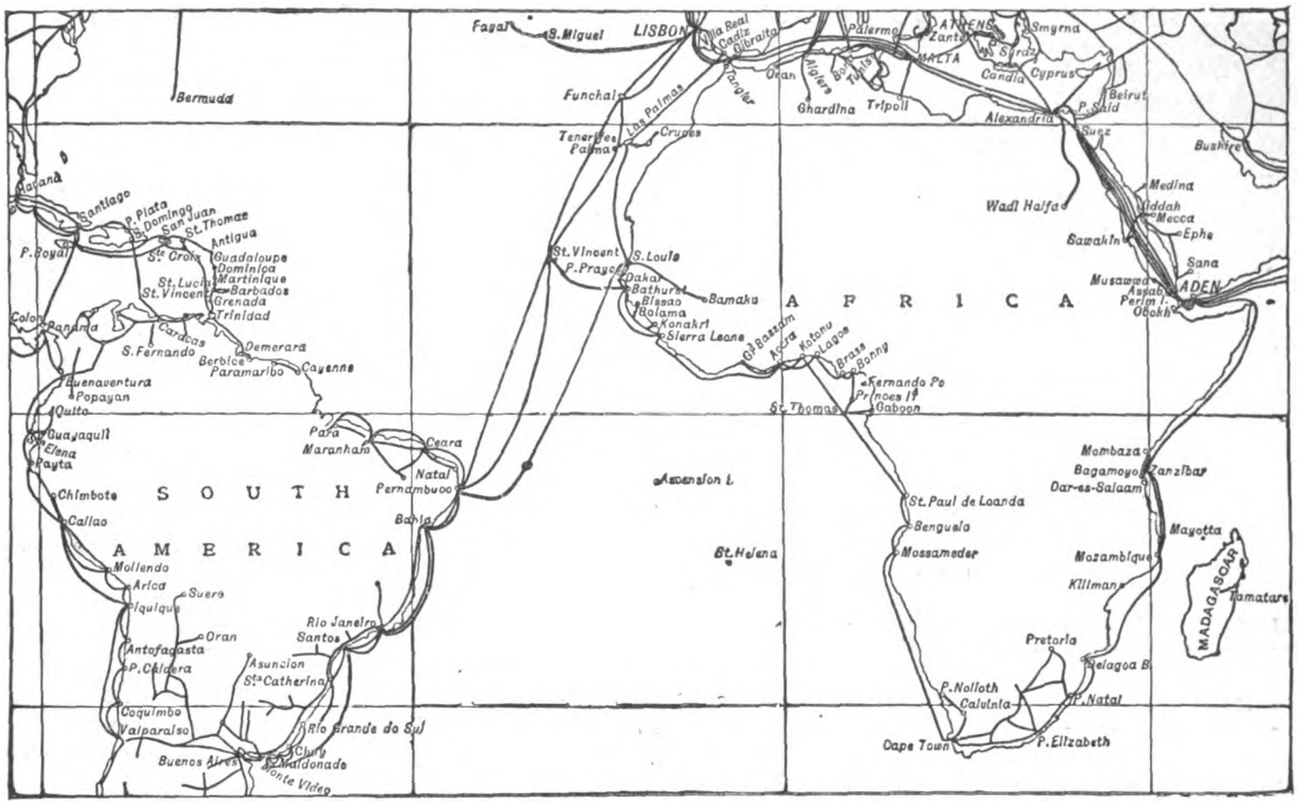


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| " All other Stations | 4 | 6 |
| Uruguay—All Stations | 4 | 6 |
| Argentine Republic—All Stations | 4 | 6 |
| Paraguay—All Stations | 4 | 6 |
| Bolivia—All Stations | 6 | 2 |
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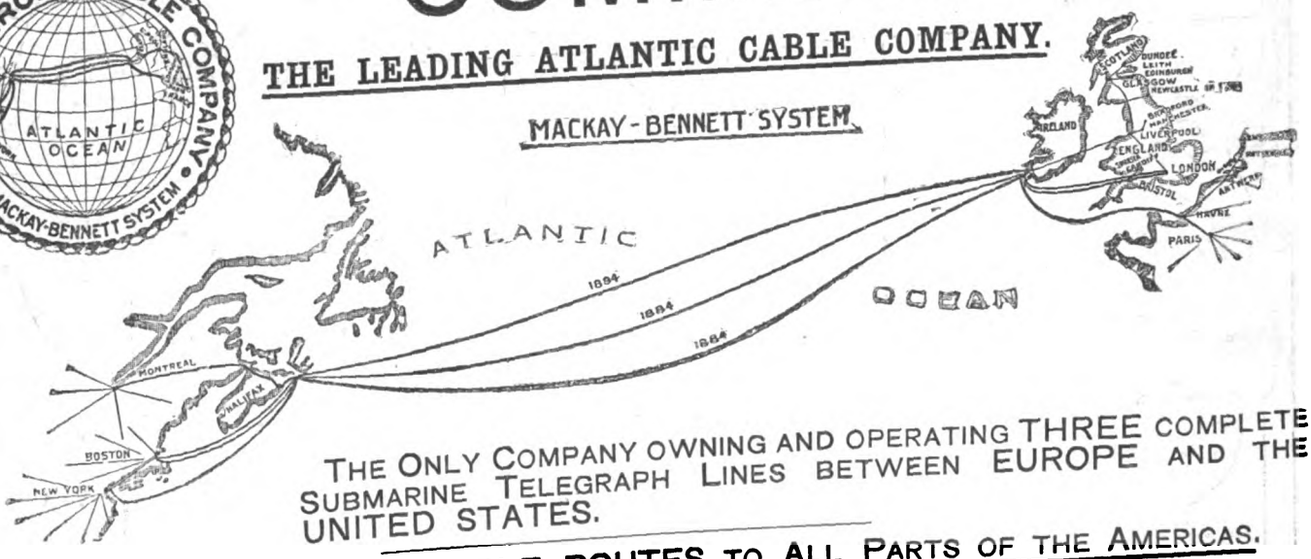


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NATURAL PHILOSOPHY, W. G. Adams, M.A., D.Sc., F.R.S.
ARCHITECTURE, Banister Fletcher, F.R.I.B.A.
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By Order,

Public Offices, Egremont, Cheshire, August 7, 1896. W. DANGER, Clerk to the Council.

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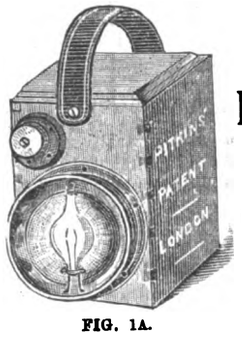


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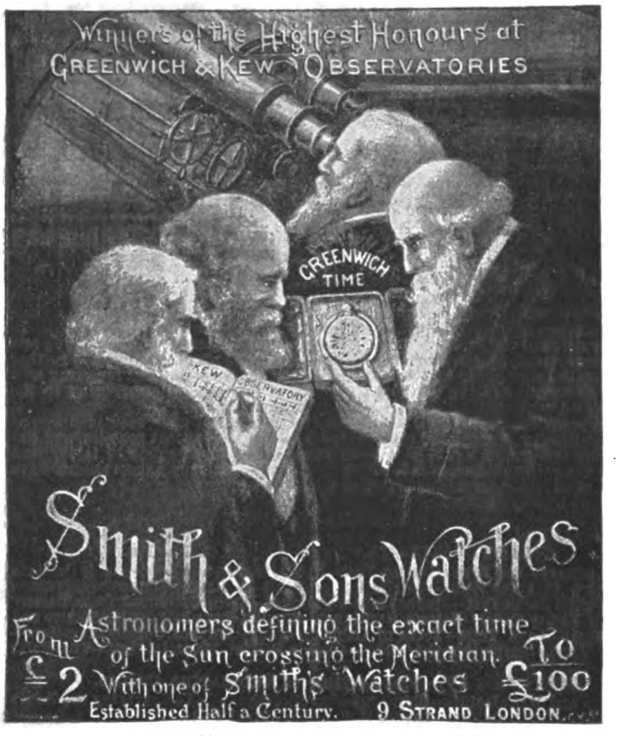


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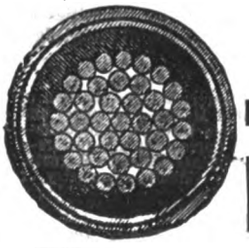

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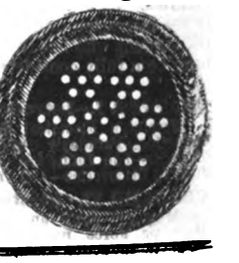

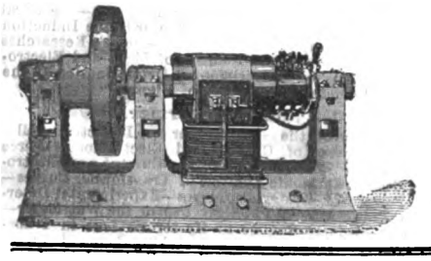

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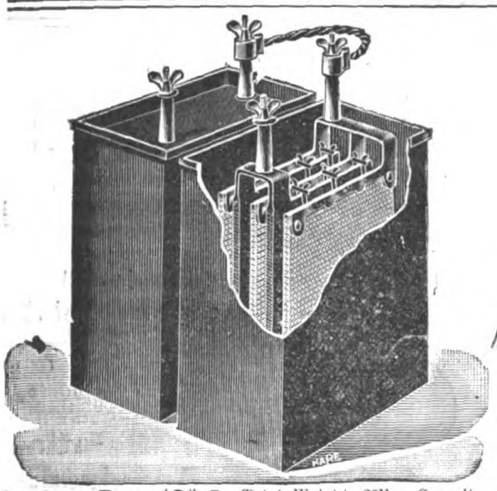

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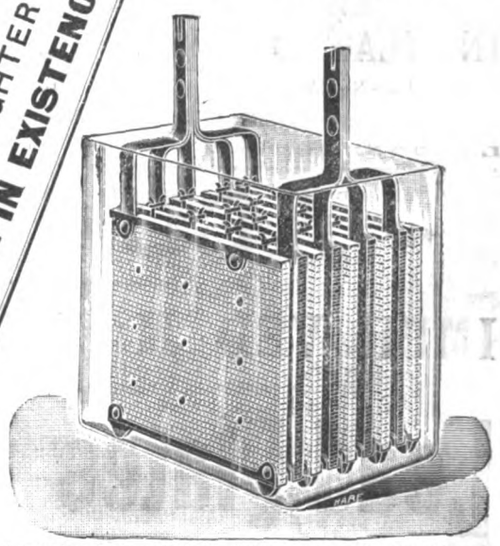

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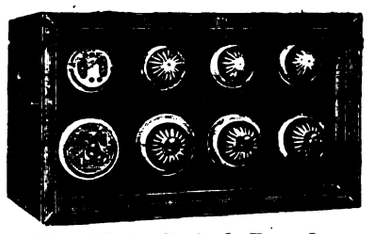

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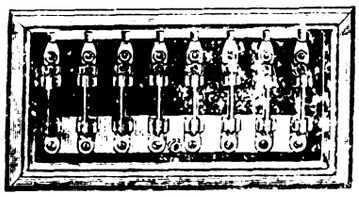

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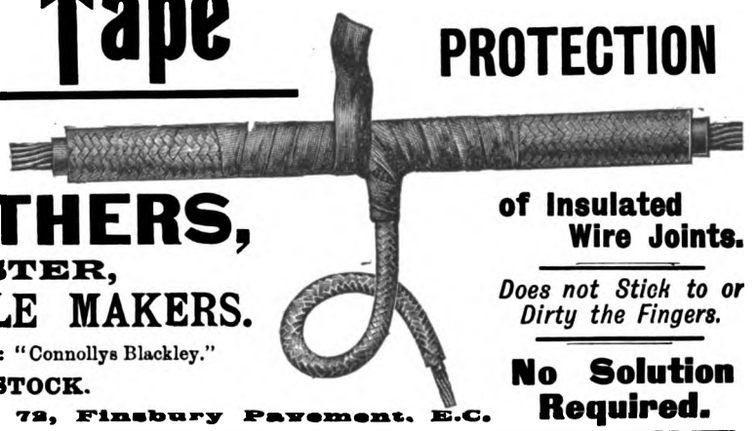

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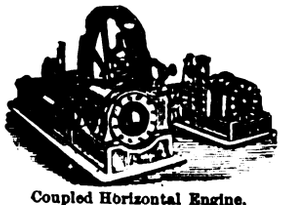

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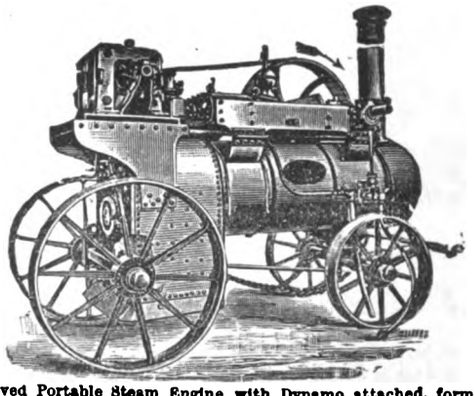

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## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 952. [Vol. XXXVII. No. 16.] FRIDAY, AUGUST 14, 1896. PRICE SIXPENCE.


## NOTES.

WE are glad to learn that considerable progress has been made in forming a strong and representative committee in connection with the proposal to inaugurate a Memorial to commemorate the inception and extension of Submarine Telegraphy. Amongst many other influential persons the following have agreed to act:—Viscount PEEL, Lord KELVIN, Lord SELBORNE, the LORD CHIEF JUSTICE, Mr. JOSEPH CHAMBERLAIN, Sir RICHARD WEBSTER, Lord GEORGE HAMILTON, Sir JULAND DANVERS, SIR SAMUEL CANNING, Sir EYRE SHAW, Sir JOHN ROBINSON, Admiral Sir HENRY J. C. D. HAY, Admiral Sir ANTHONY HOSKINS, Mr. HUBERT HERKOMER, Mr. HERBERT DE REUTER, Mr. J. C. LAMB, Mr. W. H. PREECE, Dr. JOHN HOPKINSON (President of the Institution of Electrical Engineers), Dr. ALEXANDER MUIRHEAD, Mr. ALEXANDER SIEMENS and Mr. W. S. SILVER. An executive will no doubt be formed from the larger committee, and we venture to make a suggestion for their consideration. The introduction and extension of telegraphy are almost exactly coincidental with HER MAJESTY'S reign—the magnetic needle telegraph having been patented by COOKE and WHEATSTONE on June 12, 1837, and the first telegraph line from Paddington to West Drayton being constructed in 1838-9. Our suggestion is that the Memorial in question should be inaugurated at the time of the celebration of the sixtieth anniversary of the QUEEN'S reign, on or about June 20th next.

A FURTHER communication from Mr. OTTO T. BLÁTHY appeared in our columns last week. In this contribution Mr. BLÁTHY gave concise data of two machines upon which he had made experiments in order to determine the value of their "load-loss" under varying conditions. The tests were carried out on the Hopkinson plan, and the means of a number of results were given in tabulated form. In the first set of experiments with the armature short-circuited, the values of the "load loss" were given with two values of armature current for each of four different speeds, and the "load loss" was then seen to vary nearly as the square of the current and proportionally to the speed, from which Mr. BLÁTHY draws the conclusion that the "load loss" consists of work spent in reversing the magnetisation of the iron and of Foucault currents and hysteresis. These experimental results will be of value and interest to dynamo designers; but judging by the correspondence which followed the publication of Mr. BLÁTHY'S first communication it would seem that both the existence and nature of this loss was already well known. Mr. MORDEY'S article on "Load Losses in Dynamos," which appeared on page 446 of our issue of July 31st, shows, however, that the "load loss" may have a negative value. A notable instance of this occurs to us in connection with certain large alternators built in 1882. In these machines if an armature coil were cut out of circuit it became dangerously overheated. In this case the "stray losses" were no doubt very heavy at light load, and were reduced by the load current; but, as pointed out by Mr. MORDEY, the "stray losses" in the Hopkinson machines were reduced by the load current, yet these were by no means unusually heavy, and it appears that a negative value for "load loss" is Mr. MORDEY'S usual experience. It seems somewhat difficult to reconcile this with Mr. BLÁTHY'S result, which, stated in his own words, on p. 375 of our issue of July 17th, reads:—"The load loss . . . was quite the same, with the same E.M.F. per single turn in the armature, whether the armature is wound as a drum or as a Gramme ring, for high or low pressure, as a parallel or as a series drum. It also made no difference whether the armature wires were put into slots in the armature core, or wound in a single layer on a smooth core, the air gap in this latter case being more than double that used with the slotted core." The factor which determines whether the "load loss" as defined by Mr. BLÁTHY shall have a positive or a negative value has not, so far, been made clear.

IN his "Notes on the Introduction and Development of Rope Driving," which we abstract this week, Mr. ABRAM COMBE claims that "rope gearing emanated from Belfast," and was invented in 1856 by Mr. JAMES COMBE. We have heard other claims to the invention of the transmission of power by ropes; some authorities having claimed it for the millers at Schaffhausen, others having attributed it to Glasgow. It is not necessary for us to settle these rival claims. Electrical engineers who have occasionally to use rope and other forms of gearing will welcome these "Notes" of Mr. COMBE as giving the experience of a practical man in the actual use of ropes for power transmission. In these circumstances, even the considerable departures from what we may regard as general practice command respectful attention. We observe, in the first place, that Mr. COMBE advocates a comparatively low velocity for the ropes. Mathematical analysis will show that the "theoretically best velocity" for a cotton or

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manilla rope is somewhere about 5,000ft. per minute. Mr. COMBE doubts whether any real advantage accrues from running at a higher velocity than 3,300ft. per minute. Considering that mathematical analysis does not take into consideration many important effects, such as the influence on the life of the rope, or the indeterminate windage, there may be a good deal in Mr. COMBE's recommendation. But the velocity chosen for the rope reacts on the whole design. It affects the size and weight of the pulleys, and the size and number of ropes. Where a dynamo is to be driven, it is not always easy to arrange for a low rope velocity. It would make the diameter of the pulley very small; and the size of the ropes would be correspondingly reduced, while their number would be correspondingly increased. Where the dynamo is of considerable power, and has to be run at a high rate of revolution, this will entail an awkward design. As might have been expected, Mr. COMBE gets over this difficulty by allowing more latitude in proportioning the diameters of pulley and ropes. He allows a ratio as low as 28·8, whereas the best English and American practice seems to point to a minimum ratio of about 45 or 50. Where a low ratio is used the ropes are liable to injury from excessive flexure—a much more important cause of injury, we think, than high velocity. It is not surprising, after this, that Mr. COMBE's allowance of horse-power for any given rope is very much below the usual practice. For instance, for a 2in. rope running on a 6ft. pulley at 100 revolutions per minute he allows 15 H.P.; while the common practice in America and in many parts of Great Britain is to allow about twice this amount of power, if not more. Cotton ropes will run from 8 to 12 years under these last-named conditions.

IN another column Mr. ALEXANDER RUSSELL shows how alternating and continuous currents behave towards one another—"they simply ignore one another's existence." One wonders whether there is anything corresponding to this in the relative attitudes of the respective concerns which supply them. We know of more than one building which is wired on both systems, as if each believed in the other's non-existence; and there are a good many miles of London streets where the two currents run side-by-side. But Mr. RUSSELL's interesting article discusses the case of the two currents in one and the same conductor; and he has usefully extended his reasoning to the subsidiary, but important, case of a combined continuous and two-phase alternating system. The economy in all these combinations arises from the fact that the loss of energy is proportional to the sum of the squares of the two currents, and not to the square of their sum, as given by the ammeter readings. Of course, the power wasted at any instant is proportional to the square of the instantaneous sum; but, since the alternating current *is* alternating, while the continuous current is always going in one direction, the resultant current is only an additive effect during each alternate half-period. During the rest of the time it is merely a differential effect.

IN our review of the *Jahrbuch der Elektrochemie* in the present issue, we have adverted to the fact that electrolytic nickel of tangible thickness and of a fair degree of purity may now be considered an article of commerce hailing from the States. It now appears that a German firm, GUSTAV MENNE AND Co., of Siegen, are preparing nickel of this quality, using as a raw material a nickel-copper regulus containing some 40 per cent. Cu and 30 per cent. Ni, and working by a continuous cycle of operations, which avoids the formation of waste liquors. Details are not disclosed. The German nickel thus made is somewhat harder and more brittle than the American product, and can be obtained in plates 1m. × 0·5m. × 10 – 15mm.

A PERUSAL of innumerable debates on electric lighting schemes and electric lighting extensions has convinced us that town councillors would, as a rule, be well advised if they were to record their votes, but not their reasons; though their conclusions may possibly be all right, their ostensible premisses are generally all wrong. For instance, at Hull, last week, the Electric Lighting Committee proposed an extension on the high-pressure continuous-current transformer system involving an estimated outlay of £42,000, the idea being to reach the residential district with a view to improve the load-factor, which is extremely low at Hull, and to be ready in good time to assist the existing station. The proposal was, however, rejected by 26 votes to 23 upon the altogether inadequate grounds that "an outside expert" should have been employed, that the cables should be in culverts, that high pressure is dangerous, and that "every electrician expert would say that the nearer they were to the centre of supply the more profitable would the undertaking become."

WHEN a Town Council has to deal with an entirely new scheme or a strikingly novel departure from ordinary practice, it is no doubt safer to secure the services of "an outside expert"; provided, of course, he is at once expert and impartial. On the other hand, a municipal engineer, if he is worth his salt, can very well be relied upon for simple extension work. That high pressures have their dangers cannot be denied; but, with common care, they can, like express trains, be made reasonably safe. Why a scheme should be "condemned at once" because it involves armoured cables laid direct in the ground, it passes the wit of an electrical engineer to understand. This system has always appealed to us as particularly workmanlike, and, what is more to the point, armoured cables laid direct in the ground have been extensively tried in this country, and have nowhere been found wanting. The generalisation that every electric lighting station should be in a central position sounds plausible; but for all that, it is only an approximate generalisation. If land be equally cheap, room be equally plentiful, condensing water equally handy, coal cartage equally easy, and danger of injunction for this reason or that equally small, as on the outskirts of a town—then and not till then is the law a valid one. But, no doubt, the municipal representatives wrought better than they knew, and had better reasons than they gave—at least, we hope so.

THE doctrine of "governmental ownership," as it is called in the United States, is just now receiving new developments, and among other things the acquisition of the telegraphs has

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been brought within the sphere of practical politics, if not exactly within measurable distance of being realised. One of the planks of the platform on which Mr. BRYAN takes his stand is the nationalisation of railroads, telegraphs, and telephones. Mixed up as it is with a populistic and bimetallic propaganda, which is regarded in commercial circles as socialistic and ruinous, there is, perhaps, little chance of the Nebraska Senator's programme being accepted; and it may be even feared that the indefinite postponement of a harmless and salutary measure may result from its being now in such bad company. As regards the telegraphs, we notice that the Press of America, opposed to Mr. BRYAN's Presidential candidature, is driven to make disparaging comments on the English telegraph system, pointing to it as an example of financial failure, and even of practical inefficiency. We can afford to smile at these comparisons, merely remarking that, if the telegraphs are so superior in private hands, there can be no reasonable grounds for their being the reverse in the hands of the Government. If we have made mistakes the United States may profit by them as warnings; but nobody denies that the net result has been a great national boon, and one which it is a pity the United States should lose because of its being associated with doctrines and projects which are economically and socially mischievous.

**King's College, London.**—The Michaelmas Term commences on October 1st. Some particulars of the courses in engineering and applied science are given in our advertisement columns.

**Yorkshire College, Leeds.**—The next Session commences on October 6th. Prospectuses of the courses in electrical, mechanical and civil engineering may be obtained from the Secretary.

**Cable Interruptions and Repairs :—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique ..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Gibraltar—Tangier..... | July 28, 1896 ... | Aug. 11, 1896. |
| Para—Maranhao..... | Aug. 6, 1896 ... | — |

**Energy Losses in Electric Machines due to the Armature Current.**—The following corrections should be made in the table accompanying Mr. Otto T. Bláthy's article, which appeared on p. 474 of our last issue. The heading of the fourth column should be "Load Loss," and that of the fifth column $L \cdot L/r \cdot i^2$.

**Power Locomotion on the Highway.**—We have received a handy little *brochure* bearing this title. In addition to a brief historical sketch of mechanical traction on common roads, it contains a bibliography, a catalogue of papers read before technical societies, and an index to the periodical literature of road traction. The author of the compilation is Mr. Rhys Jenkins, the publishers are William Cate (Limited), 32, Bouverie-street, and the price is 2s. 6d. net.

**Electric Traction.**—The Plymouth Town Council has agreed to the combined electric lighting and traction scheme proposed by their electrical engineer, Mr. J. H. Rider, and briefly outlined on page 493 of our last issue.——On Thursday last week the Glasgow Town Council discussed, at great length, the recommendation of the Committee on Tramways that the line from Mitchell-street to Springburn be equipped on the overhead trolley system of electric traction. In the end the question was remitted.

**Trinidad.**—Reuter's agency is informed that only the formalities in connection with the recognition by Great Britain of the sovereignty of Brazil over Trinidad require to be completed, and that the question has been practically settled in favour of Brazil. The matter was not submitted to arbitration. The island of Trinidad, it will be remembered, came into prominence upon the proposal to make it a cable station; but owing to its volcanic condition it has been found, so it is said, unsuitable for the purpose, and it has consequently again become of very small importance so far as Great Britain is concerned. The island is so closely surrounded by rocks that it is even difficult to effect a landing.

**The Amazon Cable.**—We are assured that the following editorial note which appeared in the *Amazonas Commercial* of Manaos in February last relates in some way to the inauguration of the Amazon cable system; but for the last word it might equally well refer to the Jameson raid or the Presidential crisis: "Upon the realisation of this legitimately patriotic event, the Amazon, as if wounded by the shock of great commotions, felt the red blood freezing in its arteries. Now its heart is palpitating ardently and its broad bronzed breast is absorbing with the air the light which is poured down in a golden profusion of auroras and sunbeams. And while the Giant, the haughty Lion of the North, slumbered on his couch in divine ecstacy, the universal god, the wise god PROGRESS, poured into his breast a vein of light like unto a running rivulet, limpid and brilliant. And this mighty vein, filled with a liquid compounded of globules of sunrays, is called—TELEGRAPHO!"

**Electrical Measurements.**—A special meeting of the South African Philosophical Society was held on the 2nd ult., when a lecture on the above subject was delivered by Mr. A. P. Trotter, Government Electrician and Inspector. Towards the end of the lecture the lecturer rang up the Capetown Telephone Exchange, and asked if any of the longer Post Office telegraph lines were clear. The Port Elizabeth line was then connected up, and by means of a Wheatstone bridge on the lecture table, the resistance of the line was measured. The lecturer then observed that, with the extremely sensitive instrument used in the Government Electrical Laboratory, it was not necessary to use ordinary electric batteries for signalling to such a distance as to Port Elizabeth. He disconnected the battery, and, plunging a steel knife and silver fork into an orange, sent signals by means of the feeble current thus generated. He then asked the front row of the audience to join hands, and, putting them in the circuit, sent signals through their bodies to Port Elizabeth and back by means of the orange cell. As a concluding experiment an omelette was made "under some disadvantages," and the cost of the electrical energy was stated to be only 1d.

**Wiring Regulations.**—We have received from the Manchester Corporation Electric Light Department a very neatly got up, nicely-indexed, innocent-looking little pocket-book ($4\frac{1}{2}$in. × $3\frac{1}{2}$in. × $\frac{1}{2}$in.) containing the very lengthy revised REGULATIONS AS TO THE SUPPLY OF ELECTRIC CURRENT TO BE OBSERVED BY ELECTRICAL FITTERS AND CONSUMERS. The wiring regulations are 43, and the supply regulations 19 in number. Mr. Wordingham's *ukase* is undoubtedly of a very exhaustive and practical nature, and if he finds that its innocent guise is an effectual antidote to its truly formidable character, he is to be congratulated on a thoroughness which does not stop at regulating who shall cut the hole in the wall for the admission of the service pipe (*vide* Rule 8). The chief points in which the rules of July, 1896, differ from the previous ones relate to the supply of current to motors (Rules 28-35). We note Rule 33, which reads as follows:—The magnets, frame, and shaft of all motors must be permanently connected to earth by a copper conductor, having a sectional area of not less than 10 square millimetres. Rules 38-43 deal with a 200-volt supply, Rule 42 running as follows:—"The clear break in all switches must be not less than 1in., and for switches intended to break more than five amperes the clear break must be not less than $1\frac{1}{2}$in." The Manchester rules certainly cannot be accused of working injustice to wiring contractors by reason of lack of precision.

**Horseless Carriages.**—"It is very much to be regretted," says the *Engineer*, "that a procession of horseless carriages, motor cars, or whatever else their inventors and makers may call them, is to take place by way of jubilantly celebrating the passage of the Light Locomotives Act. Nothing better calculated to damage a good cause could be thought of. There is

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not at this moment a single vehicle in London which can be said adequately to represent what a horseless carriage ought to be, may be, and we have no doubt will be. If the procession idea is carried out without disaster it is the most that can be expected, and at the best the general public will see nothing which can favourably impress any sensible man. We have always held that English engineers would not undertake the construction of such cars with any spirit until the law was so altered that they might hope to reap some profit from their labours. Up to the present we have had with us nothing but French or American or German vehicles. We have no desire to write one word in disparagement of them; on the contrary, we regard them as very ingenious attempts to solve a perplexing problem; but the public in London will not regard them as somewhat crude experiments, and the mere sight of them in our streets will, we fear, strengthen the hands of those who are already but too willing that Local Authorities should make vexatious enactments. It ought not to be forgotten that, in spite of the Act of Parliament, Town Councils can lay a very heavy hand on the horseless carriage."

**The Geneva Congress.**—The International Congress of Electricians opened on Tuesday, August 4th, in the Aula of the Geneva University. M. TURRETTINI was President of the Comité d'Honneur, which included M. MASCART, Prof. FERRARIS, Prof. ROUSSEAU of Brussels, Mr. CHARLES BRADLEY of New York, Herr VON HEFNER-ALTENECK, M. DERY of Brussels, M. HILLAIRET, Herr GISBERT KAPP of the Verband Deutscher Elektrotechniker, and Herr E. HARTMANN. The Comité over which Prof. A. PALAZ presided consisted of MM. HOSPITALIER and ERNEST GÉRARD, Herr GÖRGES of Berlin, and Prof. MENGARINI (*Vice-Presidents*) and MM. J. BLONDIN, A. BOISSONNAS, R. CHAVANNES, and C. E. GUYE. Among the 200 present there were several Englishmen, but the Institution of Electrical Engineers had no official delegate. The Congress was opened by M. Turrettini. Papers were read by Dr. Wietlisbach, M. Hospitalier and M. André Blondel on "Telephonic Disturbances caused by Electric Traction," "Magnetic Units," and "Photometric Units" respectively. Among the subjects set down for discussion was the question of transmission of power to long distances, and it furnished matter for an interesting debate, in which M. Thury, of Geneva, the distinguished advocate of the high-pressure continuous-current system, took a prominent part. The deliberations of the Congress, which lasted several days, were frequently varied by visits to the Exhibition and to different electrical works in the neighbourhood, and by receptions given by the resident members of the Congress.

**Northampton Institute.**—The appointments recently advertised at this Institute were filled at a meeting held on Monday last. The following were the successful candidates:—*Head of the Mechanical Engineering and Metal Trades Department.*—Mr. John Ashford, who has been for the last three years lecturer on engineering at the Birmingham Technical Schools. Mr. Ashford has great experience of, and is intimately acquainted with, the metal trades of Birmingham; and this knowledge will be particularly useful, it is hoped, in the Clerkenwell district. His classes at Birmingham were largely attended by students of the same type that may be expected at the Northampton. *Head of the Artistic Crafts Department.*—The successful candidate, Mr. John Willlams, has, for several years, taken an active part in the movement for the advancement of the decorative handicrafts. One of the original members of the Guild and School of Handicraft, he was, for four years, senior instructor in the school, and one of the leading workers in the Guild. During the last five years as senior instructor and inspector to the Surrey County Council, he organised and arranged the system of handicraft teaching with most successful results. As a worker in metals, he has designed and executed many important commissions, and his work exhibited at the Arts and Crafts and other exhibitions during the last few years has obtained for him a prominent position among handicraftsmen and art workers. *Assistant in the Applied Physics Department.*—The successful candidate here is Mr. C. V. Drysdale, a distinguished student of the Finsbury Technical College and the Central Technical College, South Kensington, where he obtained two diplomas of Associateship in Physics and Engineering respectively. Since his college training Mr. Drysdale has been for three years with Messrs. Nalder Bros. and Co.

**The Era of Extravagance in the Electrical Business.**—In the August number of the *Engineering Magazine* Mr. Burton E. Greene discourses under the above heading on the little profit that has hitherto accrued to the investor in American electrical insecurities. It is consolatory to find that the phenomenon has puzzled even so great a man as George Westinghouse, jun.:—"Walking up Fifth-avenue in Pittsburg one day in 1886, Mr. George Westinghouse, jun., said to one of his salesmen, who at that time had been connected with the electrical business for five years:—'What is the matter with this business? I've been in it now for six months, and have lost $40,000. Something is wrong. Everything we make is sold at a profit of from 100 to 200 per cent. above shop cost, and yet there is nothing left. On the contrary, we need more money all the time.'" Mr. Greene is inclined to attribute the phenomenon mainly to lavish capital outlay, due to the constant "scrap-heaping" of manufacturing machinery and manufactured stock arising from the rapid development of new ideas and methods. "Probably one of the greatest drawbacks to commercial success was patent litigation. It is known that in one year three of the leading companies spent $1,500,000 in this direction, or 5 per cent. on their entire capital stock. A score of law firms could be named who devoted most of their time for 16 years to electrical patent litigation. They have waxed rich. . . . How futile this continued and expensive struggle over patents has proved the world knows. One can count on the fingers of one's hand the patents which have been sustained, and on one hand those which have returned to their owners a royalty which made their winning worth the while." With regard to the future, Mr. Greene believes "that the electrical industry is now ready to take rank among the most solid, conservative, and profitable in America or any other country. The lessons have been expensive, and thoroughly learned." We sincerely hope so, though we think Mr. Greene's hopeful anticipations are scarcely warranted by his premisses.

**A Cable Story.**—The following is an extract from a letter received from an officer on board the cable ship "John Pender," now on the West Coast Africa:—"The following yarn is perfectly true, although it might well be called a 'fish' story. It happened whilst making the final splice in our last deep water repair on June 16th in latitude 5° 31′ S., longitude 10° 37′ 30″ E. The third officer was taking the sounding with Lord Kelvin's apparatus, the captain looking on, a quartermaster at the break, and I was standing by, looking over the stern. A 56lb. shot is used, and attached to it is piano wire; and by means of a patent hook the shot is detached on striking the bottom. A thermometer is usually attached to the wire, close to the shot, to ascertain the temperature of the water at the bottom, for electrical purposes. Whilst sounding, the shot struck the bottom at 520 fathoms (as was supposed), the strain being suddenly taken off the wire, and leaving it all slack. After heaving in about 100 fathoms, the shot apparently was still on, as the strain increased rapidly. After getting in 320 fathoms wire, the wire was seen to shoot rapidly in different directions a big fish (or rather a submarine monster, as the depth of water was too great for any fish to stand the pressure, as it could not stand being brought to the surface) having swallowed the shot, patent hook, thermometer, and 320 fathoms wire, when the wire parted. On taking another sounding, 1,135 fathoms (mud) was found to be the correct depth, the ship being stationary, as she had both ends of cable on board, making the final splice." Evidently there are more highly-specialised creatures in the sea than has been imagined. The idea of a submarine monster with a patent picking-up apparatus inside (perhaps fitted with Isaac's bow sheaves on a suitable scale), capable of coiling away 320 fathoms of piano wire, is delightful. Perhaps the wire was payed out at the fish's stern as it was picked up at the bows! Or, again, perhaps it was a record sea-serpent, which could accommodate, on the straight, 640 yards (1,920ft.) of wire. The monster goes one better than we are able to do. We can swallow all but the wire. Probably in its struggles to get off with the thermometer, fishes being as sensitive as cables to variations of temperature, the wire got coiled *outside*.

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# THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 486.*)

*Localising without a Return Wire.*

When no return wire, neither cable nor test wire can be obtained, it is difficult to obtain any great degree of accuracy in the localisation.

*Method* 5.—If two galvanometers of the d'Arsonval pattern are available, the best method to employ is the fall of potential method as follows:—The connections are made as on Fig. 30, the far end D being left free; one observer must be stationed at the galvanometer 2 during the test, and must keep the current constant by adjusting the resistance $d$. There is a resistance $h$ in series with the galvanometer 1 as before, so that the resistance of the galvanometer circuit is high compared with that of the cable and fault circuit A B C F. A B is again a piece of good cable. The galvanometer 1 must be exactly levelled with a spirit level. Then the deflections $d_1$ $d_3$ are read when the connections 2, 1 and 2, E are made respectively. The resistance $h$ should be given such a value that the larger of these two deflections is nearly to the end of the scale. Then the electrician at galvanometer 1 measures the distances between some marked point on the galvanometer and the centre and end of his galvanometer scale. He then disconnects his galvanometer and resistance box $h$, and takes them as quickly as possible to the end D, leaving the man at

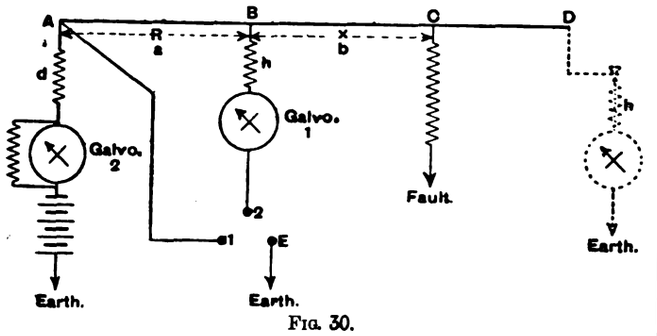


FIG. 30.

galvanometer 2 to keep the current constant. Arrived at D, he levels his galvanometer and places the scale so that the spot is at zero, and the distances between the marked points on the galvanometer and scale are the same as before. Then he connects up as shown by the dotted lines, making $h$ the same as before, depresses the key and notes the deflection $d_4$. The position of the fault is given by the equation

$$x = \frac{d_3 - d_4}{d_1} \mathrm{R}, \quad . \quad . \quad . \quad . \quad . \quad (27)$$

or

$$b = \frac{d_3 - d_4}{d_1} a, \quad . \quad . \quad . \quad . \quad . \quad (28)$$

where $b$ and $a$ are the equivalent lengths of the pieces B C and A B respectively. If the deflection of galvanometer 2 is kept absolutely constant the localisation test will be fairly accurate.

If only one galvanometer is obtainable, a low-reading ammeter must be used in place of galvanometer 2; one with an "open" scale can be used, and the current should be kept at the value which can be most accurately read on the instrument. This, of course, will not give such accurate results as the use of two galvanometers would. If such an ammeter is not available either, the most sensitive needle galvanometer or current detector one has in the station must take the place of galvanometer 2. The absolute value of the current through the main circuit is of secondary importance, but it must be kept constant.

The d'Arsonal galvanometer is about the only type that can be taken down and set up again without altering its constant. If such a galvanometer cannot be obtained for galvanometer 2, the test is complicated, as it then involves comparing the constants of the galvanometer in its two positions. For completeness sake the method is described here, though it is rare that it would be used in electric light work.

*Method* 6.—In addition to the apparatus already enumerated, a single cell is required, having a constant E.M.F. The apparatus is first connected up at end A, as shown in Fig. 31. The resistance $k$ must be high, say the resistance box with all the plugs (except the infinity plug) taken out. Then the key is depressed, and a reading $\mathrm{K}_1$ is taken. Then the connections are made as on Fig. 30, and the test at end A is completed as in the last method, the readings $d_1$ and $d_3$ being obtained. The instruments are now taken to the far end D, where the test is made as in the last method and the reading $d_4$ is obtained. The connections (Fig. 31) are now again made, and a reading $\mathrm{K}_2$ obtained. If necessary the galvanometer

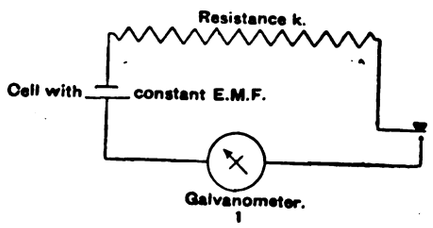


FIG. 31.

must be shunted to take the readings $\mathrm{K}_1$ and $\mathrm{K}_2$. The shunt must in that case be the same each time, but it may be removed or replaced by another when the readings $d_1$, $d_3$ and $d_4$ are taken. The distance of the fault from A is given by the equation

$$b = \frac{\frac{d_3}{\mathrm{K}_1} - \frac{d_4}{\mathrm{K}_2}}{\frac{d_1}{\mathrm{K}_1}} . a . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

or

$$b = \left( \frac{d_3 \mathrm{K}_2 - d_4 \mathrm{K}_1}{d_1 \mathrm{K}_2} \right) a. \quad . \quad . \quad . \quad . \quad (30)$$

Rare cases occur in which a fault is actually a "dead earth," having a resistance which is low compared with the resistance of the conductor itself, and which does not appreciably vary. Then one of the following methods may be used to localise the fault if no loop or return wire can be found.

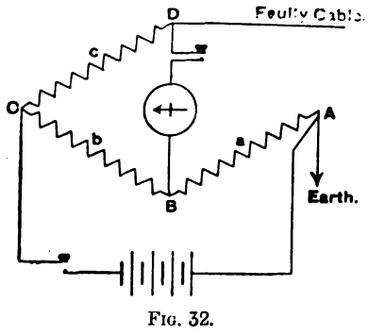


FIG. 32.

The connections are as on Fig. 32. The galvanometer key must be depressed before the battery key, and the bridge must be balanced to false zero.

*Method* 7 (*Overlap Method*).—The resistance between each end of the cable and earth is measured, the far end being free in each case. If $r_1$ be the result of the measurement at one end, and $r_2$ at the other end, $l$ being the length of the cable, and $s$ its resistance per yard,

the distance of the fault from end 1 is $\frac{r_1 - r_2 + l s}{2 s}$ yds. (31)

*Method* 8 (*Blavier's Method*).—Tests from one end only. The resistance between the cable end and earth is measured,

(1) When the far end is free,

(2) When the far end is well connected to earth.

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If these resistances be $r_1$ and $r_2$ respectively, if $l$ be the length of the cable in yards, and $s$ its resistance per yard, the distance of the fault from the testing point is

$$\frac{r_2 - \sqrt{(r_1 - r_2)(ls - r_2)}}{s} \text{ yds.} \quad . \quad . \quad . \quad (32)$$

If $s$ is not previously known, the resistance per yard is best obtained by measurements on a spare piece of the same cable in the station, or, failing this, it must be calculated from data given in the manufacturers' tables.

*Method 8a.*—If a stretched-wire bridge is to be had, it is better to slightly modify the last method. The connections are shown in Fig. 33. A piece of spare cable, of the same kind as the faulty cable, is used as third arm (C D) of the bridge, as shown. If this piece has a different sectional area to that of the faulty cable, its equivalent length must be taken for $c$. Then, if the readings for balance be $a_1$, $b_1$ and $a_2$, $b_2$, the values $d_1 = \frac{a_1}{b_1} c$ and $d_2 = \frac{a_2}{b_2} c$ are calculated, and the distance of the fault from the testing point is

$$\frac{d_2 - \sqrt{(d_1 - d_2)(ls - d_2)}}{s} \text{ yds.} \quad . \quad . \quad . \quad (33)$$

*Method 7a.*—Method 7 may be modified in the same way. The connections are again Fig. 33. C D may be a piece of wire whose equivalent length is $c$ when compared with the faulty cable. The same piece of wire should be used for the tests made at each end.

Then the distance of the fault from end 1 is

$$\frac{1}{2s}\left\{c\left(\frac{a_1}{b_1} - \frac{a_2}{b_2}\right) + ls\right\}. \quad . \quad . \quad . \quad . \quad (34)$$

For other methods of localising faults when no return wire is available, the reader is referred to treatises on telegraph-

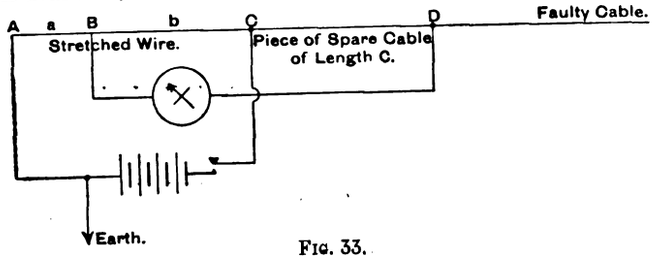


FIG. 33.

cable testing, such as Mr. Wilkinson's excellent book recently published by "The Electrician" Printing and Publishing Company, or to Mr. Kempe's standard text-book, "Handbook of Electrical Testing."

The methods to employ when no loop can be obtained having now been described, it remains to point out how the loop methods may be used to localise faults in networks without disturbing the connections more than is necessary. Localisation during working will be dealt with in the next chapter. Whenever a loop, including the faulty section, can be disconnected from the supply without too much inconvenience this should always be done, as tests on a free loop are always more accurate than tests during working.

A series arc light circuit is one of the simplest cases. At each lamp the two cables are taken out of the terminals, and are connected together. Thus a good loop is obtained including the whole circuit, and a very accurate localisation can be made at the station.

In the case of a thick network, rich in feeders,* the first approximate test before disconnecting the several sections may be made as follows:—

*Method 9.*—The feeders to the faulty main and their testing wires are disconnected from the switch-board, and two adjacent feeders are connected up, as on Fig. 34. $a$, $b$ may be a stretched-wire or resistance-box pattern bridge, $P_3$ and $P_4$ are the test wires, $H_3$ and $H_4$ the feeders, and $g$ the galvanometer. This is, in fact, Murray's method; the piece of distributing main 3, 4 is the loop, the feeders $H_3$ and $H_4$ are leads whose resistance may be neglected in comparison to that of the stretched wire or resistance box, and the test wires $P_3$ and $P_4$ are the galvanometer leads.

If the position of balance, or approximate balance, is at the end of the scale (say, *e.g.*, at the right-hand end), the next two adjacent feeders ($H_4$, $H_5$) in the direction indicated by the contact pointer, and the corresponding test wires ($P_4$, $P_5$), should be connected up in place of the former ones, and so on

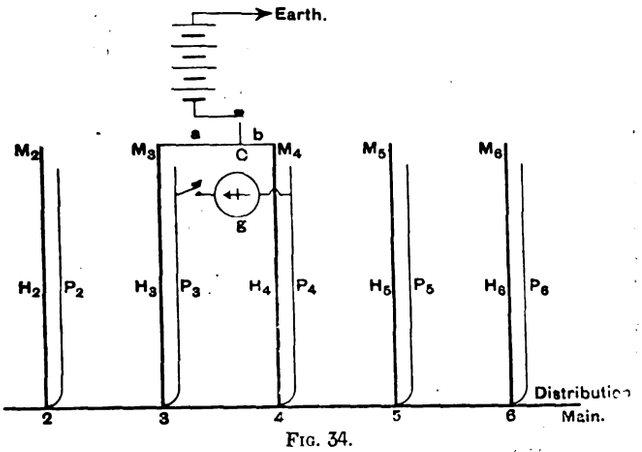


FIG. 34.

until the two feeders bounding the faulty length be found. On obtaining balance with these two feeders the distance of the fault from the left-hand one of the two feeding points is, of course, $\frac{a}{a+b} l$, where $l$ is the length of the section between the two feeding points.

*(To be continued.)*

* This method of procedure (methods 9 and 10) was originally described by Dr. O. Frohlich, of Berlin, *Electr. Techn. Zeit.*, Jan. 27, 1893, and *The Electrician*, Feb. 24, 1893.

## COMBINED ALTERNATING AND CONTINUOUS CURRENTS.

BY ALEXANDER RUSSELL, M.A.

The effects that follow the superposition of a direct on an alternating current and *vice versâ* are very curious and deserve more attention than they have hitherto received from English electricians. The theory is simple, a clear idea of what the effective value of an alternating current is and an elementary knowledge of algebra being all that is required. These effects have been already utilised for various practical purposes, and there is plenty of scope for further applications. In the Lowrie-Hall meter, for example, a small accumulator in series with a copper voltameter was put in the house circuit, and the gain in weight of a copper plate in the voltameter was proportional to the current used, and so could be used as a basis for charging for the current consumed. A similar arrangement has been used to measure the resistance of an alternating current circuit when the current is flowing, and there are several other practical applications. There are also numerous laboratory experiments with combined alternating and direct pressures, which are, however, more curious and interesting than practical.

The most important practical property of combined alternating and direct currents flowing in one conductor is that each produces its own heating effect practically independently of the other. To prove this we have to find the effective value of the combined current. The best method of doing this is, perhaps, that used in *The Electrician*, Vol. XXX., p. 652, and as the proof is very short, we shall reproduce it here. Let A be the value of the direct current, and $i$ the instantaneous value of the alternating current. Then the value of the current at any instant is $A + i$, and the square of the effective value is the mean value of $(A + i)^2$—*i.e.*, of $A^2 + 2Ai + i^2$. But the mean value of $A^2 + 2Ai + i^2$ is $A^2 + A_1^2$ where $A_1^2$ is the effective value of $i^2$. For the mean value of $A^2$ is $A^2$, since A is constant, and the mean value of $2Ai$ for a complete period is zero; for to every positive value of $i$ there is a corresponding negative one, and the mean of the positive values equals the mean of the negative values, since as much

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alternating current flows in one direction as the other. Also the mean value of $i^2$ is by definition the square of the effective value of the alternating current. It is to be noticed that in the above proof no assumption is made as to the nature of the wave form of the current.

If the resistance of the circuit be R, then the rate at which heat is being developed in the circuit is the average value of $R(A+i)^2$, which by the above equals $RA^2+RA_1^2$. Hence each current produces its own heating effect just as if the other were absent.

The following numerical example illustrates how this theorem works out for different values. It is easy to show by arithmetic that—

$$\begin{aligned} 28^2+29^2 &= 20^2+35^2 \\ &= 16^2+37^2 \\ &= 5^2+40^2 \\ &= (40{\cdot}3\ldots)^2. \end{aligned}$$

It therefore follows that a direct current of 28 amperes, combined with an alternating current of 29 amperes, would produce the same heating effect as a direct or an alternating current of 40·3 amperes. The other numbers show different combinations that would produce the same effect.

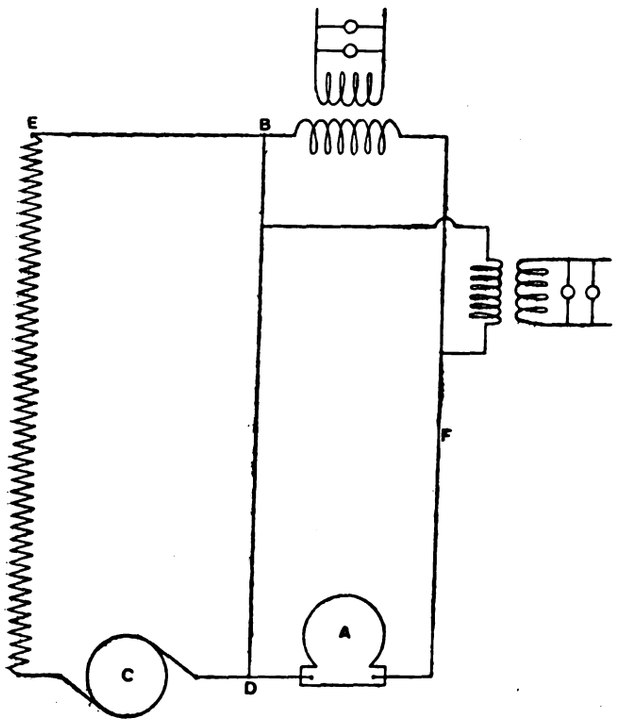


FIG. 1.

This result is an important one, as it points to a possible economy in the mains when a combined alternating and continuous-current plant is in use. We are not aware whether any economy in this direction has been attempted in this country; but in the system of supply adopted at Brunswick, Me., U.S.A., described in *The Electrician* of January 17, 1896, such a saving has been attempted.

In this system (Fig. 1) C is a Brush arc machine and A is an alternator, and the two circuits are connected as shown in the figure. It would have been more expensive if instead of using a common return conductor B D, two parallel conductors had been used and the two systems of supply kept quite distinct. To make this clearer, suppose that we are allowed a current density of 1,000 amperes per square inch, and that we have a cable carrying a current of 1,000 amperes continuous and another carrying a current of 1,000 amperes alternating alongside it, the cross-section of each cable would need to be one square inch. If they could be replaced by one cable without danger to either system of supply, then the cross-section of this cable need only be 1·4 sq. in., and the power lost by heating the copper would only be five-sevenths of what it was previously. The drop in volts also would in each case be five-sevenths of what it was before. In the above calculation we have neglected the leakage of alternating current round the branch B E D and the leakage of direct round B F D. As in general the resistance of B D will be much smaller than the resistance of these by-paths, the gain from this cause is not of any great value.

It might at first sight be thought that this superposing of direct and alternating pressures would seriously raise the pressure in the two circuits; but this is not the case. For an alternating E.M.F. of even a 100 volts superposed on 1,000 volts direct would give only an effective pressure of 1,005 volts, and so would 100 volts direct on 1,000 volts alternating. A more serious consideration is the effect of these small superposed currents on the working of the two systems. The effect of the very small alternating current in the continuous current circuit need not be injurious to the working of the arc lamps or the dynamo. In some forms of arc lamps it might even be beneficial. Professor Ewing has shown that an alternating current produces less and less effect on a transformer as a superposed direct current is increased; there would thus be a very slight loss due to this effect. To make up for this the loss due to hysteresis is less, and the more direct current that flows round this circuit the less will the load on the main B D be. Again, if V equals the drop in the direct volts between B and D, and $V_1$ is the drop in the alternating volts, then we have the following expressions for the power expended in that part of the system:—

$$\begin{aligned} \sqrt{A^2+A_1^2}\ \sqrt{V^2+V_1^2} &= AV+A_1V_1 \\ &= RA^2+RA_1^2 \end{aligned}$$

Although the combining of the alternating and continuous current systems in the way done at the Brunswick installation is of limited use, yet in some cases it may lead to a distinct economy. It is certainly very instructive to consider such cases. To a certain extent alternating and continuous currents seem to act towards one another in the same way as gases and vapours which have no chemical action on one another do in a confined space. They simply ignore one another's existence. It is for electricians to consider how this property can be utilised.

In Vol. XXX. of *The Electrician* referred to above it is shown that the effective values of two combined alternating currents differing in phase by 90deg. is the same as if one of the alternating currents was replaced by a continuous current of equal effective value. Suppose we have three currents going along a conductor, one direct and the others alternating and differing in phase by 90deg., then the three currents are quite independent of one another; and if we increase any one of them the consequent increase in the heating is due merely to the increase of that one current alone. If the three currents had a value of 100 amperes each the effective value of the combined current would only be 173·2 amperes. Hence combining direct with polyphase systems may lead to possible economies. It would be advisable, however, to try a few practical experiments beforehand to see what the effect of a very small alternating current superposed on the direct would be on the arc lamps that are to be used.

## TWO SERMONS ON SCIENCE.

M. Berthelot's recent Presidential Address to the International Congress of Applied Chemistry has served as a text for two solemn sermons in the *Spectator* and *Saturday Review* respectively. The former has "no quarrel with the men of science, for they do a great deal to make life easier, pleasanter, and more interesting," though it "cannot help observing that they are amongst the most superstitious of mankind. Their faith in chimeras, their readiness to be run away with by words, their tendency to take the part for the whole, and to worship blindly and perversely at their own little shrine, is often perfectly astounding. Not only are they sure that what they know not is not knowledge . . . . but they hold that science when applied to life is producing an absolute revolution in the world and altering man's position in the universe. Only let science have a little more time to apply its discoveries, and the earth will be a completely different place. That is the attitude

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of some of the natural philosophers of the present day." The *Saturday Review*, on the other hand, sings, or rather we should say seems to sing, a very different song. M. Berthelot, according to the *Saturday Review*, performed the mysterious feat of "transcending the occasion of the moment;" his words, we are told, "should reach beyond the delegates . . . and strike the attentive ears of the civilised world. For he spoke of the new age that dawned on the earth some sixty years ago, and that is now high daylight." England is neglecting "the real secret of modern success;" the "adventurous marauder" will in the future "fall before the chemist and physicist;" in the new age it is "the accurate knowledge of the chemist that is the great requisite," and "England will continue on the downward path" until—well, until the endowment of research is a properly recognised function of the State.

When two such very learned doctors as the *Spectator* and *Saturday Review* disagree, who, indeed, shall decide? But fortunately there is no need for anyone to intervene between "the fell incensed points" of these two almighty "opposites." The writers of these two disquisitions are in reality running in parallel, not in series and in opposition. The *Saturday Review* deals solely with the material aspect, and the *Spectator* fixes its awful eye exclusively upon the ethical side of the question, and—quite rightly from that point of view—scoffs at poor M. Berthelot for talking about "a new man being created in a new earth" solely by dint of applied science. As the *Spectator* most truly says, "the great changes in the world, the revolutions that really count, that shake the globe, and do indeed leave a new man in a new earth, come when the spirit is touched, not when this or that ingenious triumph is achieved over matter." But to contemptuously dismiss the telescope, the spectroscope, the steam-engine, the telegraph, the telephone and the dynamo-electric machine as "curious toys" and "mere pieces of machinery" is to go beyond the brief.

Who can doubt that the single-minded study of any one of the now numerous branches of science, be it astronomy, chemistry, biology or physics, tends as surely as the more ancient studies to elevate and broaden the mind? Can anyone deny that the assimilation by our great thinkers of the grand generalisations of science has no influence upon their thoughts? They may or may not "think more *deeply* than Socrates," but with their mental horizon so vastly widened, and with the food for thought so immensely increased, they can scarcely fail to think *differently* and more *profitably*. A certain degree of material comfort is a potent factor in securing for the mass of mankind a tolerable degree of happiness, in whatever sense that much abused word is employed; and in the furtherance of this end the thorough application of the discoveries of science to the use and convenience of man plays a paramount part. It is for the lawgivers and statesmen, for whom the *Spectator* reserves all its praise, to see to it that the mass of the people receive their fair share of the benefits that accrue; so far their success in this direction has not been particularly remarkable. From the majority of men, as at present constituted, educated and employed, the import and beauty of the great discoveries of pure science are, it is true, completely hidden; but the applications of science tend not only to increase the material comfort of but to bring home to the average citizen of a modern State many wholesome truths, many ennobling ideas, many grand conceptions to which he has hitherto been inaccessible. Let us take one single example out of half a hundred. Thanks to the submarine telegraph and the ocean steamer, Imperial Federation has become a grand possibility, and, thanks to the Press, itself indebted' in manifold ways to science for its present supreme position, the conception kindles a glow of pride in the heart of even the most dull-spirited. Had not the ground been prepared, doubtless the idea would not have borne good fruit; but it is the rapid interchange of news and of thought, made possible by applied science, that prepared the soil, and prevented our kinsmen at the antipodes, living, as they do, under new conditions and in a strange land, from developing tribal jealousies and idiosyncracies such as would have rendered impossible united action for a common end.

Science notwithstanding, and indeed "morality touched with emotion" notwithstanding, men still steal and slay, and, in all probability, will continue to do so, after a fashion, to the end of the chapter; but for all that we do not think the smart writer of "The Superstitions of Science" would stake such reputation as he has on a reasoned denial that the next ethical "revolution that really counts" will be unaffected by the discoveries and applications of science.

## THE RÖNTGEN RAYS.*

Prof. Röntgen, of Wurzburg, at the end of last year published an account of a discovery which has excited an interest unparalleled in the history of physical science. In his Paper read before the Wurzburg Physical Society, he announced the existence of an agent which is able to affect a photographic plate placed behind substances, such as wood or aluminium, which are opaque to ordinary light. This agent, though able to pass with considerable freedom through light substances, such as wood or flesh, is stopped to a much greater extent by heavy ones, such as the heavy metals and the bones; hence, if the hand, or a wooden box containing metal objects, is placed between the source of the Röntgen rays and a photographic plate, photographs such as those now thrown on the screen are obtained. This discovery, as you see, appeals strongly to one of the most powerful passions of human nature, curiosity, and it is not surprising that it attracted an amount of attention quite disproportionate to that usually given to questions of physical science. The interest this discovery aroused in men of science was equal to that shown by the general public. Reports of experiments on the Röntgen rays have poured in from almost every country in the world, and quite a voluminous literature on the subject has already sprung up.

After a brief summary of the history and relations and origin of the cathode and X-rays and an explanation of the Helmholtz theory referred to in our issues of July 17th and July 24th, the author proceeds as follows:—

A characteristic feature of all varieties of light is the existence of polarisation, and polarisation is indisputable evidence of transversal vibration; hence, many experiments have been made to see whether any polarisation of these rays could be detected. All these experiments have practically been confined to seeing whether the Röntgen rays could traverse two plates of tourmaline more freely when the axes of the two plates are parallel than when they are crossed; there is a great difference in the transparency to ordinary light in the two cases. The results of these experiments are somewhat conflicting. Prince Galitzine and M. de Karnojitsky are of opinion that they have succeeded in detecting a slightly greater absorption of the rays when the axes are crossed than when they are parallel; on the other hand, Becquerel, Mayer, and I were not able to detect any appreciable difference in the two cases. If the result of Prince Galitzine should be confirmed, it would prove beyond cavil that these Röntgen rays were light; but even if the presence of polarisation is not definitely established in this case, it does not follow that these rays cannot be polarised—the methods for polarising one kind of light may not be successful when used for another. For example, a wire bird-cage will polarise the long electrical waves, but will not affect the shorter waves of radiant heat, much less those of visible light. By winding exceedingly thin wires close together on a framework, Rubens and Du Bois were able to polarise the waves of radiant heat, the wave lengths of which are long compared with those of light. This arrangement, however, is much too coarse to polarise visible light, much less ultra-violet light. And it is possible, and indeed likely, that the structure of the tourmaline, though fine enough to polarise ordinary light, may not be fine enough to polarise the Röntgen rays.

So far, I have confined myself to showing that there is nothing in the effects known to be due to these rays inconsistent with their being a variety of light. I must now pass on to some evidence of a more positive character. Since the discovery of the Röntgen rays, Becquerel has discovered a new kind of light, which in its properties resembles the Röntgen rays more closely than any kind of light hitherto known. Becquerel found that certain uranium salts emitted, after being exposed to the sunlight, radiations which, like the Röntgen rays, could pass through plates of aluminium or of cardboard, and affect a photographic plate behind, after a long exposure of from 20 to 40 hours, the photograph. Becquerel has shown that the radiation from the uranium salts can be polarised, so that it is undoubtedly light; it can also be refracted. It forms a link between the Röntgen rays and ordinary light; it resembles the Röntgen rays in its photographic action in power of penetrating substances opaque to ordinary light, and in the characteristic electrical effect, while it resembles ordinary light in its capacity for polarisation, in its liability to refraction. The persistence of the radiation is very remarkable. Becquerel found that the potassium-platinum com-

* Abstract of the Rede Lecture, given at the University of Cambridge, on June 10th, by Prof. J. J. Thomson, F.R.S.

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pound of uranium went on emitting these radiations with nearly undiminished zeal for 15 days after it had been exposed to the sunlight. It would seem that under the influence of sunlight some change in the chemical or physical nature of the substance occurred, and that after the sunlight was cut off, the substance gradually went back to its original state, and that while doing so it emitted this peculiar radiation. The radiation from the uranium salts is of especial interest from another point of view. Sir George Stokes has shown that in the case of phosphorescence caused by sunlight or the arc lamp, the light emitted by the phosphorescent body is of longer wave-length than the light causing the phosphorescence; in the case, however, of the phosphorence discovered by Becquerel, the light emitted is of a shorter wave-length than the incident light. The case resembles that called calorescence by Tyndall, when the body placed in a focus of dark radiant heat becomes luminous, and gives out the shorter luminous waves. From this discovery of Becquerel we may conclude that besides the vibrations emitted by luminous bodies with which we have hitherto been acquainted, there are others having a much greater frequency, and, it may be, arising in a different way.

To sum up, we may say that though there is no direct evidence that the Röntgen rays are a kind of light, there is no known property of these rays which is not possessed by one or other forms of light.

One of the most remarkable phenomena connected with these rays is the way in which the absorption depends upon the density of the body; if we measure the transparency of a series of bodies, we find that the order of capacity is the same as the order of their density. No other factor in the constitution of the body seems comparable in importance with density. In this respect the relation between the opacity and the other properties of a body in the case of the Röntgen rays is simpler than that for luminous waves or electric waves. There seems no simple relation between the density of a body and its transparency to visible radiation or electrical vibration; in the case of the Röntgen rays, however, it seems the greater the density the greater the opacity. This appears to favour Prout's idea, that the different elements are compounds of some primordial element, and that the density of a substance is proportional to the number of the primordial atoms; for if each of these primordial atoms did its share in stopping the Röntgen rays, we should have that intimate connection between density and opacity which is so marked a feature for these rays.

I now pass from the consideration of the rays themselves to some of the effects they produce on bodies through which they pass.

There seems considerable evidence that the energy associated with these waves is small. I am not acquainted with any effects produced by them which involve the expenditure of an amount of energy comparable with that emitted in a second by a candle. They do not produce any appreciable rise in temperature when they fall on the thin metallic strips of a bolometer. Mr. Skinner has found that they exert no appreciable effect on the combination of hydrogen and chlorine, though this is a good test of the intensity of very faint light; and, what is more unfortunate, they do not exert any of those deleterious effects on bacteria which are fortunately associated with ultra-violet light. Some of the other effects exerted by ultra-violet light seem to be associated with these rays; thus some observers who have had undue curiosity about their bones, and have in consequence exposed their hands frequently to these rays, have found that the hand so exposed became sunburnt. There seems considerable evidence, too, that these rays are not good for the eyes, though it is difficult to disentangle any distinctly injurious effect due to the rays from the bad effect that may be produced by the straining of the eye in the endeavour to see only a faintly luminous object.

There is one property of substances which seems peculiarly suitable for testing if these rays affect the substance through which they pass; it is the property of transmitting electricity. When we investigate the effect of the Röntgen rays on this property, we find the remarkable result that bodies which, when shielded from these rays, insulate to all appearance perfectly, allow electricity to pass through them when exposed to the action of these rays. Gases in their normal state are of all substances the most perfect insulators. Mr. McClelland and I have investigated the rate of leak in different gases, and we find that they can be arranged in the following order: hydrogen, coal gas, ammonia gas, air, carbonic acid gas, sulphuretted hydrogen, chlorine, mercury vapour. That the gas itself is put into a peculiar state by the passage through it of these rays—a state which it attains for an appreciable time—is shown by the following experiment: Take an electrode shielded from the direct action of these rays; charge it to a high potential, and even though the rays are on, it does not leak. Now blow some of the air through which the rays have passed on to the electrode, and at once there is a rapid leak. The rate at which electricity passes through the gas depends upon the pressure; the lower the pressure the slower the leak. Mr. McClelland and I found that for an air space of about 1cm. the rate of leak over a considerable range of pressure varies as the square root of the pressure. In some experiments recently made by Mr. Rutherford and myself, we found that using a constant potential difference the rate of leak was smaller across a very thin plate of air than across a thicker one; it thus appears that the process of conduction through a gas is one that requires a considerable amount of room. Another very interesting point about the rate of leak is the connection between the rate of leak and the E.M.F. This can, perhaps, be most easily understood by means of a curve (Fig. 1). The ordinate represents the rate of leak, the abscissa the E.M.F. At first, when the E.M.F. is small, the curve is a straight line, showing that the current is proportional to the E.M.F.; in other words, that the conduction of electricity through gas, like the conduction through metals and electrolytes, obeys Ohm's law. But it is only when the E.M.F. is small that the curve is straight. We soon get to a stage where the current increases more rapidly than the E.M.F.; beyond this, again, we reach a part of the curve where the current increases but slowly as the E.M.F. increases, and we finally reach a stage where the current seems independent of the E.M.F., and is, to borrow a term from magnetism, "saturated." I have here a diagram (Fig. 2) of three curves taken for the same gas, but at different distances from the bulb. You see that the first ascent is much steeper near to the bulb—that is, when the rays are strong,

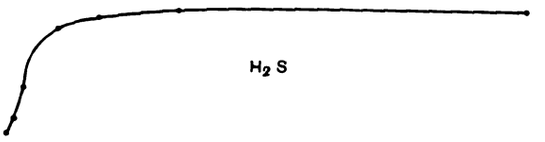


FIG. 1.

than when it is far away and the rays are weak, and practical saturation is attained sooner when the rays are strong than when they are weak. These curves bear a remarkable resemblance to those which represent the relation between the magnetisation of a piece of iron and the magnetic force acting upon it. When the rays are strong the curve is like that of soft iron; when the rays are weak, it is like steel.

Gases are not the only substances that conduct when transmitting these rays; solids also conduct, though the conductivity obeys different laws and only lasts for a short time. The conduction through solids very closely resembles the phenomenon called "electric absorption," a well-known example of which is the residual charge of a Leyden jar.

I have here some experiments which illustrate the effect of the Röntgen rays on solids. In the first of these we have a lead cylinder with a thin base made of aluminium. At the bottom of the cylinder there is a thin layer of solid paraffin; on the top of this, and sticking to it, there is a large leaden disc, over which paraffin has been poured, so that the disc is entirely embedded in

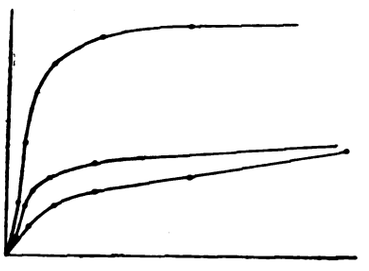

FIG. 2.

the paraffin (Fig. 3). This cylinder rests on the aluminium window in the iron chest containing the coil and the tube, this window being very much smaller than the lead plate in the paraffin. I now connect the lead plate to one pair of quadrants of a highly charged electrometer, and then connect the two pairs of quadrants together, and with one of the poles of a battery of 200 small storage cells, the other pole of which is connected with the iron chest, and so with the earth. I now disconnect the quadrants from the battery, and then the quadrants from each other. There is now very little movement of the spot of light reflected from the mirror of the electrometer. When we turn on the Röntgen rays, however, the spot of light begins to move, and though the movement is small compared with that which occurred in the experiment with air, it is quite decided. The rapidity with which the spot of light moves soon, however, begins to decrease, and after a short time becomes almost inappreciable. I now discharge the lead plate by connecting it and both pairs of quadrants of the electrometer to earth for a short time, then keeping one pair of quadrants connected with the earth, and leaving the other connected with the lead plate, we see that when the rays are off there is a very slight movement of the spot of light in the opposite direction to the original

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deflection ; this is due to the leaking out of the "residual charge." This movement is, however, greatly increased as soon as the rays are turned on, and continues until we get quite a large deflection ; "the residual charge," or polarisation in the paraffin, has then been enormously increased by the rays. The conductivity of the paraffin under these rays resembles, in its properties, that of the insulating sheath of a telegraph cable. In testing the resistance of such a sheath, the current passing through it does not remain constant, it rapidly falls off in intensity ; and if, after the E.M.F. has been applied for some time, it is removed, and the inside and outside of the sheath connected with the terminals of a high-resistance galvanometer, a current flows through the galvanometer, and this current is in the opposite direction to that which originally flowed through the sheath.

Ebonite shows the effect of the Röntgen rays in increasing the conductivity even better than paraffin. I have here a plate of ebonite about 1mm. thick, coated on both sides with tinfoil. I put this on the aluminium window, and on the top of the ebonite plate I place a lead disc, which is much larger than the aluminium window ; the object of this disc is to prevent the Röntgen rays from striking against the wire connected with the disc, and so discharging the disc through the air. That it is effectual in doing this, is proved by there being no leak when the rays are on, and the wire (raised to a high potential) disconnected from the disc. If we now repeat with this plate of ebonite the experiments we previously tried with the paraffin, we get similar but decidedly larger results. I may mention that different specimens of ebonite vary considerably in the magnitude of this effect.

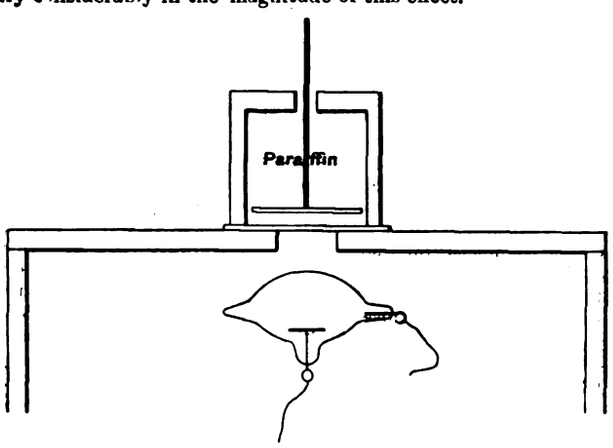


FIG. 3.

There is one variation of the preceding experiments which is of some interest. I will charge up the ebonite plate without putting the Röntgen rays on at all ; on discharging, you see that the electrometer indicates that the "residual charge" is coming out. I keep discharging the disc until the residual charge is almost inappreciable. I now for the first time put on the rays, and you see that the residual charge of polarisation, which could not previously be detected, now becomes quite marked.

These experiments show how greatly the properties of bodies are modified by the Röntgen rays, and show that by their discovery physical science has received an agent which promises to be of the greatest service in investigating some of the properties of bodies which are now most urgently pressing for explanation.

## EXTENSIONS TO OUTLYING DISTRICTS.*

BY A. H. GIBBINGS (Bradford).

The municipal electrical engineer is face to face with the problem of extending the supply in the most economical and satisfactory way ; the town councillor has before him the demand for the supply from the members of his constituency in outlying districts. Let us deal with both sides of the question from a general point of view. The chief considerations apply equally to all municipal electric light undertakings, irrespective of the particular system adopted in each borough.

There are at present in operation in England, Scotland, Ireland, and Wales about fifty-one municipal electric light stations ; and those towns which have already obtained their Provisional Order, and have electricity works in course of construction, number about twenty, making a total of seventy-one municipal electric light enterprises in the United Kingdom. Of the above number, nineteen have been in operation over three years, and it is generally after the lapse of this period that the *necessity* to extend the hitherto confined area begins to be felt. The word "necessity" is used advisedly, because it accurately describes the situation, both as regards the majority of the ratepayers and the business itself as a trading concern. The period of three years is really too long to delay the actual extension of the mains ; the writer is inclined to curtail the time by twelve months, for reasons which will be put forward towards the end of this Paper.

Having decided that the necessity for extension will surely arise, *nolens volens*, the points to be considered may be stated to be (1) The cost of extending the supply, (2) The effect on the cost of production and on the revenue, (3) The advisability of extensions.

### 1.—*The Cost of Extending the Supply.*

Priority is given to this particular phase of the subject, as, very naturally, it is the one upon which great stress is laid by electric light committees. It is often made the most important point, other aspects being considered secondary matters. Unfortunately, too, comparisons are only made with what has been the cost of supply in the central portion of the town. It can be shown, however, that such comparisons are incorrect, and that too great prominence is often given to the initial cost of extensions.

The cost of extending the supply is affected by—(1.) The method of laying cables. (2.) The characteristics of the suburban or outlying district. (3.) The extent and class of demand.

By the method of laying is meant the system which in economy and efficiency is found to be most satisfactory when the character of the suburban district, and the extent and class of the demand, are taken into account. It is, therefore, essentially a question to be decided for each district separately, by each town individually, considered with reference to the general system of electrical supply adopted by each. But after all this has been said and emphasised, it is also universally true that many of those items which form so large a part of the cost of laying mains in the centre of a town are very much modified, if not entirely eliminated, in connection with the extension of mains in the suburbs. Such items are :—(1) The reinstatement of footways and road paving ; (2) the necessity for making ample provision for future demands by laying additional conduits ; (3) the avoidance of obstacles under the footways and roads.

It is not necessary to enlarge upon the very different effects which these items have upon the cost of laying the mains in the central and outer districts respectively. One or two illustrations will suffice. Attention is drawn to them, merely because in some towns the difference will no doubt be very much greater than in others. In the matter of reinstatements, the cost of different paving is given in the following table for towns differing in size, position, and configuration :—

*Cost of Reinstatement per Yard Run.*
(About 2ft. wide.)

| Town. | York stone, including new stone. | Patent asphalte. | Compo. stone. | Granite sets and concrete. |
|---|---|---|---|---|
| City of London.. | 3s. 8d. | { Footway 6s. 4d. / Roadway 11s. } | ... | 7s. 6d. |
| Hove ..... | 1s. 6d. | 3s. | 3s. | ... |
| Hull ..... | 2s. 7d. | ... | ... | 6s. 5d. |
| Bradford ..... | 3s. 8d. | ... | ... | 8s. 4d. |

From this table it will be seen that the cost of reinstatements varies considerably ; but the figures also indicate the width and depth of trench made, and from this it may be inferred that more or less provision has had to be made, at the time of opening, for future extensions. A proportion, therefore, of the cost of reinstatement of conduits and cables laid really represents capital already spent for an extended supply, capital lying idle until a revenue is derived from outside. The method of laying cables in the central area is very naturally determined by the conditions referred to above ; but where such conditions do not exist, as in the outer districts, other methods of laying mains may be adopted, by which the cost may be still further reduced when compared with that involved by the original method. For instance, in the case of a low-tension supply, the first necessity of heavy feeders and distributing mains laid in expensive conduits might be substituted in the outer areas by armoured cables laid directly in the ground ; or, in the case of high-tension, by a system of banked transformers substituted by direct supply to each consumer.

The characteristics of the outlying districts and the probable extent and class of demand, considered in relation to the cost of extending the mains, may now be considered. Let us take these two items together, as the one depends very largely upon the other. In the very broadest sense these, of course, are really the determining factors with regard to the size and length of mains to be laid down. It can be shown that this may be ascertained as a very much more definite quantity than is possible when estimating the probable demand in the central area. The outlying districts may be scattered and thinly populated, or they may be the reverse. There are usually both instances in most towns. Scattered districts are likely to be composed of large houses, rich residential neighbourhoods, and unpaved streets ;

* Paper read before the Municipal Electrical Association, June 12th.

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in the second case, main streets leave the town, with a continuous run on each side of terrace houses, occasional shops, with a surrounding neighbourhood of side streets and residences. Now the very first advantage we have in considering the possibilities of supply in the above cases (and the consequent size of cables ultimately required) is the knowledge that, while the probable demand from business quarters is a greatly varying quantity, utterly impossible to forecast, in residential districts it may be comparatively easily gauged. Some shops in the centre of a town are let and re-let in the course of two or three years; one tenant requiring eight or ten lights, another requiring no light at all, and a third demanding a supply for 40 or 50. This is only a typical instance of what occurs over and over again in the course of twelve months. Under such circumstances there is no basis upon which to work, and hence we have to be prepared for any demand. But it is different with residential houses. The annual rental is a safe guide, as the following table of rentals and corresponding gas bills, real and not imaginary, will show. The gas is 2s. 3d. per 1,000 cubic ft., and the length of the street is about three-quarters of a mile.

| Description of property. | Annual rental. | Number of houses, shops, &c. | Aggregate amount of annual gas bills. | Average annual amount per house, &c. |
|---|---|---|---|---|
| Shops only ... | £20 to £40 | 19 | £76 3 0 | £4 0 0 |
| Ditto ... | 40 to 50 | 2 | 11 18 0 | 5 19 0 |
| Ditto ... | 50 to 100 | 6 | 58 19 4 | 9 16 6 |
| Houses only... | 20 to 40 | 24 | 91 8 4 | 3 16 2 |
| Ditto ... | 40 to 50 | 19 | 147 16 2 | 7 15 7 |
| Ditto ... | 50 to 100 | 50 | 506 0 2 | 10 2 4 |
| Ditto ... | 100 to 150 | 2 | 27 18 10 | 13 19 5 |
| Houses and shops combined ..... | 20 to 40 | 11 | 49 9 2 | 2 4 11 |
| | 40 to 50 | 17 | 146 1 4 | 8 11 10 |
| | 50 to 100 | 20 | 243 7 0 | 12 3 4 |
| | 100 to 150 | 4 | 92 16 10 | 23 4 2 |
| Hotels ..... | 100 to 350 | 3 | 233 10 6 | 77 16 10 |
| Theatres ..... | £1,000 | 1 | 333 14 8 | 333 14 8 |

Each single account represented in the above summary showed, upon comparison, very little variation from one year to another; and, therefore, it should not be a difficult matter to estimate the maximum number of electric lamps likely to be required for many years in such a district. The table, of course, represents only one main street; but the illustration will serve for branch streets and abutting property. Hence we can see how the characteristics and probable demand enable us to make accurate calculations, and so economise in the method of laying and the capacity of the mains.

Now, it will readily be admitted that the points just dealt with are the very points which form the basis of comparison in estimating the relative value of one system over another. But, whatever the system, there can be no doubt that the cost of extending the mains can be very considerably reduced when compared with the cost of laying mains in the centre of the town.

2.—*The Effects on the Cost of Production and on the Revenue.*

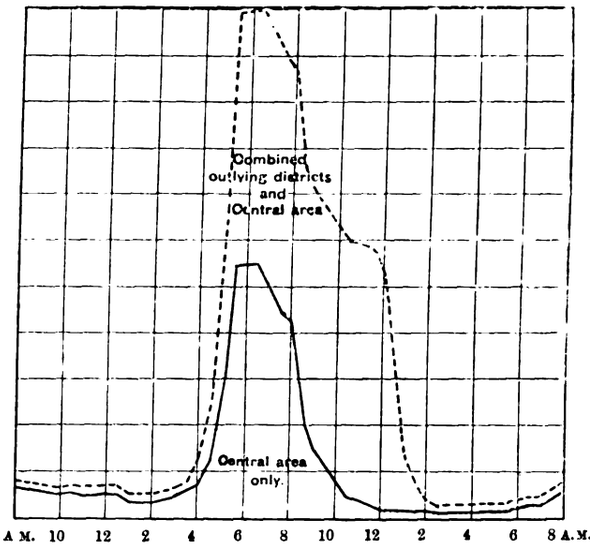
Supplying outlying districts with electricity appears at first sight simply to entail increasing the output at the central station, with a corresponding increase in the revenue. And the cost of production appears to be affected just in the same way as if the additional supply occurred in the central portion of the town. In reality, however, the effect on the cost and revenue is of a much more important nature, and it is this feature which gives the supply a relatively higher value. This is due entirely to the fact that the number of units consumed for a given maximum demand is very much greater in the outlying districts than for a corresponding demand in the centre of the town. In other words, private houses, small shops, &c., use the light for a greater number of hours than business offices and large shops within the central area. While the latter use a large number of lamps for a few hours a day, the former use only a few lamps, but burn them a considerable time. And so it comes about that the number of lamps installed cannot be made a direct and all-sufficient basis of calculation in estimating the probable revenue. We must also take into consideration the number of hours the lamps burn. Considerable assistance may be obtained in arriving at an approximately correct estimate if we know what is the general figure in lamp-hours per day in several towns. In the following towns the number of units sold per average 8 c.p. lamp connected at the end of 1895 is found to be as follows:—

| Town. | Units sold per lamp. |
|---|---|
| Hull | 11·23 |
| Aberdeen | 12·85 |
| Hanley | 16·80 |
| Leicester | 17·46 |
| Blackpool | 18·05 |
| Bradford | 18·68 |
| Manchester | 20 60 |
| Bristol | 22·02 |

If we take these figures and reduce them to the number of hours per day during which the total number of lamps would be burning in order to produce the above annual output in units, we get the following result:—

| Town. | Watts per 8-c.p. lamp per day. | Average hours per day per 8-c.p. lamp would be burning. |
|---|---|---|
| Hull | 70 | 1 hour 0 min. |
| Aberdeen | 35 | 1 hour 2 min. |
| Hanley | 46 | 1 hour 32 min. |
| Leicester | 48 | 1 hour 36 min. |
| Blackpool | 49 | 1 hour 38 min. |
| Bradford | 51 | 1 hour 42 min. |
| Manchester | 56 | 1 hour 52 min. |
| Bristol | 60 | 2 hours 0 min. |

The average of these representative figures is 1 hour 33 minutes; or, in other words, the total capacity of the station is being used for only 1 hour 33 minutes per day in producing the satisfactory results to which these towns have attained. There can be no




question that the time during which the major portion of the revenue is earned is for the first two or three hours after dusk. A reference to any central-station load curve will prove this; and further, that more than 50 per cent. of the lamps connected are not in use at all for six months of the year. Now, this is just where the private consumer comes in and fills the gap. His lamps, although adding to the plant capacity at the station, also increase the average earning capacity, and in the proportion estimated in the following instance:—

If we assume that an equal supply is demanded by the central and the outer districts respectively, then of course the plant capacity at the station would be double that required for the central portion only; and if both classes of the demand were like that in the central area, the whole plant would still be earning its entire revenue in 1½ hours per day. But it may be safely assumed that 75 per cent. of the demand in the outlying districts will be continued from 7 to 11 p.m. on an average throughout the year, or say for fully four hours longer than the central portion. Now, 75 per cent. of half the maximum demand is equivalent to a little above one-third of the maximum demand continued fully for four hours, and this is, of course, equal to the full demand continuing for one hour and three-quarters. It will at once be seen from this simplification of the matter that the earning capacity of the plant has been increased from 1 hour 33 minutes to 3 hours 18 minutes, or more than two-fold; or, in other words, the number of units sold is doubled for the same maximum demand. But what is true of the whole is true of a part, and hence the earning value of every 8-c.p. lamp connected in the outlying districts is three times as great as that of a corresponding burner in the central portion of the town. In addition to this relatively higher value of the residential supply as compared with the shop and office supply, the former would be required very largely on Sundays, thus giving an additional fifty-two days' consumption on the year. It would also form a better load on holidays, and during the winter months from 6 a.m. to 8 a.m. For all these reasons such a supply is eminently desirable. The above curve, taking the case just given, represents the relation of the one supply to the other.

Having determined the relative value of the demand from the residential districts, it is an easy step to ascertain the effect on



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the cost of production and on the revenue. The cost of production is made up of the actual cost of generation, viz., coal, oil, &c., and the standing charges, viz., wages, salaries, repairs and maintenance, interest on capital, sinking fund, depreciation, rent, rates, taxes, &c. Taking the average of a score of central stations, the charge per unit is about as follows :—

| | | | | |
|---|---|---|---|---|
| Generating cost ... | ... | ... | ... | 1d. |
| Standing charges... | ... | ... | ... | 3·5d. |
| Total | ... | | | 4·5d. |

With a slightly increased efficiency of the generating plant, that portion of the cost is likely to be slightly reduced ; but it may be taken nevertheless to remain practically the same per unit, namely, one penny. But, assuming an equal demand in both central and outlying districts, the number of units sold for the same standing charges is doubled, and therefore this item of the cost would decrease in the same ratio ; that is to say, the 3·5d. per unit would become 1·75d. and the total cost per unit 2·75d. instead of 4·5d. This at once opens up the possibility of a substantial reduction in the price ; a reduced price would probably attract new customers, and thus, step by step, we might ultimately arrive at a universal adoption of the light. We can even imagine the demand from the outlying districts being twice as much as that in the central area (a very common feature of gas supply) and in that case a general price of 3d. per unit would then be most remunerative. This at least seems to be certain, that every lamp connected in the residential districts has the effect of helping to reduce the standing charges in the ratio of 2 to 1, as far as its own consumption is concerned.

With the foregoing explanation it is easy to see what is the effect on the revenue. The price to the consumer remaining the same, 5d., 6d., or 7d., the revenue or *net profit* would be increased by exactly the same amount as the standing charges would be decreased. In the example given the standing charges would be decreased by 1·75d. per unit, and by itself this amount would form a very considerable net profit even if the average charge per unit was only 4½d. The average price obtained, however, by most municipalities is more than 4½d., and at that price a net profit is made of from 3 to 5 per cent. Of course the object of the municipalisation of these undertakings is to supply electricity at as low a price per unit as is consistent with fairly paying expenses and providing for contingencies ; but the price will never descend to a popular figure while the supply is confined to the central area. The possibility of a reduction commences, however, as soon as the many hours private householder has the opportunity of using the light. Such a reduction should take place naturally and gradually, as the demand in the other districts increases ; and when we remember that every lamp supplied there brings in the same revenue as three in the central portion, the effect on the profits of the department would not be long in becoming apparent.

3.—*The Advisability of Extensions.*

The writer has endeavoured to show that, as a question of finance, extensions would probably be very remunerative ; but there is, of course, still another factor to be taken into consideration, and that is the rate at which consumers will avail themselves of the new light in these districts. The same uncertainty existed not so many years ago, when the public supply of electricity from a central station was first commenced. At that time, too, there were many other problematical features which do not exist to-day ; there were obstacles, prejudices, conflicting interests, which have since been overcome ; and the responsibility of such an enterprise as a wholly new undertaking was beyond all comparison greater than any question which electric lighting committees are now called upon to consider. The venture then was almost entirely speculative, owing to the absence of fundamental data, and in many instances (notably Bradford, the first municipal central-station supply) the business was started to keep out a private company. The success which has been met with, however, has been beyond expectation, and this fact is in clear evidence by the present 51 Corporation electricity supply undertakings, and by the efforts of several other municipalities to buy up the rights which they have so recently allowed to fall into the hands of private companies. These rights and undertakings will undoubtedly have to be paid for very heavily before the Corporations become possessed of them. Yet in the face of these practical experiences we still hear of towns and parishes, such as York, Barrow, Lambeth, &c., which are fighting the same old battles and traversing the same dreary ground about the establishment of electricity works as the pioneer municipalities encountered many years ago. We might reasonably infer, I think, from what has been the experience in regard to the central area, viz., that while it was difficult to forecast the probable demand, yet the result has been a very general adoption of the electric light ; so with regard to the outlying districts, the result should be an equally steadily increasing demand. As to the probability of this deduction being verified, I am able to give an instance in point. In 1893 the Bradford Electricity Committee canvassed, among other districts, the street to which I referred in the second section of the Paper, and for which I have given the representative annual gas bills. This canvass was a personal house-to-house inquiry, but not a single individual would give a guarantee to take a supply. The price per unit was the same as at present, namely, 5d. In June, 1894, the Committee made a further effort by means of a circular letter. Very few replied, and only one individual definitely promised his patronage. At the beginning of this year I brought the question again before the attention of the Committee, and advised them to lay the mains as a matter of speculation, and they so far conceded as to grant the extension for three-quarters of a mile. Of course, in face of what I may call the negative results of the canvass, this was a great and bold step to take. When this was known to the wiring firms, they, on their own account, immediately canvassed the street but in one month only succeeded in getting three applications, with a total of 70 8 c.p. lamps. A month later we commenced to lay the mains, the wiring firms in the meantime continuing to solicit orders but without success, the general excuse being a desire to wait until the mains were laid. So the mains were started with three promised customers. Before the entire length was laid, however, the number had increased to ten, demanding a maximum supply of 210 8 c.p. lamps ; and as an instance of what a little judicious speculation will do, the number at the end of May, or one month after the mains had been completed, was 16, with 260 8 c.p. lamps connected. Now, I think this instance is a very good argument against relying to any extent upon canvassing. Of course, the streets with which to commence the extension have to be selected with discretion, but, once started, a supply will soon be demanded over the entire area of the borough.

I mentioned in the first part of this Paper that I considered two years a sufficient period after the establishment of the electricity works to initiate a scheme for the supply to the outlying districts. My reasons for naming two years are two-fold. First, at the end of that period the supply will probably have become generally known and appreciated, and the financial position of the undertaking is generally sound and good. Secondly, I think it very desirable that the inner and outer districts should then grow simultaneously. The load curve would thus be improved, and the probable future needs of the town would be more readily gauged and satisfactorily provided for than would be the case if the extension were long delayed.

To sum up the whole matter : To me it appears that at the present time the great object for municipalities to aim at is the reduction of the price at which electricity can be supplied. I contend, and have endeavoured in this Paper to justify my contention, that this object is attainable. Not only so, but that it may be attained in a most satisfactory manner by developing the enterprise. Like the railway companies of old, I have every confidence that we should go *forward*—certainly not in a headlong spirit of reckless extension, but, on the other hand, with an unhesitating and deliberate movement of advance.

## THE TRANSFORMATION OF THE ENERGY OF CARBON INTO OTHER AVAILABLE FORMS.*

BY C. J. REED.

The energy of carbon and hydro-carbons, such as coal, is probably the most stable form of energy with which we are directly supplied by nature. There are five general methods of utilising this form of energy, the thermal, the thermo-dynamic, the thermo-electric, the thermo-magnetic, and the thermo-chemical. The first, which consists in the simple combustion of the fuel, is used for warming and lighting. By the second method the heat evolved in combustion is transformed into kinetic energy by means of a heat engine. This method, which is well understood, gives an efficiency of from 3 to to 10 per cent. In the third method the heat is converted into electrical energy by means of a thermo-electric junction. No thermo-electric couple has yet been produced which can transform more than 1 per cent. of the heat applied to it into electrical energy, and no radical improvement is to be looked for in this method, not only because it is precluded by the second law of thermo-dynamics, but also because of the Peltier effects, and the circumstance that the substances which are good electrical conductors are equally good conductors of heat. In the thermo-magnetic method of transformation the energy is first liberated as heat, and the heat is used to vary the intensity of magnetisation in a magnetic body, with the production of either mechanical motion or an electric current. This method, discovered by Thomson and Houston in 1879, and communicated to the Franklin Institute at the time, has not yet been employed commercially.

The thermo-chemical method includes two distinct processes, each of which consists of two steps or operations. In the one the

* Abstract of a Paper read at the Franklin Institute, May 26th.

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energy is liberated in the form of heat, and is subsequently absorbed as chemical energy by a secondary substance in an endothermic reaction. In the other, the molecular energy is transferred, without transformation, from the molecules of the carbon to the molecules of a secondary substance, where it is less stable, and consequently more available. In both cases the second step of the process consists in the transformation of the energy of the secondary substance into electrical energy by the agency of a galvanic cell. The thermo-chemical method is the only one by which even a portion of the energy of the fuel may be brought into an available form without a primal degradation into heat. In this process it is necessary to develop as heat only so much energy as may be required to maintain the substances involved in the operation at a temperature at which the transference, without transformation, of the energy of the molecules of the carbon to the molecules of a secondary substance which is less stable, takes place. If the reaction is endothermic, additional heat for absorption must be supplied, but if it is exothermic, the heat given out in the reaction may be utilised to maintain the requisite temperature. In general only exothermic reactions are easily and economically performed.

The usual method of carrying out the thermo-chemical process is to heat the fuel in a closed chamber to a high temperature in contact with a chemical reagent capable of acting upon the fuel in such a manner as to absorb the energy. The only reagents hitherto employed for this purpose are oxides, and generally metallic oxides, which in the reaction become reduced to the metallic state by oxidising the fuel. There are two limitations to the efficiency of the process: (1) The loss of the heat necessary to raise the metals to the temperature at which reaction takes place, and to maintain them at that temperature. (2) The heat necessarily involved, and which is the equivalent of the difference between the formation heat of the reagent and that of the oxidation product.

Illustrations and diagrams are here given to show the analogy between molecular and molar potential energy.

A familiar example of the thermo-chemical method is given by the ordinary battery, in which the transforming substance is metallic zinc, which has been obtained from its oxide by the reducing action of carbon at a temperature of about 1,100° C. The amounts of coal required in practice for the reduction of one pound of zinc from the ore are given as follows:—

| | |
|---|---|
| Roasting | 0·34 |
| Reduction | 1·25 |
| Firing (external heat) | 5·00 |
| Total | 6·69 |

This represents an expenditure of about 48,000 thermal units in effecting the reduction of one pound of zinc. The reduced zinc acquires only 1,300 units, and if it were all available in a galvanic battery, its efficiency as a transformer would be

$$\frac{1{\cdot}300}{48{,}000} = 2{\cdot}6 \text{ per cent.}$$

But the reduction of zinc to the metallic state is not the only step in the process, and by the time it has been recast, and amalgamated and connected in the cell, its net efficiency as a transformer is reduced to 1·3 per cent. Unfortunately, the reactions which take place in the cell do not form the original zinc oxide, but salts which require the expenditure of much more energy to reduce them to metallic zinc. The process, therefore, is not cyclic, and is really more one of transforming matter than of transforming energy.

The objections to zinc as a transforming substance teach us what is to be desired and what is to be avoided in seeking an ideal one, and we see that but little improvement is to be hoped for so long as the transforming substance is a metal, or, indeed, forms one of the electrodes. The ideal cell should consist of two indestructible, or reasonably permanent, conducting solids, in contact with a liquid electrolyte, which should consist of two solutions separated by a porous partition, through which one of the solutions flows. Each of the two solutions should contain a chemical reagent capable of combining with the other, on the contact of the solutions, in an exothermic reaction. The transforming substance should be capable of acting upon carbon at as low a temperature as possible without evolution or absorption of much energy, and with the formation of an unstable carbon compound easily oxidised to $CO_2$, and should also be capable of combining with atmospheric oxygen at as low a temperature as possible without the evolution or absorption of much energy, and with the formation of an unstable oxygen compound. These two compounds of the transforming substance, one of carbon and one of oxygen, should constitute the active chemical reagents of the cell, and should be capable of uniting on contact in the cold electrolyte, with formation of $CO_2$ and precipitation of the transforming substances in its original free state. Arrangements should be such that the exhausted electrolyte may continuously flow out of the cell, and regenerated material flow in. Such a set of reactions would be represented by the following equations, in which T represents one combining equivalent of the transforming substance, C, an equivalent of carbon, and O, an equivalent of atmospheric oxygen:—

$$T + O = TO \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$
$$C + T = CT \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$
$$2TO + CT = CO_2 + 3T \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

There are substances fulfilling these requirements to a greater or less extent; but they do not pass into the metallic state at any stage of the cycle of chemical reactions.

As an illustration of the method a battery is described in which the two electrodes are formed of carbon, whilst the two combining substances are $H_2S$ and $SO_2$, which produce the electrical energy with the regeneration of the original sulphur according to the equation $2H_2S + SO_2 = 2H_2O + 3S$.

The process employed is as follows:—Sulphur is burned in the air to $SO_2$, which is passed through water and forms the oxidising electrolytic solution, to which some sulphuric acid may be added to increase the conductivity. The heat given out by the combustion of the sulphur is employed to heat a retort which contains sulphur at one end, coal in the middle, and broken crockery on which water is allowed to drop, at the further end. The vaporised sulphur in its passage over the red hot coal forms carbon bisulphide, which, on meeting with the steam, undergoes double decomposition, with the production of carbon dioxide and hydrogen sulphide, which latter is absorbed in water to form the reducing electrolytic solution, or it may be used in the gaseous state. The sole function of the transforming solutions, water and sulphur, is to receive 59,000 units of the 97,000 units of energy contained in an atom of carbon, and to deliver it as electrical energy from a reaction which takes place at a low temperature. The balance-sheet of the energy expended stands thus:—

| | | |
|---|---|---|
| 1 atom of carbon expended | 97,000 | |
| 3 atoms of sulphur expended | 213,000 | |
| 3 atoms of sulphur regenerated | | 213,000 |
| Heat lost in furnace | | 38,000 |
| Transformed into electrical energy | | 59,000 |
| | 310,000 | 310,000 |

The theoretical efficiency of the process is therefore

$$E = \frac{59{,}000}{97{,}000} = 61 \text{ per cent.}$$

and the theoretical E.M.F. in volts is

$$\frac{59{,}000}{4 \times 23{,}260} = 0{\cdot}63 \text{ volts.}$$

The highest E.M.F. which has been obtained on closed circuit is 0·36 volt, corresponding to an efficiency of

$$61 \times \frac{0{\cdot}36}{0{\cdot}63} = 35 \text{ per cent.}$$

Two forms of the battery were shown; in the one the carbon electrodes were solid plates immersed in solutions of $H_2S$ and $SO_2$ respectively, which were separated by porous partitions, and in the other the electrodes were hollow carbon cylinders to which the respective gases were admitted under pressure. The electrodes were immersed in dilute sulphuric acid and separated by a porous partition as before. The regenerated sulphur is precipitated, and may be collected and used again. The author does not regard this particular process as commercially of great importance; but believes it indicates the only direction in which any great improvement over thermo-dynamic methods is to be obtained.

With regard to the so-called direct processes for the conversion of the energy of carbon into electrical energy, no evidence has yet been published which shows that it has ever been accomplished. The claims for such a method have generally been made solely upon the indications of a voltmeter attached to a carbon electrode, in combination with chemical reagents, which alone were sufficient to account for the indications. In some cases, also, thermo-electric junctions, in which carbon and a metal were joined by a fused salt, have been mistaken for galvanic batteries. As for the development of electrical energy by the combustion of hydrogen and certain gaseous hydrocarbons in contact with an electrolyte and platinum-black, it must be remembered that these substances are neither carbon nor original fuel, and that their energy is obtained, by a thermo-chemical process, from the energy of fuel.

Experiments were made with an extemporised Jacques battery,* which showed that its action was thermo-electric. At low temperatures, while the caustic alkali contained considerable water, the carbon was positive to the iron; but at high temperatures, after the alkali had become highly dehydrated, the carbon was negative to the iron. The carbon rod was replaced successively by rods of brass, copper, German silver, and iron, without appreciably affecting the result, and a current of illuminating gas was passed into the fused alkali in place of the current of air employed by Jacques. The result was unchanged, showing that the action of the current of air was not to produce oxidation, but to cool the upper layer of the alkali.

* See *The Electrician*, Vol. XXXVI., p. 768, April 3, 1896.



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# The Electrician.

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## THE ELECTRICAL TRANSFORMATION OF THE ENERGY OF CARBON.

The conversion of the energy of carbon into electrical energy is rapidly coming to the front. Dr. COEHN experimented on the subject, and came to the conclusions that carbon could be made to go into solution by the action of an external current, that it could be separated from such solution at the cathode, and that a cell could be constructed with carbon as the soluble anode. Full details of the conditions necessary were wanting, and his conclusions have been directly traversed by Dr. VOGEL, and no satisfactory reply has, as yet, been forthcoming. Dr. W. W. JACQUES brought out a battery, on which we commented at the time, in which the anode was carbon and the cathode iron, the electrolyte being fused caustic soda, through which air was blown. This battery gave a large current, but a low voltage; and now we have Mr. C. J. REED, at the Franklin Institute, not only stating that there is no satisfactory evidence that a current of electricity has ever been obtained direct from carbon, but performing experiments, which, if correctly reported, show that in the case of the JACQUES battery, at least, the current is not due to the oxidation of carbon, but is probably thermo-electric.

Not content with this, which of itself was sufficient to involve its author in a heated polemical controversy, Mr. REED has invited attack by bringing out a battery of his own. In his view the solution of the problem is to be sought by finding a transforming substance which shall be capable of combining easily with carbon at a low temperature to form a compound readily oxidisable to carbonic anhydride; and further the

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transforming substance should be capable of combining with atmospheric oxygen at a low temperature without the evolution or absorption of much energy, and with the formation of an unstable oxygen compound. These two products of the transforming substance should be capable of combining in the cold with the production of electrical energy, and the regeneration of the original body. Mr. REED has constructed an apparatus in which the combustion of sulphur vaporises another quantity of sulphur, the fumes of which, in passing over red hot coal, form carbon bisulphide, which, in its turn, meets with steam, also produced by the heat of the burning sulphur, and forms carbonic anhydride and hydrogen sulphide by double decomposition. The sulphur dioxide given off by the burning sulphur and the hydrogen sulphide are allowed to combine in a battery provided with carbon electrodes, with the production of electrical energy and the regeneration of the sulphur, so that the process is partly cyclic, though not completely so, owing to the carbon which is lost as carbonic anhydride. It will be noticed that the electrodes themselves are not concerned in the production of the current, and that the intermediary employed in the conversion of the energy of carbon into electricity is non-metallic. Mr. REED lays great stress on these points, for he considers that the consumption of an electrode in a battery is wrong in principle, and that a battery in which this takes place is comparable to a steam engine, which should derive its energy from the oxidation of its working parts. But we have still to discover the material for, and the method of, manufacture of electrodes which shall be permanent; and hence it becomes a question of relative cost whether it is better to consume a cheap electrode, or to employ dear electrodes which are disintegrated in a longer or shorter time without the production of useful energy. The chief objection to soluble anodes is not on the score of mechanical efficiency, but rather that the salts formed have little or no commercial value, and it usually requires the expenditure of more energy to recover the metal from them than it does to produce it from its ore in the first instance. It is scarcely fair to cite the case of the use of zinc in a primary battery as one in which a metal is employed as a transforming substance; for though the metal does undoubtedly play an important part in a battery, that is not the purpose for which zinc was originally smelted. Zinc, it is true, is reduced from its ores by a lavish expenditure of carbon, but it is not produced solely, or even chiefly, for electrical purposes, for it had extended use in the arts and manufactures long before man discovered that it could be utilised for the generation of electrical currents; and the amount of zinc consumed in batteries is very very small compared with that employed in other ways. Electricity merely provided a fresh sphere of usefulness for an already existing substance.

The direct conversion of the energy of carbon into electrical energy presents many practical difficulties. Coal is impure, and retort carbon is costly by the time it has been manufactured into anodes, and further some fused salt must be employed as the electrolyte, and this means the consumption of fuel to maintain the requisite temperature. The gas battery, however, affords the means of effecting an indirect conversion; but there is no need to construct an apparatus and burn coal for the express purpose of producing the combining agents. There are many manufacturing processes in which gases are given off which go to waste, and are often highly deleterious when allowed to escape into the atmosphere, but which might be utilised in a gas battery, and it is in the direction of finding how these already *existing* substances may be utilised that we think it would be well for the electrochemist to work if he wishes to discover a way of superseding the present plan of obtaining electricity by thermo-dynamic means. The alkali industry is a case in point, and although we think that the gruesome picture of the condition of the workers popularly given is somewhat highly coloured, still there can be no doubt that hydrogen sulphide is an evil-smelling and very poisonous gas, and that any fresh opening for its utilisation or suppression is to be welcomed. Of recent years the evil has been considerably mitigated, thanks to agitation on the subject, and to economic considerations, but it would be a good thing if the hydrogen sulphide necessarily generated in the course of manufacture could be utilised in the production of electricity. The experiments carried out by Mr. LUDWIG MOND with a view to improving the original Grove battery, have not yet made that battery commercially successful, but they have led to the discovery that carbon monoxide forms carbonyls with iron and nickel, a fact which was quickly utilised in the extraction of nickel from its ores. Let us hope that investigations carried out on Mr. REED's new battery may lead to as useful commercial results as those which were obtained in the attempt to improve the gas battery originally invented by the late Sir WILLIAM GROVE.

## REVIEWS.

**The Alternate Current Transformer.** (Vol. I., New Edition.) By J. A. FLEMING, M.A., D.Sc., F.R.S. (London: "The Electrician" Printing and Publishing Company.)

On the appearance of the first edition of this book it fell to the writer of the present article to contribute a review of the work which certainly did not entirely fulfil that modern definition of criticism, that it is the art of praising. For on looking back at that which he then indited the writer is struck with the comparatively small importance of the matters which he singled out for blame, compared with those features upon which he bestowed praise. But what is a critic to do to justify his existence? Where errors exist, be they ever so trivial, he is in duty bound to suggest their removal in preparation for the appearance of that second edition to which author and publisher alike look forward. And now that the second edition has come, with its excisions and revisions, with its chapter suppressed here and added there, it is again the critic's duty, as the watch-dog of the body of readers to whom the author addresses himself, once more to play his part, judiciously mingling praise with blame. Happily, in the present case, Prof. Fleming has not left his reviewer without an adequate pabulum. The new edition bulks larger than its predecessor, mainly by reason of a whole new chapter added at the end. Naturally, the reviewer precipitates himself upon a feature so excellently planned to give him a chance. So he reads that last chapter first, and delivers judgment accordingly. When the hum of the sine-curve alternator and the din of the controversy to which it has given rise are still in the air, it is gratifying to have put into one's hands a work that sums up the effect of all the positive and negative opinions that have been advanced upon the subject during the last three years. In the new chapter we get at the root of the mean square value of all these opinions taken throughout that period.

In the first place it is shown that no alternator can claim to yield a model sine-curve under all circumstances. It may be that when running gaily, and with but little load to bear, its pulses throb with the pure spirit of the mathematical analyst; and even with a heavy load of lamps it may still preserve a bold rotundity in the outline of its curves. But when there comes on the weary all-day load, consisting mainly of transformers with their self-seeking, self-induced demands, its features lose their symmetry and youthful roundness, and become haggard and depressed. Not that they become less useful then, for it is shown that in some respects these distorted, hard-worked, hump-backed creatures, can be even more efficient than their prim scholastic brethren. Indeed, Prof.

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Fleming is prepared to discuss any kind of curve, from the haughty, high-peaked individual that tries the patience of the insulation, down to the stolid level-headed sort, whose only vice is a tendency to extravagance in iron. This he does by means of two factors, an "amplitude-factor" and a "form-factor," the latter being a generalised algebraic conception for that for which, following Gisbert Kapp's initiative, numerical coefficients have hitherto been employed. Having clearly defined these two elements, Prof. Fleming shows, by the aid of the stern symbols of the calculus, why a peaked curve involves a smaller iron loss and a greater secondary drop than a flat-topped curve does. The process of reasoning is not complex; rather is it entertaining in its simplicity, and lures on the gentle reader in its flow of argument, until, on page 588, he stops short suddenly at a flaw.

$$\text{"}S N_1 B_1 = \int_0^{\frac{T}{4}} e_1 \, dt = m \cdot e_1 \frac{T}{4},\text{"}$$

says the book. "No," says the reader, "that is only true for a symmetrical curve, and we are here talking about irregular curves. There is not necessarily a connection between $B_1$" (the maximum flux-density called by Prof. Fleming sometimes the "induction" and sometimes the "induction density,") "and the integral of $e_1 \, dt$ throughout a quarter only of the period."

And he thereupon quarrels with the author and goes off in the sulks, refusing to admit any further an argument which has landed him in a bog. Perhaps, however, he is a cautious reader, and looks over all the definitions again to find a way out; and straightway he comes upon the following:—

"$m e_1$ = the true mean value of $e_1$ during the period."

Having always supposed that the *true mean* of $e_1$ during the period was zero, he is again in a puzzlement, and cudgels his brains to discover whether he or the author is wrong; or why, if both are right, there should be any such block in the way. On reflection it becomes obvious that what the author meant to say was during a half-period; and as for the other difficulty, there must be something wrong. If the gentle reader would only curb his feelings and allow the author a little grace for inadvertent slips, he would see that, in spite of these erroneous lines, the argument is, in the main, right. But, then, readers are not always so generous, nor are they always able to see the good in an argument which contains a flaw, though it be only in its statement. The main fact remains that the "form-factor" and the "amplitude-factor" afford a very simple method of attacking what at first sight is not a simple or obvious problem to solve.

Apart from the slips mentioned above and a few misprints here and there, the great value of this chapter lies in the thoroughness with which every investigation in it is carried out, and the explicitness of the instructions given to the student. This is well illustrated in the few pages devoted to the subject of the taking of alternator-curves, wherein are given all those little particulars as to the setting of the brushes, the units employed, and the like, which make the difference between knowing vaguely how a thing is done and being able to do it.

Besides this last new chapter, there are to be found in this new edition a great number of additions and improvements. To Chapter I. have been added a few paragraphs on Henry's researches. Chapters II. and III. are entirely recast and amplified, to the great gain of the reader; they now form a very convenient collection of electromagnetic theorems. The distinctive meanings of the suffixes "-ivity" and "-ance" are not sufficiently well preserved, and it seems a pity that in a standard work like this an effort should not be made to get rid of some of the many senses in which that poor hard-ridden word "induction" is used. The expression "induction-density" is extremely awkward, and conveys no notion of its intended meaning, unless one happens to know the particular weakness of the author who uses it. "Magnetic flux-density" is perfectly precise and self-explanatory. How long is it going to be before writers on physics agree upon a uniform nomenclature?

A few useful pages are added upon Fourier's theorem; and it is shown in a very simple manner how the graph of any single-valued periodic function, though it be ever so irregular in profile, can be built up of a happy family of curves, consisting of Mr. Wriggle, Mrs. Wriggle, and all the little Wriggles in their various sizes.

To the new edition the author has added ten pages on the flow of currents into and out of a condenser, and an explanation of a valuable method of obtaining the root-mean-square value of a curve by means of a polar diagram. A few pages are devoted to initial conditions and complex functions.

The only other new matter of importance is a full description of a number of experiments on electromagnetic repulsions. For the theory of these there is not room for more than a popular explanation, in which the repulsion is explained by the method of ascribing to self-induction in the copper conductor the cause of current lag which brings the induced current partly into phase with the magnetic field. It may be doubted whether this method is so precise or useful as the method in which, instead of dealing in the lump with a so-called self-induction, one considers the magnetic field of the induced current, and, by compounding this with the impressed field, arrives at a consideration of a resultant field, which is the only source of electromotive force in the conductor. It does not make things clear to a student to attribute effects to "self-induction." The word is a convenient short expression for the effects of a circuit's own magnetic field; but if, in using it, there is any danger of that magnetic field being lost sight of, it had better not be used at all.

To the chapter on the dynamical theory of induction two headings have been added, one on the propagation of currents along conductors, and the other on the experimental determination of electromagnetic wave velocity. These embody the work of Hertz and Lodge, and the more recent researches of Trowbridge and Duane. But the pages on dynamical theory in this book seem somehow rather too good to form merely a chapter interpolated in a book on transformers. The subject is one of ever-increasing importance. It may be that the engineer of the future, instead of designing mains and magnetic circuits, will have to apply his mind to ethereal energy-paths, and calculate the cost of charging stresses in a surrounding medium. At any rate, he will be required to know a good deal about these things; and it would be well if there were some book which, beginning *ab initio*, would lead up by successive stages to the most modern developments of the subject. There is no one better qualified than Prof. Fleming to present the world with such a book.

A word of commendation is due finally to printer and publisher for the great improvement which has been made in the typography of the new edition. SILVANUS P. THOMPSON.

**Jahrbuch der Elektrochemie.** Vol. II. By Drs. NERNST and BORCHERS. (Halle: W. Knapp.)

This book is the second yearly volume of a work which, it is intended, shall give an adequate account of the progress that has been made in the study and the technical application of electro-chemistry. The scheme of the undertaking is clear and good. In the first place, Dr. W. Nernst edits such purely scientific researches as have appeared during the past year; secondly, Dr. W. Borchers describes all noteworthy industrial advances that have been achieved in the same period, dividing his work into appropriate sections. The scope and merits of the whole volume may be gathered from our succeeding remarks.

In the first section, dealing with pure research, some space is occupied with the record of those numerous observations of molecular conductivity which are being made in quantity by the great cloud of witnesses to the hypothesis of electrolytic dissociation. It is convenient to have all facts and figures of this kind in a concise collection. A chapter is devoted to the theory of the production of current in a cell, and of polarisation thereof, which contains little likely to advance existing knowledge. To the theory of the accumulator nothing is added but the conception of a $PbO_2$ ion, based on somewhat slender evidence. A poor halfpennyworth of fact and an intolerable quantity of speculation is too often the fare provided by the over-ardent ionist. The interesting work of W. von Bolton on the valency of mercury in solutions of

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varying dilution, which has been largely transcribed into these pages, is here abstracted. To what we have already published may be added that whereas mercury, when present in an electrolyte as the iodide $HgI_2$, appears to become monovalent when its solution is sufficiently diluted, yet the mercury of the salts mercuric cyanide and mercuric thiocyanate, is always divalent. Copper shows a similar change of valency. In the chapter on electro-chemical measurements, the influence of dissolved gases upon the indications of the silver voltameter is discussed; a similar cause of irregularity in the readings of the copper voltameter has already been dealt with in *The Electrician*.

Passing to the second part of the work, which relates to technical matters, we find an interesting account of Korda's experiments on the production of electrical energy by the oxidation of carbon. Carbon pressed against a piece of barium peroxide—the point of contact being heated in a bunsen flame—oxidises and produces a current at a pressure of 0·85 to 1·0 volt, corresponding with about 66 per cent. of the calculated output. The peroxides of lead and manganese give no such effect, as their conductivity is too great, and a short circuit results. It may be noted that gravity cells may be made easy of transport, without having their internal resistance unduly raised, by gelatinising their electrolyte—a simple and apparently efficient device. Case's electrolytic thermo-couple, depending on the fact that the equation $Cr_2Cl_6 + Sn = SnCl_2 + 2\,CrCl_2$ holds good at a temperature of about 100°C., and is reversed at the ordinary temperature, has been made the subject of an investigation by Skinner, who has corrected certain of Case's conclusions, and has devised an improved form of the cell. The chapter on accumulators does not contain any great novelty; one patentee, however, in describing his process for forming plates, incidentally defines the light metals as those which are of lower specific gravity than their oxides; *per contra* for the heavy metals. We believe these definitions to be novel.

Electrical heating by means of metallic or other conductors embedded in the material to be heated is adequately treated, and includes a description of Peuchens and Clarke's patent for concentrating sulphuric acid in this manner. The proposal has been made by others, and discussed a year or two ago in the technical press; it is not likely to prove an economical method. The various novel forms of electric welding apparatus are also described.

Of electrolytic products, hydrogen is now often obtained as a more or less waste material, and finds some sale in a compressed state. Its purity adapts it for use in lead burning. Ozone is quiescent for a time. The process for making phosphorus devised by Readman appears to have been bought up and suppressed, rather than worked. A description of the Siemens and Halske process for the deposition of antimony, recently given in these columns, is duly recorded. The electrolytic manufacture of magnesium is particularly well described. We learn that Oettel has shown that the difficulty in inducing the aggregation of the small globules of reduced metal is caused by their being covered by a film of oxide, generally due to the presence of magnesium sulphate as an impurity in the double chloride (carnallite) used as the electrolyte. The addition of fluor-spar to the bath greatly mitigates the evil. Concerning aluminium, there is nothing new to be said just yet. The electrolytic "parting" of gold and silver has been so recently described in this journal that its repetition is unnecessary here; it is sufficient to say that the account given in the "Jahrbuch" is full and good. The Ashcroft process for working lead-zinc sulphide ores is described, and condemned as impracticable in its present form. The deposition of coherent zinc from a solution of the sulphate containing zinc sulphide in suspension, according to Lindemann's patent, is discussed at some length.

Some admirable work (which might better have found a place in the first section of the book) on the preparation of zinc of 99·999 per cent. purity, by Milius and Fromm, is clearly and adequately abstracted. Mere mention of it must suffice in a review, but those interested may be referred to the original, appearing in the *Zeitschrift für anorganische Chemie*, 1895, Vol. IX., p. 144.

Under the head of tin we are told that although long disquisitions are still being made on the possibility of recovering tin from scrap, yet several large factories are already at work in Germany actually performing this feat, and turning out scrap iron so thoroughly de-tinned that it is eagerly bought up by the steel works. If this is true it is high time that the same should be done in this country. Electrolytic nickel, 5mm. and more in thickness, and of fair purity, is now put on the metal market by the Orford Copper Company of New Jersey. The process is jealously kept secret. Of calcium carbide it is pungently said: Those who like to pay royalties to patentees may certainly do so, but it is in nowise necessary. Passing to the production of acids, alkali and bleach by electrolysis, it may be remarked that with the increased production of chlorine instead of hydrochloric acid, as the bye-product of the manufacture of caustic soda or sodium carbonate, the former will become a drug in the market and the latter a highly-prized article, a quaint reversal of the natural order of things. A remedy is at hand in the ease with which chlorine is converted into the less energetic hydrochloric acid by the reactions represented by the two equations:—

$$(1)\quad C + H_2O + Cl_2 = 2\,HCl + CO.$$

$$(2)\quad C + 2\,H_2O + 2\,Cl_2 = 4\,HCl + CO_2.$$

An immediate plethora of chlorine and shortage of hydrochloric acid by reason of the over-production of electrolytic processes is hardly to be feared. A good account is given of the best conditions for the preparation of persulphuric acid and its salts by electrolysis. A novel manure has been proposed by Faure in the shape of calcium cyanate, to be made by heating a mixture of lime and carbon, first to 1,500°C., then to 2,500°C. in the presence of nitrogen, and concluding by oxidising the product (presumably cyanide) with air. The idea is ingenious, but we should recommend investors in nitrate shares to hold for a while. The evolution of the Kellner apparatus (now merged with the Castner), in which mercury functions as a carrier of sodium and as a mobile diaphragm, is luminously detailed. On page 238 there is a not very intelligible description of a process for obtaining $Na_2O$ by the limited oxidation of a lead-sodium alloy with the intermediate formation of sodium plumbate. As misprints are not rare, plumbite may be meant; but the adoption of this reading does not greatly mend matters. The generation of chlorine as a main instead of as a bye-product is treated of, and the increased output of a mixed electrolyte containing both hydrochloric acid and an alkali chloride is mentioned, and the reason for it explained. The progress of electrolytic synthesis or resolution of organic substances seems not to have been great; the displacement of ordinary chemical methods takes place slowly, and with doubtful advantage. In analytical chemistry but little of importance has been done; perhaps it is now becoming recognised that except for assays of a particular metal (*e.g.* copper), required in large numbers with a minimum of skilled labour, the use of electrolytic methods in the laboratory is quite minor. For general purposes electrolytic methods are too slow, cumbersome, empirical and uncertain to find favour with the chemist, and their use is usually confined to their inventors. The electrolytic production of bleaching liquors is dealt with quite as fully as the subject deserves, and one gathers that the whole matter is still in much the same state of fog as it was ten years ago. The Hermite disinfecting process is dismissed in a few words. It is refreshing to note, a page or so further on, that "Humbug" (with a capital, too) is now a recognised German word.

The book ends with a bibliography and index, which are likely to be useful; moreover, every chapter is provided with a list of recent patents on the subject of which it treats. The whole arrangement is clear and systematic, there is very little padding, and the quantity of actual rubbish in the shape of preposterous processes of patent absurdity is creditably small. As an intelligent, intelligible and fairly concise record of what has been done in electro-chemistry during the past year the book has our commendation, and to the authors we offer our acknowledgments for an excellent piece of work.

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## THE BUDAPEST INTERNATIONAL TELEGRAPH CONFERENCE.

The complete text of the Service Regulations attached to the International Telegraph Convention of St. Petersburg, as revised at Budapest, has been issued, and it is now possible to indicate exactly what changes have been made.

The eighth International Telegraph Conference was opened on June 16th last by the Hungarian Minister of Commerce, in the Academy of Sciences at Budapest, M. Pierre de Szalay, Director of Posts, Telegraphs and Telephones of Hungary, being appointed President of the Conference. After paying graceful tribute to the memory of those delegates who had attended previous Conferences, and had since passed away, it was announced that for the first time delegates had been sent to the Conference by Chili, Ecuador, Mexico, Salvador and Venezuela, although they had not been able, up to the present, for various reasons, to adhere to the Convention. Also, that Western Australia, the Portuguese Colonies, New Caledonia and Queensland, the Telegraph and Telephone Company of La Plata, the South American Cable Company, the Halifax and Bermudas Cable Company, and La Cie. Française des Cables Télégraphiques (in respect of the Bundaberg-Quaco cable) had given in their adhesion to the Telegraphic Union. Règlement, Tariffs, and Editorial Committees were then appointed, Mr. J. C. Lamb, of the British Post Office, being appointed President of the Tariff Committee. On June 17th the Règlement Committee held its first sitting. On the motion of Belgium, clear language was defined as that which offers an intelligible sense in one *or several* of the authorised languages; and even the presence of commercial marks in a telegram, otherwise so written, should not remove it from that category.

A long discussion, lasting nearly two days, ensued on the subject of the authorised vocabulary, and the question as to its use being made compulsory from a given date for extra-European code telegrams. All the British, Imperial, and Colonial delegates, and those of the Cable Companies opposed the obligatory use of the vocabulary in its present form. Eventually the following proposition was unanimously adopted:—"From a date to be fixed by a future Conference, all the words employed in private telegrams in code language shall be taken from the augmented official vocabulary, to be prepared by the International Bureau."

At the third sitting of the Règlement Committee, held on June 22nd, it was agreed that proper names in the authorised vocabulary may be used as code words. The consideration of the German proposal for a uniform European tariff was postponed until the next Conference, which is to be held in London in 1901. In extra-European plain language messages it was decided that 15 letters instead of 10 should count as one word, and five figures instead of three should be allowed as a group.

Some reductions of tariff were agreed to, and the various changes made will come into operation on July 1, 1897.

The Cable Companies gave a banquet to the delegates and Hungarian officials, at which 170 sat down, in the magnificent dining hall of the Royal Hotel, Commander Suenson, of the Great Northern Telegraph Company, presiding. The Chairman proposed the toast of the evening, "King Francis Joseph the Second and the Hungarian People," in an eloquent speech in French. Dancing was afterwards kept up until an early hour. The entertainment was a great success, and made a marked impression on the Hungarians and delegates present.

## POWER TRANSMISSION DEVELOPMENTS AT NIAGARA FALLS.

BY ORRIN E. DUNLAP.

Probably the most important power contracts ever made in the United States have just been closed in Niagara Falls and Buffalo. The contracts have to do with supplying Buffalo with "Niagara energy." There has been much discussion as to the price of transmitted power, and your correspondent is in a position to state that this first contract calls for the delivery in Buffalo of the first 1,000 H.P. at $40 per H.P. Should the Buffalo Street-Railway Company want more than this 1,000 H.P. the price will be $36 per H.P. for the additional amount used.

The Cataract Construction Company of Niagara Falls has awarded the contract for the construction of its power transmission line between Niagara Falls and Buffalo to the White-Crosby Company. The pole line for which these contracts have been given will be of sufficient capacity to carry wires for the transmission of 40,000 H.P. to Buffalo. The transmission will be carried out on the three-wire system.

About the same time the above contract was awarded, another important contract was made. The parties to this second contract are the Cataract Construction Company Niagara Falls, the Buffalo Power and Conduit Company, the Buffalo Street-Railway Company, and the General Electric Company of Schenectady. The Buffalo Power and Conduit Company controls the distribution of Niagara Falls electric power in Buffalo. The contract which has been closed between these four great companies provides for all of the apparatus and machinery necessary for the transmission, transformation and delivery of 1,000 H.P. to the lines of the Buffalo Street-Railway Company for the operation of the electric cars on the various lines in Buffalo. The contract requires everything to be ready to run the cars of the Railway Company not later than November 4th next. It is not the intention of the Street Railway Company to wholly supersede its present power plant by Niagara power, although it is hoped in time to do so. The Buffalo Street-Railway Company produces the electric power which it is now using by steam, and at a remarkably low cost; and the adoption, even partially, of Niagara Falls power in the face of this fact would appear to indicates the belief of the Company in the successful and cheap transmission of power to Buffalo. The steam power of the Buffalo Street-Railway Company is said to be one of the very cheapest developed powers in the country. The contract entered into with the Cataract Construction Company of Niagara Falls covers three transformers, which will be the largest ones ever built. These transformers will "step up" the alternating current of 2,200 volts generated by the dynamos in the Niagara Construction Company's power house, to either 10,000 volts or 20,000 as may be thought desirable. The transformers which the General Electric Company have contracted to furnish to the Buffalo Power and Conduit Company will reduce this voltage or pressure again to 400 volts, and at this voltage the electric current will enter two 500 H.P. rotary converters, which will be erected in the Niagara-street power house of the Buffalo Street-Railway Company. In these rotary converters the alternating current will be transformed into a direct current of 550 volts. The rotary transformers will be used in parallel with the direct-current generators in the power house already referred to.

## THE CAPILLARY ELECTROMETER IN THEORY AND PRACTICE.*

BY GEORGE J. BURCH, M.A.

(*Continued from page 473.*)

It remains to describe in what way the factor $l$, which turns the scale readings of the sub-normal into volts, is ascertained. A "normal excursion," *i.e.*, that given by the action of a constant P.D. of known value, is photographed. The method of doing this has been described. The resistance must be approximately the same as that in circuit when the curves to be analysed were taken. But as 1,000 ohms more or less makes very little difference, one photograph will serve for a large number of experiments. The curve of such an excursion is shown in Fig 11.

The most accurate measurements of the sub-normal are obtained when it makes an angle of about 45deg. with the

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MSS. received October 17, 1895.

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radius vector $o r$. It is also easier to find the tangent to the curve at a point some little distance from its commencement. Selecting a convenient point, I measure its vertical distance from the zero line. Deducting the known value of this from the E.M.F. given by the potentiometer, the remainder is the E.M.F. corresponding to the velocity of the meniscus at that point, and therefore also to the length of the polar subnormal N,

whence $$l = \frac{V - k\Delta r}{N}.*$$

In the electrometer at present in use 15cm. on the subnormal = 0·02 volt, so that $l = 0{\cdot}13$. And an excursion of 10mm. is given by 0·018 volt, so that $k = 0{\cdot}0013$.

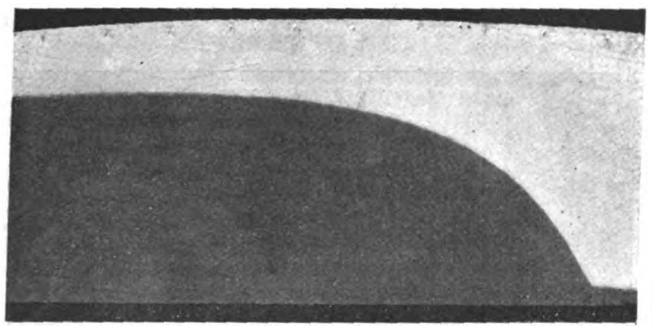

FIG. 11.—A Normal Excursion of the Capillary Electrometer given by communicating to it a known constant P.D.

The measuring machine shown in plan and elevation in Figs. 12 and 13 enables these operations to be rapidly and accurately performed. The negative is clamped to a carrier B, pivoted at O upon the high table A, in the top of which a hole is cut so as to allow the photograph to be examined by transmitted light. Two screws, C and D, serve to adjust it to a position corresponding exactly to that which it occupied on the pendulum machine. The staff E is two metres long, and corresponds to the fixed line $t o n$ of the diagram (Fig. 10). It is graduated in centimetres, and the values of the subnormal are read off upon it. F is a brass plate, projecting sufficiently high above the front edge of the table to support a fine thread,

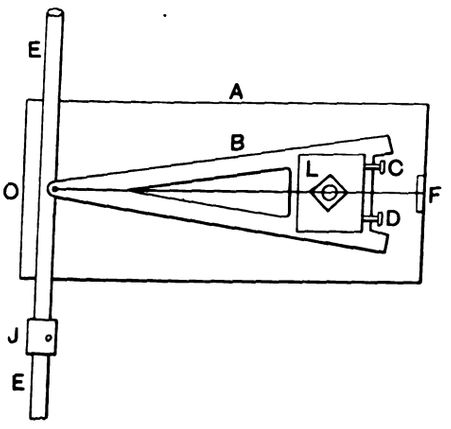


FIG. 12.—The Measuring Apparatus, Plan.

attached to the pivot O, and stretched by a weight, just clear of the surface of the negative. This thread corresponds to the radius vector $o r$ of Fig. 10. But it is only used in adjusting the apparatus. The line which actually represents the radius vector is the image of a very fine copper wire G, stretched across an adjustable frame about a foot from the floor. There is a mirror underneath the wire G, and the lens H—an ordinary lantern objective—serves to focus the wire upon the negative.

In using the machine, the thread is laid in a notch in F, exactly at right angles to the centre of the staff E. The wire G is set so that its image on the plate, as seen through a lens, coincides with the thread, which is then removed. The plate has now to be centred. This is done by adjusting the screws C and D, till, on traversing the plate carrier from side to side, the reference circle on the negative runs truly against the image of a pin fixed by the side of the wire G.

To find the zeros of time and of E.M.F. that part of the record of the signal key at which it drops suddenly is brought up to the radius vector, the image of G, and a mark is made with a needle point where it cuts the serrated record of the tuning fork. The distance $c q$ along the radius vector between the reference circle and the electrometer curve is measured with a glass millimetre scale. It is entered in the note book under the

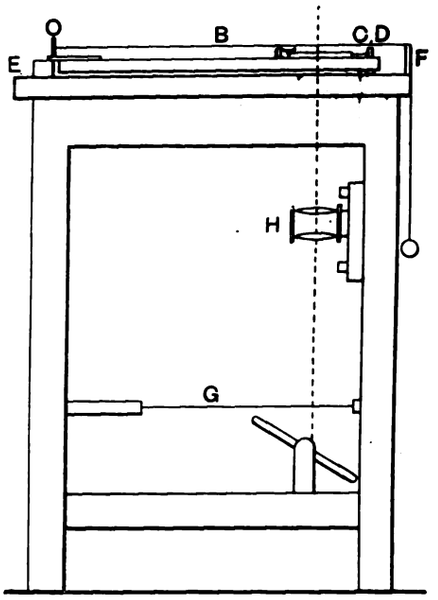


FIG. 13.—The Measuring Apparatus, Elevation.

column R, against the entry $t_0 = 0$ of the first column. The carrier is then shifted until the earliest point at which any change in the level of the meniscus can be detected comes under the radius vector. The time $t_1$ at which this took place is noted. From this point the analysis of the curve commences. The carrier is moved on through a suitable time interval, usually less than 0·001sec., so as to make the next value of $t$ a whole number. The distance $c p$ is entered in the column $R - r$, and the difference $c q - c p$ in a third column $\Delta r$. Then the subnormal is measured by the following method.

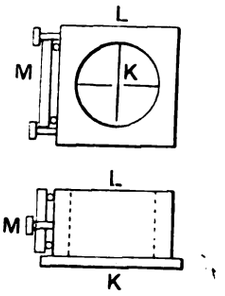


FIG. 14.—Plan and Elevation of Mirror-Block.

The block L, shown in plan and elevation in Fig. 14, has upon its under surface a glass plate, $k$, on which are ruled two lines at right angles to each other. One of these, the tangent, is continuous, but the other, the normal, is broken where it crosses the tangent. On the side of the block, set exactly parallel with the tangent line, is the mirror M, and on the mirror, in a line with the end of the normal, is a pointed index. To measure a subnormal, the block L is placed upon the negative and adjusted so that the three lines, tangent, normal and radius vector, may intersect at the point where the radius vector line crosses and the tangent touches the curve. Then, passing to the back of the staff E, the observer moves the

* $\Delta r$ is measured in millimetres, N in centimetres.



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slider J upon it until the pin of the slider and its image in the mirror M coincide simultaneously with the point of the index on the mirror. In this way the length of the subnormal can be measured within about 1 per cent. The values so obtained are entered under the column N.

The process is repeated for a number of points on the curve. Where the changes of P.D. are very sudden the time intervals may be less than 0·001sec., and any changes of direction separately noted. Finally, the results are calculated out by the formula already given, and plotted in graphic form. All measurements are made with a lens magnifying 10 or 12 diameters.*

The relative importance of the two components of the indicated E.M.F. varies according to the character of the experiment. Slow changes, *e.g.*, from 0 to 0·1 volt in a tenth of a second, are shown mainly by the change of level of the meniscus, but the same P.D. established in the course of the hundredth part of a second would produce a comparatively small rise with large values of the subnormal. That the method is reliable was proved by applying it to the estimation of known P.D.'s, which were caused to act for 0·01sec. on the electrometer.

It must be borne in mind that the value in volts of the subnormal scale-readings depends on the velocity of the plate during the observation. It is, therefore, essential that the rate of the pendulum should be the same as when the normal excursion was taken from which this value was calculated. The velocity of the plate, with a given load on the pendulum, is so nearly constant that the error resulting from it may be neglected; but for different loads, or for greater accuracy, the values of the subnormal may be either calculated or ascertained by measuring a specially photographed normal excursion.

Each photographic record represents the integration of the charges received by the electrometer during its production. And as the electrometer throughout that portion of its range is generally of constant capacity, the curve represents also the integration of the quantities of current which have flowed through the circuit, if there have been no changes of resistance. The derived curve, obtained by this method of analysis, shows the changes of E.M.F. also on the supposition that there have been no material changes of resistance. But as the equivalent resistance of the electrometer circuit is seldom under 100,000 ohms, such variations must be considerable to affect the result.

It may be asked, How does this method distinguish between the natural return of the meniscus to its zero position by discharging itself through the experimental circuit, and the reversal of any given movement by a difference of potential in the opposite direction? In such a case, if the E.M.F. indicated by the subnormals is exactly equal and opposite in sign to that corresponding to the distance of the meniscus from the position of zero potential, the electrometer is simply discharging through the circuit, and the E.M.F. calculated by the formula is zero. If there is an excess in either direction, that excess corresponds to the E.M.F. acting at the time. The curve of discharge and the curve of charge have precisely the same time-relations.

I have already explained the method of finding the value of the subnormal when the resistance in circuit is not the same as that used in photographing the normal excursion.

### *Application of the Capillary Electrometer to the Study of Telephone Currents and Dynamos.*

In the spring of 1887 I photographed the result of blowing a whistle near a telephone connected with the electrometer. It was found that the currents so produced were of sufficient intensity to electrolyse the acid in the capillary, and the shadows of the gas bubbles were very evident upon the plate. Electrolysis is also brought about by a single induction shock whenever the resulting E.M.F. exceeds a certain limit, and in such cases, of which Fig. 15, photographed June 21, 1892, is an example, no measurable interval can be detected between the establishment of the P.D. and the evolution of the gas. I am investigating the bearing of this fact on Kohlrausch's method of measuring resistance. It had been long known that a good electrometer would respond visibly to certain sounds spoken into the telephone, but no attempt had been made to photograph these excursions.

In the summer of 1893 I made one of the assistants sing a high falsetto note at a distance of about two feet from a telephone in circuit with the electrometer. The result is shown in Fig. 16, which was the last of several photographs taken

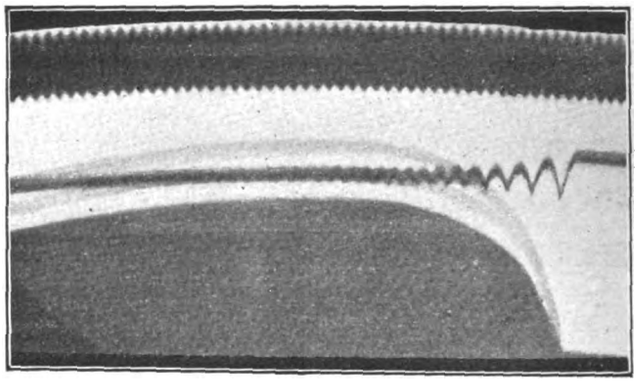

FIG. 15.—Effect of a Single Induction Shock strong enough to cause electrolysis. The upper serrated line is produced by a tuning fork making 500 double vibrations per second. The narrow band beneath it is the gnomon of the signal key, the fall of which breaks the primary circuit of the induction coil. The curve at the lower part of the plate is the shadow of the meniscus, and the faint streaks above it are produced by bubbles of hydrogen. This photograph shows that the interval between the fall of the signal and the evolution of gas is too small to be measured even with a plate moving 80cm. per second.

in succession. His voice was beginning to be fatigued, and the sound wavered. It will be noticed that there is a periodic change in the inclination of the serrations.† This is absent in the earlier negatives taken when the voice was steady. The pitch of the note, as judged by comparing it with the sound of the tuning fork, corresponded exactly with the number of vibrations recorded, viz., 650 double changes of E.M.F. per second. Had the photograph showed simply a serrated band, it might have been ascribed to a mere vibration set up in the meniscus under the action of an alternating current; but this

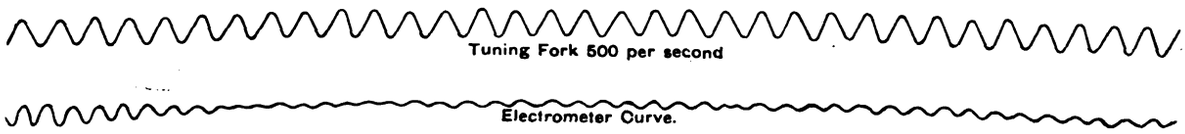


FIG. 16.—Outline of Excursions produced by singing a high tenor note (650 double vibrations per second) near a Telephone. Voice fatigued. Curves show the wavering of the sound.

evidence that the electrometer could record changes in the quality of a tone determined me to make further experiments on the subject.

No opportunity offered till the spring of 1894. I then found that an ordinary telephone did not give currents of sufficient intensity to record more than the pitch of the voice, unless the mouth was placed quite close to the diaphragm, and in that case the disturbing influence of air currents made the results irregular. I therefore tried the microphone, using a contact between two carbon buttons resting on a diaphragm

* Detailed examples of the method of analysis will be given at the conclusion of the series.

† These details were too small for reproduction by the method used in Fig. 15. An enlarged image of the curve was thrown on a sheet of Bristol-board, carefully outlined, and reduced by photography to 1½ times the size of the original. I have measured the E.M.F. of these serrations, and found it to vary between 0·01 and 0·02 volt. In another experiment of the same kind the maximum E.M.F. was 0·06 volt. This is much greater than is commonly supposed in the case of telephone currents.

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of thin vulcanite. The microphone circuit was connected with the primary of an induction coil, the secondary of which was in circuit with the electrometer. This arrangement was so very sensitive that I could do nothing with it. I succeeded once in photographing the sound of the letter "r"; but in most cases there was an irregular vibration running through the records. The cause was discovered by placing a telephone in the circuit, when the sound of the engine and dynamo, which supplied the arc lamp, was plainly heard. The apparatus was fixed to the wall of the room, and this transmitted the sound. Another reason induced me to abandon the microphone. The slightest change of the adjustment would completely alter the clang-tint of a sound reproduced by it. For instance, the ticking of a watch placed near the microphone could be made to resemble that of a clock by merely adjusting the weight upon the carbons. And although the sound was always recognisable and even characteristic, it was impossible to doubt that in one case the deeper vibrations were reinforced and the upper tones suppressed, while in the other case the lower tones were absent. Then I tried a

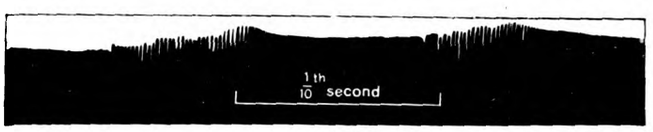


FIG. 17.—The Syllables "pop-op-op" Spoken near a Battery of Five Telephones in series. Plate moving more slowly. (Enlarged).*

similar experiment with a number of telephones, and found that each one reinforced certain notes more powerfully than others, and that the effect depended on the shape and size of the diaphragm, and was constant for each instrument. This accounts for the fact that electrolysis is produced in the capillary of an electrometer when certain notes are sounded near a telephone connected with it, while other notes, although much louder, produce no such effect. I decided, therefore, in order to obtain more faithful records of the vibrations of the voice in speech, to join up all my telephones in series. This plan had also another advantage, namely, that of increasing the E.M.F. of the currents. For the capillary electrometer differs from the high-resistance galvanometer in requiring much less current but a higher E.M.F. to give good readings. I used five telephones of three several types—each one, as it chanced, sensitive to a different fundamental tone. These were placed close together in a convenient position for receiving the sound of the voice. To shield the electrometer from the

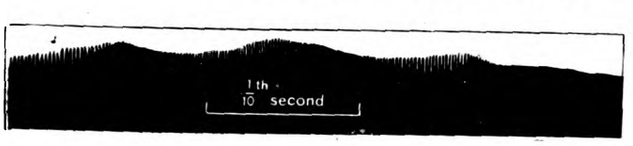


FIG. 18.—The Syllables "dod-od-od" spoken in the same way (enlarged).*

effect of accidental noises two mercury keys were attached to the pendulum machine, one to short-circuit the electrometer until the plate had begun to move, and the other to perform a similar function directly it had passed the slit.

Vowels and sibillants are easy to photograph, because they can be sounded continuously from the moment the handle is raised until the click of the pendulum against the catch warns the operator that the plate has passed the slit. But consonants are more difficult to catch. I was obliged to use a slower rate, and to repeat the sounds as fast as possible. Thus the characteristic vibrations of the letter "p" are given by the syllables "Pop-op-op-op," and those of "d" and "k" by "Dod-od-od" and "Kok-ok-ok" respectively. It will be observed that the vowel is the same in all three cases. This was done purposely for the sake of uniformity, although the plate did not move fast enough to bring out the vibrations due to the vowel. The accompanying illustrations, Fig. 17 and Fig. 18, show a marked difference between the labial and dental consonants. The guttural sound gave a curve different from either, but unfortunately the two examples I obtained were not well adapted for reproduction. The vowel "ē" in "me" was easily distinguishable from the short sound of "ŏ" used in the experiments on the consonants, and

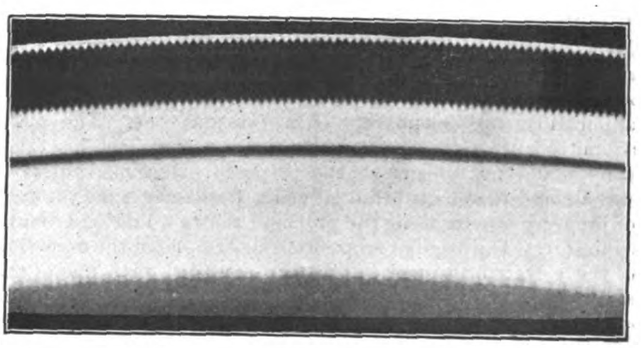

FIG. 19.—The vowel "ē" as in "mē."

it is here reproduced (Fig. 19). It will be observed that the plate was driven much faster than in the two previous cases, and that the negative has not been enlarged as those were. While it was still wet, fine serrations could be distinguished with a lens, and, I have no doubt, that by using a still higher velocity these could be rendered visible to the eye. The letter "r," strongly trilled, was taken on the slow rate with the battery of telephones, and on the fast rate with the microphone, the result of the latter experiment being

FIG. 20.—The Letter "r" Trilled with the Tongue, about 2ft. from a Microphone. Plate moving very rapidly, shows about two-thirds of the complete cycle of vibration, as ascertained from other photographs with slowly-moving plates.

given in Fig. 20. The tuning fork was not sounded in this case, as it would have affected the microphone, but the velocity of the plate was between two and three metres per second. By comparing it with the telephone records, it was evident that the microphone photograph represents about two-thirds of a very complex series of vibrations, the repetition of which constitutes the characteristic sound of the trilled lingual "r."

*(To be continued.)*

* Figs. 17 and 18 are simplified drawings, more or less diagrammatic, of the original negatives, showing only the principal excursions and the general shape of the curves. The peculiar flat-topped groups in Fig. 17 are characteristic of the labials, and the more or less lenticular series of fine oscillations in Fig. 18 always result from the dental checks. The intervals between the fine lines correspond to the pitch of the voice. The excursions extend a good deal farther both upwards and downwards than is here represented, and many of them have a hazy outline, indicating that they are in reality groups of excursions, which on a more rapidly moving plate would be separately visible.

**Fuel Problems.**—Mr. J. D. Weekes, in *Cassier's Magazine* for August, commences an article on the problems of the utilisation of fuel with the following dithyrambic fanfare:—"The primary problems of civilisation are material ones; their answers are writ in fire. When these problems in their higher aspects have pressed for solution, it has been out of the burning bush that the Divine voice has spoken, or in the cloud and smoke that the Divine finger has traced the rules by which these problems shall be solved."

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## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July 24, 1896.*

**The Rapid Transit Problem in New York City.**—The necessity for better means of transit in this city is urgent in the extreme, and is recognised by all classes, yet the accomplishment of the desired end is a problem that has vexed engineers for several years past. At the present time the solution of the problem does not seem any nearer the final stage than it was two years ago. Many people look to the existing elevated railway system as a means of securing ample rapid transit facilities for some time to come, but the legal limitations have, so far, proved serious obstacles in this direction. Mr. George J. Gould, President of the Manhattan Elevated Railroad Company, last week submitted to the Rapid Transit Commission an application to extend his Company's lines, which application was amendatory of a previous one. The plans submitted, Mr. Gould said, were an ultimatum, and his Company would not undertake the proposed extensions unless it was assured that no substantial claim for damages on the part of property owners along the proposed routes would be brought against it. The original proposition contemplated the extension of the elevated systems, but in the amended plan one of the most important provisions is for the building of a surface overhead trolley road in certain sections of the northern part of the city. Mr. Gould also asked that, excepting on the proposed trolley road, his Company be allowed to use as motive power compressed air, electricity, or steam. He said that the trolley system was devised simply as a temporary remedy, through a district that was so sparsely populated that the Company could not, from a pecuniary standpoint, see its way clear to operate or build an elevated structure. When the business warranted it, he said he would be only too willing to build an elevated structure to take the place of the trolley system, but at the present time it was out of the question. The proposition has not yet been acted upon by the Commission.

**Convention of the North-Western Electrical Association.**—The fourth semi-annual convention of the North-Western Electrical Association was held in Marinette, Wis., on July 15th and 16th. The society consists of electrical people in the middle States, with Chicago as the centre. Several good papers were read, but for various reasons not a single one of them was discussed, the mere reading of each paper evidently satisfying the members. In a paper on "The Insurance of Electrical Plants" by Mr. R. H. Pierce, the author stated that as a good many of the existing stations needed to be rebuilt in order to have a fair earning capacity, the loss of the plant might in many cases be considered less of a hardship than the loss through the interruption of service and the attendant loss of revenue and patronage. He stated that the question of insurance could be met in three ways, namely:—1st, by insuring in responsible and reliable insurance companies; 2nd, by the formation of a mutual company by central-station owners; 3rd, by securing the maximum safety by the use of proper construction, care and fire protection and taking the chances of a fire loss. The first, he said, was the plan generally adopted. By conforming to the rules of the underwriters, he stated that the insurance rate was very low and eagerly sought by insurance companies. The best rate was 50 cents per $100. For inadequate fire protection, the rate might be as high as $10 per $100. In conclusion, he stated, that the solution of the insurance problem was intelligent construction and operation, and he advocated a close adherence to the rules and requirements of the National Board of Fire Underwriters in the installation of plants. The municipal control of electric light plants was considered, and Mr. John I. Beggs thought that it was not difficult to demonstrate to almost any municipality that the price at which private companies were rendering service was as low or lower than they could render it themselves. Touching the question of incandescent lamps, Mr. Beggs stated that there was no lamp, the candle-power of which was within 20 per cent. of its nominal rating, and that the economy of any lamp was over 30 per cent. out of the way. Tests showed that lamps guaranteed not to exceed 50 watts really took 56 watts on the average. A 20 c.p. lamp was needed to-day, Mr. Beggs said, to compete with gas and the Welsbach burner. Not a lamp manufacturer in the country, he asserted, dared take up the proposition to produce a 2 1/2 watt lamp that would last 300 hours with a candle-power of from 12·2 to 20. He sold his current at 15 cents per kilowatt-hour, which was equivalent to gas at $1·60 per thousand.

**Death of Two Well-Known Telegraph Men.**—Last week Mr. John M. Gamewell, inventor of the fire-alarm telegraph system bearing his name, and which is very extensively used in this country, died at his home on July 19th at the age of 74 years; and Mr. W. O. Lewis, who built the first telegraph line between New York and Sandy Hook for the purpose of reporting the arrivals at New York Harbour of transatlantic vessels, died in Germantown, Pa., on July 15th. Mr. Lewis was one of the early advocates of the Atlantic cable, and was a warm friend of the late Mr. Cyrus Field. He developed the ship news department of the principal Press Associations in this country, the object of which department is the reporting of arrivals at the important ports of vessels from all over the world. Mr. Lewis became one of the managers of the Boston and New York Telegraph Company when that concern was organised, and it was largely owing to his industry and intelligence that the line was put on a paying basis.

**Motor-Carriage Exhibition.**—Among the features of the Rhode Island State Fair Association Meeting, which will be held in Providence, R.I., on Sept. 7th to 11th next, will be the exhibition and races of motor carriages. The points forming the basis of awards will be speed, control, simplicity, cost, maintenance and appearance.

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NEW YORK, *July 31, 1896.*

**Compressed Air Motor Test.**—On July 30th a practical test was made of the Hardie compressed air motor for street car propulsion. The test was made on the 125th street branch of the Third Avenue Railway Company, and was satisfactory as far as control, speed, &c., were concerned. The pressure carried in the reservoir was 2,000lb. The compressed air is carried in long cylindrical reservoirs under the car and also a number of short ones at either end, the total capacity being 51 cubic ft. at a pressure of 2,000lb. The air is expanded by means of a reducing valve to a working pressure of from 140lb. to 160lb. At this pressure the air is supplied to the air brake cylinders as well. Before entering the cylinders the air passes through a number of pipes which are surrounded by hot water. The hot-water tank has a capacity of 500lb., and is located under the floor of the car being accessible by trap doors. The water in the tank is heated by steam, which is supplied through a flexible pipe at the power station. The steam is admitted under suitable pressure to produce a temperature of water of 340deg., and it rarely falls more than 150deg. on a trip. This enables the engine to exhaust at a temperature of about 80deg. to 100deg., avoiding trouble due to the freezing of the exhaust, and at the same time nearly doubling the efficiency of the motor. The weight of the car complete is nearly 18,000lb., made up as follows: 6,000lb. in the car body, 500lb., of hot water for heating the air, and 500lb. of air itself, and the rest by the truck and motor equipment and the air cylinders. The controller and reversing lever are situated on the front platform and resemble the ordinary electric controller. It is too early yet, of course, to state whether this system will be adopted or not on this or any line, because its efficiency has not yet been practically demonstrated. A good many claims are made, however, by the inventor; but there seems to be a general sentiment that it will not make very serious inroads on the existing systems.

**Tunnel under the East River.**—The Company which was recently incorporated in this city to construct a tunnel under the East River between New York and Brooklyn, which incorporation was briefly noted in a previous communication, is making active preparations to carry forward the work for which it was organised. The plan is to build the tunnel on the Greathead system, employing a steel hood. The present plans contemplate a structure 24ft. in height, with a flattened arch, and about 28ft. in extreme width. A double track is

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to be used, and ample ventilation and illumination provided for. The capacity of the tunnel is estimated at 12,000 passengers each way per hour during the busy parts of the day, and it is thought that the electric cars can make the trip from one end to the other in about 3min. The minimum time now required for a trip across the Brooklyn Bridge by the existing cable system on that structure is 6min. The estimated cost of the tunnel is $3,500,000, which includes terminal facilities and property rights. The work will be commenced in October, and it is expected that the tunnel will be completed within one year thereafter.

**Combination of Incandescent Lamp Interests.**—The various manufacturers of incandescent lamps in this country have effected a combination among themselves with the object of terminating the competition existing in this industry. Among the concerns entering into this compact are the General Electric, Westinghouse Electric and Manufacturing Company, Bryan-Marsh Company, Columbia Incandescent Lamp Company, New York and Ohio Company, and the Perkins, Beacon and Bernstein Companies.

## CORRESPONDENCE.

### NEGATIVE RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The closing paragraph of my last letter to you on this subject, in which I queried the value of further discussion until the experiments of Messrs. Frith and Rodgers should have been published, has not deterred Prof. FitzGerald from plunging still further into the bog. Does he seriously suggest that in Messrs. Frith and Rodgers's Paper there was any hint that the current flowed in a direction not parallel to the electromotive force? If so, where did the component at right angles to the conductor flow to? It is very unnecessary of him to suggest (for my information) that if two vectors are not parallel, their ratio is not simply a scalar quantity. Familiar as this fact has been to me for 29 years, I fail to see what it has to do with the Frith and Rodgers experiment. Nor does the circumstance that the legal definition of the ohm does not explicitly state that it is a positive scalar quantity affect the question. The definition, for example, of the Clark Standard Cell does not say that it has a positive mass. But he who were to argue that therefore the definition includes cells having negative mass would be as illogical as Prof. FitzGerald when he argues that the legal definition of the unit of resistance includes a possible negative and vectorial case. This is definition-stretching with a vengeance; and definition-stretching in exactly one of those cases where the complexity and obscurity of the phenomenon ought to make us all the more wary of departing a hair's breadth from the sound practice of using terms that have once been established, accurately in that sense in which they have been defined, and in no other. Want of precision in use of definitions is the very bane of exact science.—Yours, &c.,

Wolfach, August 10, 1896. SILVANUS P. THOMPSON.

**Telephone Charges in Switzerland.**—Since January 1st last a new and reduced telephone tariff has been in force in Switzerland, and from reports to hand it appears to have worked satisfactorily all round. The former charge per annum for a telephone, with an annual limit of 800 conversations, was 80 francs (£3. 4s.). The new tariff now in force is 40 francs (£1. 12s.) per annum, plus an additional charge of 5 centimes for each local connection. The charges for interurban connections, with a time limit of three minutes, are as follows:—Up to a distance of 31 miles, 3d.; up to 62 miles, 5d.; and above 62 miles, 7½d. The telephone system throughout Switzerland is owned by the Government, and the service is first-class in every respect.

## NOTES ON THE INTRODUCTION AND DEVELOPMENT OF ROPE DRIVING.*

BY ABRAM COMBE.

*Introduction of Rope Driving.*—So much has been said and written on the advantages and application of rope driving, and so many data and formulæ have been published from time to time, that it is hardly necessary to add to the information already available in these respects; but as rope driving emanated from Belfast, and has now grown to such large proportions in the industrial transmission of mechanical power, a short history of its origin, introduction, and development, may prove of interest on the present occasion. Its introduction is due to the late Mr. James Combe, who in 1856 applied an expanding pulley with V-shaped sides to the differential motion of flax and tow-roving frames. The expanding pulley was driven by a round leather rope from a driving pulley grooved with a V-shaped groove. In the course of his experiments in perfecting this motion, he was struck by the large amount of power obtained from round ropes working in V-shaped grooves; and this led him to try their application to the transmission of larger powers. With a view of arriving at the most effective angle for the grooves, a series of experiments were made in the Falls Foundry works in the following manner. A pulley, fixed from revolving, was made with a number of grooves, each having its sides sloping at a slightly different angle from the others; ropes were then laid over these grooves with weights hanging from them at one end and counterbalance weights at the other; and the effect produced on the biting power of the rope in the groove by increasing and diminishing the weights and the counterbalance weights was carefully noted. The object was to determine in a practical manner the most suitable angle of groove for a driving rope, so that the rope should neither slip nor yet bite too much into the groove; and the angle chosen after the above simple experiments, namely 45deg., was adopted in the first pulleys set to work, and is at present generally used for rope driving under ordinary conditions.

After several years' use of grooved pulleys and ropes for driving from the main shaft of one of the workshops at the Falls Foundry to that of another, the advantages of rope driving under certain conditions were found to be so great that, on the occasion of replacing one of the main engines in the beginning of 1863, rope driving was adopted for transmitting the entire power of the engine, amounting to over 200 H.P., from the second motion shaft to the principal shaft. This is the first instance of rope driving being used for a main drive of such importance, and the original pulleys are still in existence and working daily.

*Material of Ropes.*—About that date round ropes made of leather strips were generally used. These, however, were found to have the objection that they were liable to untwist, and the ends of the leather strips were apt to fly out during the working and cause trouble. Moreover, the strips of leather being cut out of the hide in a spiral were less strong where cut from the smaller diameters, and were liable to break at those parts. Manila ropes were then tried with good results, and leather ropes gradually gave place to ropes made from manila.

*Relative Diameters of Ropes and Pulleys.*—It was early recognised by the late Mr. James Combe that it is necessary to proportion properly the diameter of the ropes to the diameter of the pulleys on which they work; and he adopted the following minimum diameters of pulleys for the various sizes of ropes:—

1¼in. diameter rope, 3ft. diameter pulley; ratio 1 to 28·8.
1½in. diameter rope, 4ft. diameter pulley; ratio 1 to 32·0.
1¾in. diameter rope, 5ft. diameter pulley; ratio 1 to 34·3.
2in. diameter rope, 6ft. diameter pulley; ratio 1 to 36·0.

Experience has shown that the results have not been so satisfactory when ropes of above sizes have been used on pulleys smaller than the above minimum diameters.

*Power Transmitted.*—When working under ordinary conditions, the following simple bases were taken from which to calculate the power that each of the foregoing sizes of rope would transmit for each 100 revolutions per minute made by the pulley upon which it is working:—

Rope 1¼in. diameter on a 3ft. pulley, 5 I.H.P.;
Rope 1½in. diameter on a 4ft. pulley, 8 I.H.P.;
Rope 1¾in. diameter on a 5ft. pulley, 11 I.H.P.;
Rope 2in. diameter on a 6ft. pulley, 15 I.H.P.;

and for other sizes of pulleys the power transmitted is calculated to be increased in direct proportion to the diameters of the pulleys. When working under the most advantageous conditions—for instance, where the ropes are running horizontally at good speeds, with the pulleys at a proper distance apart, and with the bottom rope acting as the driver—the above bases may be increased by 20 to 25 per cent. with safety. On the other hand, when the ropes are working under unfavourable conditions, with centres of pulleys too close together or ropes running vertically, these bases must be

* Abstract of a Paper read before the Institution of Mechanical Engineers.

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diminished by 20 to 25 per cent. The exact amount of increase or decrease on these standard bases has to be determined in each individual instance, according to the circumstances under which the ropes are working.

*Speed of Ropes.*—The speed originally adopted as being the most advantageous was about 3,300ft. per minute. This speed has since been far exceeded in many instances; but it is a question whether advantages have been reaped proportionate to the power gained by the increased speeds. On the contrary, the gain of power by increased speed is largely counteracted by loss of power from atmospheric friction and from centrifugal action; and when this loss is taken into account, along with the increased wear and tear on the ropes and bearings, the speed originally adopted, and speeds within certain limits of it, have been found to give the best results.

*Cotton Ropes.*—Later on in certain districts, especially those in which the cotton industry prevailed, cotton ropes began to be used. These have the advantage of being rather more pliable than manila ropes, especially when the latter are new. The relative merits of ropes made of manila and those made of cotton have frequently been discussed; but experience has shown that, if the pulleys are properly designed and applied, and if the ropes are the proper diameter, good results are obtained, whether the ropes are made of manila or of cotton.

*Endless Rope for Close Shafts.*—In 1878 grooved pulleys and rope driving were introduced to replace pairs of large geared wheels, which from one cause or another were giving trouble; for example, in places where they were used to combine the power from a steam engine with that from a water wheel, or to combine the power from two engines working under slightly different circumstances. Here the centres of the wheels were so close together that ropes, if applied separately in the ordinary way, would have been too short for effective driving, and there would have been difficulty in putting equal tension upon each of the several ropes. Consequently, in order to secure a proper length of rope and equal tension, a single continuous rope was used, which was laced round and round the pair of pulleys, passing from the first groove of the driving pulley to the first of the driven, thence back to the second groove of the driving pulley, and on again to the second of the driven, and so on; and a tension pulley was added for leading the rope back from the last groove into the first.

*Rope Fly-Wheels.*—The continued rapid extension of rope driving, and more especially of driving direct from the fly-wheel of the engine to the various shafts, led to designing fly-wheels to suit the high speeds. A rope fly-wheel was designed by Mr. James Barbour in 1879 to meet the special requirements. The peculiar advantage of this method of constructing fly-wheels is that, instead of depending solely on a cast-iron arm for connecting each segment to the nave, a strong wrought-iron bolt is used, which passes down through the middle of the tubular cast-iron arm, and connects each segment directly with the nave; consequently, this bolt not only receives the tensile strain caused by centrifugal force while the wheel is in motion; but it also withstands the driving home of the cotters when the wheel is being put together. When cast-iron alone is used for the arms, the driving home of cotters is a frequent source of breakage, which may not be detected until the fly-wheel gives way; whereas by driving the cotters into a long malleable-iron bolt there is less danger of fracture. The starting worm or barring engine is made with three pauls for barring round, in order that the motion may be continuous, instead of intermittent, as it is when only one or two pauls are used.

*Substitution of Rope Driving for Geared Wheels, and Relative Amount of Power Absorbed.*—In many instances existing gearing and upright shafts have been thrown out and replaced by rope driving; and where the rope driving has been properly designed and erected, the total power required for the rope driving has in none of the installations which have come under the writer's observation exceeded that which was required when driving by wheel gearing; and in many cases the power required to drive the same amount of work by ropes has been less than it was before the change in method of driving took place.

The above examples of the transmission of mechanical power by ropes serve to illustrate the development of this method of driving. Numerous variations have, of course, been made upon each of these plans, which have largely extended the field for the application of rope driving; so that this method of driving, which arose from such a small origin, is now widely adopted for industrial purposes. There is also no doubt that other developments will take place in the future, which will further extend its sphere of usefulness.

**New Glow Lamps for Old.**—At the recent Hamburg meeting of the Association of Representatives of German Electric Supply Stations it was stated that the gratuitous replacement of glow lamps by electric supply undertakings, as recommended by the Association in their report on the glow-lamp question in Germany (see *The Electrician*, January 3, 1896, p. 308), has been introduced in several towns, and has given every satisfaction.

# LEGAL INTELLIGENCE.

## Clark v. Julius Sax and Co. (Limited).

This case, which was brought in connection with a claim for all rights in a registered design for an electric lamp, was heard by Mr. Justice North last week, on a motion on behalf of the plaintiff that all further proceedings might be stayed, and the defendants ordered to pay the costs of the action. The plaintiff claimed to be the registered proprietor of the design, which was used by the defendants in the Central Meat Market, London. In February last the plaintiff moved for an interim injunction to restrain the defendants from infringing his registered copyright in the design, and at the same time the defendants moved to take the plaintiff's mark off the register. Both motions were dismissed, it being held that the design was a good registration, but that there was no infringement. The defendants then proceeded to construct a lamp which was almost identical with the plaintiff's registered design; and in March his Lordship granted an injunction until trial, restraining the defendants from infringing the registered design in respect of the new infringement. In April there was judgment in the Queen's Bench Division in an action between the same parties. There was an agreement between the parties under which the defendants were to take all their lamps for the electric lighting of the Meat Market from the plaintiff, who bound himself to sell to the defendants all the lamps required for the purpose. The plaintiff complained that the defendants obtained lamps elsewhere, and sued them for damages. In that action Mr. Justice Mathew gave judgment for the plaintiff for £142 damages, and the defendants undertook not to put up in the Market any electric lamps not supplied by the plaintiff. In May the Court of Appeal, on appeal from his Lordship's order as to the registration, directed the registration to be expunged; but it was contended that this did not affect the Queen's Bench action, because, whether the plaintiff's registration was good or bad, the agreement between the parties still stood. On June 29th the defendants issued a summons that an inquiry might be directed as to what damages they had sustained, and which the plaintiff ought to pay, by reason of the order made in March, and that, except so far as might be necessary for the purpose of the inquiry, this action might be dismissed with costs, for want of prosecution. In the result the Chief Clerk adjourned the summons into court to come on with the defendant's motion to stay proceedings. Counsel submitted that this was not a case in which there ought to be an inquiry as to damages, and that the defendants should pay the costs.

For the defendants it was contended that it was a matter of course for the Court to direct an inquiry, because the defendants had been caused expense by having to pull down the lamps, the plaintiff, of course, being safeguarded by the costs of the inquiry being reserved. As regarded the costs of the action, he submitted that as the defendants' summons to dismiss the action for want of prosecution was before the plaintiff's motion the defendants were entitled to their costs.

His Lordship ultimately made an order on both motions staying proceedings in the action, and gave no costs to either side.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

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"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the atest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied. price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application,

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. s also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issu of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

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TENDERS INVITED.—The Electric Lighting Committee of the Bath Corporation invites tenders for (*a*) boiler-house plant—boiler and fittings, feed pump, &c.; (*b*) engine-house plant—steam alternators, oil filter, fittings, &c., steam, exhaust, feed, blow-off and sundry pipes, valves, &c.; (*c*) mains; (*d*) crane; and (*e*) arc lamps and posts. Tenders must be sent in to the Clerk (Mr. F. H. Moger), 3, Wood-street, Bath, on or before Monday, the 31st inst.

——— The St. Pancras Vestry invites tenders for supplying and erecting 80 arc-lamp columns. Tenders should be sent to the Vestry Clerk (Mr. C. H. F. Barrett), Vestry Hall, Pancras-road, London, N.W., by the 24th inst.

——— The Oldham Electric Light Committee invites tenders for an electrically-driven feed pump, capable of delivering 2,000 gallons of water per hour against 125lbs. steam pressure. Specifications, &c., may be obtained from Mr. Arthur Andrew, Gas and Water Offices, Oldham, to whom tenders should be sent by Tuesday, the 18th inst.

——— The Dundee Gas Commissioners invite tenders for the supply of india-rubber covered electric light cables. Tenders to Mr. Thos. Thornton, Clerk to the Commissioners, City Chambers, Dundee, by the 19th inst.

——— The Radcliffe District Council requires tenders for the supply and erection of a gas engine and dynamo, and for wiring and fitting up the Technical School for the electric light. Tenders to the Clerk (Mr. J. Sharples) by the 17th inst.

——— Tenders are invited for wiring the Dewsbury and District Technical School. Tenders to the Secretary (Mr. P. F. Lee) by the 22nd inst.

——— The Spanish Government is inviting tenders for the construction and working of a telephone system in Mayagüez, in Porto Rico. Some particulars may be seen at the Commercial Department of the Foreign Office between 11 and 6 daily. Tenders should be sent in to the Minister of Public Works, Madrid, by October 8th.

——— The Telegraph Department of the South African Republic requires tenders for the supply of 7,000 kilogrammes hard-drawn copper wire of 2mm. diameter. Tenders to the Consul-General of the Republic, Doelenstraat, Amsterdam, by the 15th inst.

——— The Municipal Committee of Lahore invites tenders for the electric lighting of the principal streets and thoroughfares of the city, as well as the public buildings, for a number of years. Further information from the Secretary, Lahore Municipality. The successful tenderer will be privileged to supply electric current for private light and power purposes within the area of the municipality. Tenders by September 15th.

——— The Dutch Minister of the Colonies invites tenders for the supply of a quantity of iron telegraph posts, galvanised iron wire, and insulator supports, &c. Tenders to the Minister, at The Hague, Holland, by the 25th inst.

ALTERNATORS REQUIRED.—An electricity supply company desiring to increase its plant requires offers for the supply of alternators. Communications should be addressed to the consulting engineer, Mr. Robert Hammond, Ormond House, Great Trinity-lane, London, E.C. Additional information is given in our advertisement columns.

TENDERS ACCEPTED.—The tender of Messrs. Wm. Coates and Sons has been accepted by the Belfast Corporation for the installation of the electric light at the gas works.

——— The tender of Messrs. Lowdon Bros., of Dundee, has been accepted by the Perth School Board for installing the electric light at the Academy for £448.

——— The Walsall Town Council has accepted the tender of Messrs. Babcock and Wilcox (Limited) for the supply of a water-tube boiler at the electricity works for £486. 10s.

——— The tender of Messrs. A. Broxup and Son has been accepted by the Wakefield City Council for the construction of foundations and the erection of a chimney shaft at Calder Vale for the electric lighting and sewage works. The amount of the contract is £2,743.

——— The Health Committee of the Wallasey District Council has accepted the tender of Messrs. Lachlan and Bathkin, of Birkenhead, for supplying a dynamo, and for wiring and fitting up the refuse destructor works for the electric light, at £145. The Committee has also accepted the tender of Messrs. Manlove, Alliott and Co. for adding six new cells to the refuse destructor, at £3,835, and for extensions to the refuse-destructor works, at £1,160. 10s.

——— The Hampstead Vestry has accepted the tender of the We Soften Water Syndicate for water-softening apparatus in connection with the new boilers at the electricity station, at a cost of £221. 10s. 6d.

APPOINTMENTS.—Mr. S. J. Watson has been appointed resident engineer at the Bury (Lancs.) electricity works, at a salary of £200 per annum.

——— Mr. E. G. Okell has been appointed draughtsman and assistant electrical engineer by the Plymouth Town Council, at a commencing salary of £150 per annum.

APPOINTMENTS VACANT.—The Wallasey Urban District Council invites applications for the appointment of assistant electrical engineer. Salary £150 per annum. Applications, addressed to the Chairman of the Gas and Water Committee, should be sent to the Clerk to the Council (Mr. W. Danger), Public Offices, Egremont, Cheshire, by Thursday, the 20th inst. Further particulars appear in our advertisement columns.

——— There is a vacancy for an assistant at the City and Guilds Central Technical College. Commencing salary £150 per annum. Applications to Prof. Ayrton, Central Technical College, Exhibition-road, S.W. Additional particulars appear in our advertisement columns.

——— The Dundee Gas Commissioners require a switchboard attendant. Salary 35s. per week. Applications should be sent to Mr. Walter H. Tittensor, City Electrical Engineer, by Friday, the 21st inst. Our advertisement columns contain additional particulars.

——— The National Electric Supply Company, of Preston, require an assistant engineer. Salary £120 per annum.

——— A clerk of works is required by the Leeds Corporation for the construction of the electric tramway from Roundhay to Kirkstall. Applications to the Town Clerk (Mr. Jno. Harrison), Town Hall, Leeds, by the 22nd inst.

——— A Lecturer in Physics, Applied Mechanics and Steam is required for the Technical School, Huddersfield. Salary £200. Applications to the Principal, Dr. S. G. Rawson, by the 29th inst.

——— The appointment of Demonstrator in the Chemical Department of Mason College, Birmingham, is vacant. Applications to the Secretary.

——— Applications are invited for a Demonstrator in Chemistry at the Yorkshire College, Leeds. Salary £100. Particulars from the Registrar.

PLANT FOR SALE.—Our advertisement columns contain particulars of the sale by public auction on Thursday, the 20th inst., at Cadby Hall, Hammersmith-road, London, W., of a quantity of electric lighting plant, motors, dynamos, &c. Catalogues may be had at the place of sale, and of the auctioneers, Messrs. Horne, Son and Eversfield, 17, Great George-street, S.W., and 85, Gresham-street, E.C.

——— Particulars are given in our advertisement columns of some electric lighting plant, consisting of a Norwich D-type dynamo, meters, switch, belting, &c., which Messrs. Lewis P. Garrett and Co., 58, Broomielaw, Glasgow, have for sale.

DISSOLUTION OF PARTNERSHIP.—Messrs. Arthur Edwin Slade Templeton and William Heath Merriman, hitherto carrying on business as telegraph construction engineers, under the style of Slade Templeton and Co., at 15, New Broad-street, London, E.C., and as mechanical engineers and dealers in engineers' tools, under the style of Schischkar and Co., at 67, Stafford-street, Birmingham, have dissolved partnership as from the 24th July. Mr. Slade Templeton continues the business at 15, New Broad-street, E.C., for his own use and benefit; and Mr. Merriman at 67, Stafford-street, Birmingham, continues the business of Schischkar and Co., also for his own use and benefit.



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DISSOLUTION OF PARTNERSHIP.—The partnership business of electric bell manufacturers, carried on under the style of M. Feetham and Co., at 9, Clifford-street, and 17, Soho-square, London, W., has been dissolved. Debts by Messrs. W. F., M. J. and J. F. Sayer, who continue the business.

PERSONAL.—We are informed that Mr. Bennett Pell and Mr. James Brockie have ceased to be members of the staff of Messrs. Johnson and Phillips.

LIQUIDATIONS.—It has been decided to wind up the Val d'Aosta Electric Power Company (Limited) voluntarily.

——— In consequence of the purchase by the Canadian Syndicate of the undertaking of the Birmingham Central Tramways Company, it has been decided to wind up the Company voluntarily; and Mr. Howard S. Smith, C.A., Birmingham, has been appointed liquidator.

"JANDUS" ARC LAMP.—Messrs. Drake and Gorham inform us that a 2-ampere "Jandus" arc lamp has been designed, and will shortly be placed upon the market. The lamp, which is only 2ft. high, burns direct on the 100-volt circuit, and the carbons are stated to last about 100 hours. The new design will prove especially suitable for small shop windows, large halls, and other places where the ordinary-sized arc lamp would be impracticable. Already a large number of orders for the lamp have been received.

FOWLER-WARING CABLES COMPANY.—We are informed that the National Telephone Company has just placed a contract for dry core telephone cables to the value of nearly £100,000 with this Company. The factory at North Woolwich has recently been equipped with a most complete plant for the manufacture of rubber and allied substances, and for the insulation of rubber-covered wires and cables. These, together with every description of mechanical rubber goods, will now be added to the manufactures of the Company. Mr. Alfred E. Mavor, who has been General Manager since the formation of the Company, becomes Technical Director, and Mr. J. A. Blackwood has been appointed Secretary in place of Mr. B. J. Diplock, who has resigned that position.

LONDON ELECTRIC WIRE COMPANY.—We are informed by the Secretary of this Company that the "collapse," which was recently reported to have taken place at the Company's premises has been much exaggerated, and that it is by no means of such a serious character as represented. Through a small portion of the flooring giving way in one of the rooms of the Company's warehouse, a boy was precipitated into the room below, and had a leg broken. The Company's business has been in no way interfered with, and the lad has well-nigh recovered.

A NEW BELL-PUSH.—Mr. J. W. Creasey, of Kingston, has brought out a new indicator bell-push. Above the push-button a disc is visible, which is acted upon through the medium of a small coil worked by the same current that rings the bell, the indicator oscillating if the proper intermittent current is passing through the circuit, and remaining stationary if not. This idea is likely to have many useful applications, though, of course, it is desirable to so proportion the sensitiveness of the indicator that it will not be moved by a current of less strength than is required to properly ring the bell itself, otherwise the indicator may exhibit the most lively oscillatory movements, the bell at the far end may be remaining, for all practical purposes, completely stationary.

INCANDESCENT LAMP CATALOGUE.—Sections 1 and 2 of the new Ediswan catalogue are now ready, and deal very fully with incandescent lamps. As might be expected, the illustrations form a conspicuous feature of the catalogue, and afford every assistance to intending purchasers in making their selections of the various types and sizes of lamps manufactured by the Edison and Swan Company. The difficulty of compiling a catalogue of this character is shown by the number of corrections already necessary, commencing with the cover. It would be advisable for those consulting the catalogue to take particular notice of this list of corrections, which is attached to the title page, as the list deals with prices, voltages, and other important matters. A useful index and foredge reference notes are given, and the textual matter introducing tabulated and illustrated particulars is very full, and affords the trade more than usual assistance in executing orders for special types of lamps.

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AYR.—The Town Council has decided to extend the electric light mains from Seafields to the South Lodge, provided Mr. Coats, of Belleisle House, guarantees to take current for five years, with a minimum consumption equal to £100 per annum.——The contract for the installation of the electric light at Wellington Chambers, Ayr, has been entrusted to the Tayler Smith Electric Company, 53, South Molton-street, London, W.

BATH.—A special meeting of the City of Bath Electric Lighting and Engineering Company (Limited) was held on Friday for the purpose of considering the terms of the proposed agreement for the purchase of the electricity works by the Corporation. After discussion the contract was approved and signed. The actual transfer will take place as soon as the Local Government Board has sanctioned the borrowing of the purchase-money.

BLACKBURN.—The Town Council has decided to apply to the Local Government Board for sanction to borrow an additional sum of £15,000 for electric lighting purposes.

BRADFORD.—On the recommendation of the Electricity Sub-Committee the Town Council has decided to reduce the price of current for electric motors from 3½d. to 2½d. per unit, the reduction to come into operation on January 1st, 1897. The demand for current continues to increase in a most satisfactory manner; but local manufacturers do not seem to realise the many advantages of electricity as a motive power. The Committee is naturally anxious to create a day-load, and it is hoped that the present reduction will stimulate the demand for current for power purposes. The Council has decided to lay two additional cables, one in Horton-lane and one in Harris-street and Barkerend-road. A number of applications for current has been received from the East Parade district, including one for 500 lights from the Roman Catholic Church.

CALCUTTA.—It is stated that Messrs. Kilburn and Co. have applied to the Local Government for sanction to establish an electricity supply station in Calcutta. It is proposed to introduce electric traction on the local tramways, and an arrangement has been arrived at under which Messrs. Kilburn and Co. undertake to supply the necessary current. The low-tension continuous-current system will be employed.

CHURCH LIGHTING.—St. Matthew's Parish Church, Walsall, has been fitted up for the electric light. There are 69 16 c.p. lamps in the body of the church, 14 of 25 c.p. in the chancel, and 10 of 32 c.p. in the north and south galleries, while the west gallery is illuminated by means of six 16 c.p. lamps. In addition there are 14 lamps of 16 c.p. in the pulpit, staircases, porches, &c. The installation has been carried out by a local firm, Messrs. Bayley Bros.——It is intended to introduce the electric light into St. Anne's Church, Soho-square, London.

CREDITON.—As the Local Gas Company refuses to come to terms with the District Council, or to supply gas except by meter, the Lighting Committee has been instructed to obtain estimates for lighting the town by electricity.

DARWEN.—The Town Council has decided to engage Mr. E. M. Lacey, A.M.I.C.E., for the purpose of preparing a report upon the cost of establishing electricity supply works, probable income, &c.

DEVIZES.—The District Council has resolved to appoint an Electric Lighting Committee.

DUNDEE.—The electrity rental for the three months ended July amounted to £686, 8s. 5d., an increase of £278 on the previous year. The electricity department seems to be making good progress, as at the present time there are over 270 customers, representing an equivalent of about 17,000 8 c.p. incandescents, connected. The use of arc lamps for lighting the windows and fronts of shops has developed to an abnormal degree in Dundee, shopkeepers regarding this means of illumination with great favour.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from August 6th to August 11th, with the ports of destination:—

*Argentina*—Buenos Ayres, £494. *Australasia*—Adelaide, £43; Melbourne, £20; Sydney, £660. *Belgium*—Brussels, £84. *Brazil*—Para, £8,520 (telegraph cable); *British Burma*—Rangoon, £33. *Canada*—Quebec, £56. *Ceylon*—Colombo, £195. *China*—Shanghai, £32. *Egypt*—Alexandria, £79. *Holland*—Amsterdam, £285; Flushing, £20. *India*—Calcutta, £57 (including £14 telephone stores); Madras, £18 (telephone stores). *Japan*—Yokohama, £3,608 (including £3,545 submarine cable). *Malta*, £50. *Siam*—Bangkok, £24. *South Africa*—Cape Town, £117; Delagoa Bay, £21; Durban, £259; East London, £1,281; Laurenco Marques £25 (telegraph apparatus); Port Elizabeth, £19. *Straits Settlements*—Singapore, £34. *Sweden*—Gothenburg, £276 (telegraph cable, &c.); Stockholm, £144. *United States*—New York, £1,000. Total, £18,454.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows:—

*Australasia*—Sydney, £145. *Italy*—Venice, £80. Total, £225.

FORT WILLIAM (N.B.).—The electricity supply station of the Fort William Electric Light Company (Limited) was formally opened last week. Power is obtained from the river Kiachnisch, which falls into Loch Linnhe, about three miles below Fort William. At the power house there are two 60 H.P. vortex turbines, which drive two dynamos by Messrs. Laurence, Scott and Co. The accumulator house at Fort William is supplied with a battery of 164 E.P.S. cells (central-station type), with the requisite distributing switchboard. The charge for current is to be 9d. per unit from an hour before sunset till nine o'clock in the evening, and for the remainder of the 24 hours 4½d. per unit. The town is lighted by four 1,000 c.p. arcs and 60

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16 c.p. incandescents, the total cost for lighting the streets being £180 per annum. Already there is a fair demand for current, several of the principal shops and hotels, churches and other public buildings, and a number of private houses having been connected. The chief engineer for the work was Mr. R. F. Yorke, Messrs. H. W. Bagot and A. C. Dormer acting as assistants.

GLASGOW.—A curious condition of affairs has arisen in connection with the Council's electric traction scheme. In our issue of the 31st ult. we gave an abstract of the Tramways Committee's report, which recommended that the Springburn-Mitchell-street route be equipped electrically on the overhead trolley system. This report was duly discussed by the City Council and referred back for further consideration At the meeting of the Committee on Wednesday, Councillor Colquhoun moved that a sub-committee be appointed to collect additional information for the purpose of preparing a fresh report. This led to a long and acrimonious debate, and on a division seven voted for and seven against the motion. The Chairman, Councillor Walter Paton, declined to give a casting vote, and left the matter in the hands of the Council.—— The Town Council has decided to light St. Andrew's Halls electrically, at a cost of £1,647.

GREAT YARMOUTH.—A memorial has been received by the Electric Light Committee from the clergymen of seven places of worship for a reduction in the price of current to their buildings. The consideration of the matter has been postponed until the electricity department is in a position to pay its way. Requests for current continue to come in in a fairly satisfactory manner. There are at present 655 customers, representing an equivalent of 9,020 8 c.p. lamps, connected. The income for the past month amounted to £150. 6s. 8d., while the cost of production was £136. 9s. 11d.

HAMPSTEAD (LONDON).—The Vestry has sanctioned the laying of electric light mains in certain additional streets, at a cost of about £400. A deputation from the ratepayers in the High-road, Kilburn, has presented a memorial asking the Vestry to consider the question of lighting that road by means of arc lamps.

HANDSWORTH.—The District Council has decided, on the recommendation of Mr. J. C. Vaudrey, to introduce the electric light at the Council House, Public Library and new Technical School. Consent has been given to the purchase of the undertaking of the Birmingham Central Tramways Company by the Canadian Syndicate.

HULL.—The insurance company with whom the Corporation effect the insurance of their electricity supply works has decided to increase the insurance premium on the works from 2s. to 10s. 6d. per cent. The Electric Lighting Committee naturally resent this great increase in the rates, and the question of considering the desirability of the Corporation itself undertaking the insurance of the whole of the property of the Corporation has been referred to the Audit Sub-Committee.

KILLARNEY.—The contract with the Local Gas Company expires on September 30th next, and the Town Commissioners have decided to advertise for tenders for lighting the streets during the coming year. This is a town where a foretaste of the pleasures of electric lighting has been experienced, the district having been lighted electrically for a few months, and it is to be hoped that the Electric Lighting Company will on this occasion succeed in obtaining the contract.

LAMBETH (LONDON).—The Vestry has at last approved the terms of the agreement for the transfer of the Provisional Order to Mr. C. W. Sax.

LEAMINGTON.—The Midland Electric Lighting Company recently submitted an estimate for lighting the Parade by means of arc lamps. The Watching and Lighting Committee has decided to postpone the consideration of the matter pending inquiries as to the cost of "improved" gas lighting.

LIGHT RAILWAYS.—At a meeting of the Light Railways Association last week Sir Albert Rollit, M.P., who presided, called attention to the success of the Association's labours to interest and engage public opinion respecting the Light Railways Bill, which has now practically passed through Parliament. Sir Albert expressed the view that the Bill would prove a great assistance to trade, and that light railway and motor-car communication, which would eventually be created between rural districts, would help to materially improve the prospects of agriculture and trade generally.

MORECAMBE.—The District Council has decided to apply to the Board of Trade for consent to the purchase by the Council of the powers and undertaking of the Morecambe Electric Light and Power Company (Limited), in accordance with the terms of the agreement of February last.

NEWFOUNDLAND.—*The Times* of the 8th states that the Governor has reserved for the consideration of the Crown the Bill for the construction of an electric tramway at St. John's. It is thought that this step has been taken in deference to a protest from the receiver of the Newfoundland Railway, to the effect that the proposed tramway would seriously affect the chartered rights of the railway.

NEWPORT.—The accounts of the Electricity Department for the year ended March 25th last have just been published. After paying working expenses there was a balance of £180 left for sinking fund purposes and payment of interest. The accounts were discussed and approved at the last meeting of the Town Council, several members expressing themselves as highly pleased with the progress made during the year.

SHEFFIELD.—The Cutlers' Hall is to be wired for the electric light. Current will be taken from the mains of the Sheffield Electric Light and Power Company.——The Tramways Committee has prepared a scheme for considerable extensions to the municipal tramways. The Committee recommends the City Council to promote a Bill in the next Session of Parliament for power for the construction of the suggested extensions, and for the employment of electric traction throughout the entire system. A deputation has been appointed to visit various continental cities and towns for the purpose of acquiring further information as to the most suitable system of traction to be employed.

ST. JAMES'S (LONDON).—An agreement has been arrived at between the Vestry and the St. James's and Pall Mall Electric Light Company whereby the latter undertake to supply electric current to about 60 arc lamps for lighting some of the principal streets in the Vestry's district for seven years, at £30 per lamp per annum.

ST. PANCRAS (LONDON).—The Vestry has decided to light the Chalk Farm, Kentish Town, St. Pancras and Gray's Inn-roads, and Great College-street, by means of arc lamps. It is also contemplated to erect arc lamps along the Crowndale-road, Highgate. The demand for the supply of current to private customers is increasing in a most gratifying manner.

SUNDERLAND.—The Highways Committee received 35 applications for the position of borough electrical engineer. This number was reduced to six, viz, Messrs. Gilbert Bell (assistant at Manchester), John Christie (electrical engineer at Londonderry), E. W. Dean (London Electric Supply Corporation), N. Applebee (electrical engineer at Cardiff), J. F. C. Snell (resident engineer at the King's-road station of the St. Pancras Vestry), and A. K. Greener (the present assistant at Sunderland). On Wednesday the Committee finally decided to recommend the appointment of Mr. Snell to the vacant position. The engagement to be for four years certain, with option to the Corporation to determine it by three months' notice at the end of the first year. The salary is £300 for the first year, £350 for the second, and £400 per annum for the third and fourth years.——The Sunderland Tramway Company are considering the advisability of adopting electric traction throughout their system, and Mr. Reginald P. Wilson, of 3, Princes-mansions, is preparing a report on the subject.——At the meeting of the Town Council on Wednesday Alderman Bruce moved that the Special Tramways Committee be empowered to consider the question of purchasing the tram lines of the local company, with the view to substituting mechanical traction for the present system of horse traction, and to extending and otherwise improving the present lines. Alderman Bruce said the Council and the ratepayers were dissatisfied with the existing arrangements, and he advocated better accommodation, cheaper fares, &c. The Council was counted out before a decision was arrived at.

THE JAPAN RELIEF FUND.—The fund which was recently started at the Mansion House for the relief of the sufferers by the earthquake and tidal wave in Japan now amounts to nearly £4,000. The Eastern Extension Telegraph Company and the associated lines, in addition to subscribing liberally to the fund, have offered to send all telegrams between the Relief Committees in Japan and England on the subject of the fund free of cost.

TONBRIDGE.—Mr. Rice has induced the District Council to appoint a special committee to consider the electric light question. In the event of the Council deciding not to take the matter up an effort will be made to form a company for the purpose of establishing an electricity supply station.

TRAIN LIGHTING.—The Directors of the Highland Railway Company are making experiments as to the suitability of the electric light for train lighting. The carriages on the through trains between Perth and the North are at the outset to be fitted up.

## BOOKS RECEIVED.

*Record of the Transactions of the Institution of Junior Engineers.* Vol. V., 1894-5. Edited by W. T. Dunn. (Published by the Institution.)

"Fortschritte der Elektrotechnik." By Dr. Karl Kohle. (Berlin: Julius Springer.)

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# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 3, 1896.

14,766. E. WORRINGEN, of the Constantia Incandescent Lamp Manufactory. London. Improvements in or relating to sockets or holders for incandescent electric lamps, and the attachment of lamps thereto.

July 4, 1896.

14,846. SIEMENS BROS. AND CO. (LIMITED) and Dr. E OBACH. London. Improvements in conducting contacts with carbon or other non-metallic electrodes.*

14,848. A. APPS. London. Improvements in or connected with electric induction coils and transformers.

14,872. S. BERDITSCHEWSKY-APOSTOLOFF. London. Improveme ts in bottle-sealing devices.

14,876. C. THURON. London. System of single wire electric transmission based on a method of emitting inverse currents giving absolute control and safety.

July 6, 1896.

14,946. W. S. SMITH and W. P. GRANVILLE. London. Improvements in insulating electric conductors.

July 7, 1896.

14,993. F. JONES. London. The external walls telephonic connection.

15,013. T. MCKENNA. London. Improvements in electrical selectors and answer-backs. (J. M. Drysdale, United States.)*

15,031. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED). London. Improvements in dynamo-electric machines and in methods of compounding the same. (C. P. Steinmetz, United States.)*

15,074. J. HENCKEN and J. H. MEYER. London. Improvements in or relating to electrically ignited torches, cigar lighters, or the like.*

15,078. A. M. BILLINGTON. London. Method of and means for recording in connection with electricity supply.

July 8, 1896.

15,102. F. H. ROYCE and E. A. CLAREMONT. Manchester. Improvements n the method of winding armatures for multipolar continuous-current dynamo electric machines and electro motors.*

15,129. F. W. GOLBY, London. A process and apparatus for effecting electrolysis. (O. Arldt, Germany.)*

15,162. SIEMENS BROS. AND CO. (LIMITED). London. Improvements in electric meters. (Siemens and Halske, Germany.)

15,176. J. G. JOHNSON. London. Improvements in or connected with dynamo-electric machines for use in what is known as the three-wire system. (The Electricitäts Actien-Gesellschaft vormals W. Lahmeyer and Co., Germany.)

July 9, 1896.

15,223. H. F. KIRKPATRICK-PICARD. London. Improvements in or relating to the production of electricity.

July 10, 1896.

15,292. A. T. SCHMIDT and F. T. SCHMIDT. Birmingham. Improvements in arc lamps.

15,303. J. L. KENDAL. Manchester. Improvements in the method of and means for protecting electric lamp fittings from damp and corrosion and for preventing short circuiting.

15,318. M. BYNG and L. D. COLE. London. Improvements in apparatus for the ignition of hydrocarbon and other gases by electricity.

15,321. W. BOOTH. London. Automatic switch for sending the current always in the same direction through the whole or some part of the circuit independent of the current in the mains.

15,332. W. BOOTH. London. Converter for changing alternating current into continuous to be used in connection with transformers.

15,326. R. E. B. CROMPTON and E. J. FOX. London. Improvements in insulating and supporting electric wires intended to act as electrical resistances applicable as radiators of heat for cooking, warming, and other purposes.

July 11, 1896.

15,380. S. SCARGILL and A. HANSON. Bradford. Improvements in the means of connecting branch electric-light wires to the main or line wires.

15,433. H. WEYMERSCH and A. MCK. CARDWELL. London. An improved preparation of electrolyte for use in semi-dry primary or secondary electric batteries.

July 13, 1896.

15,447. G. E. FRANCIS. Sheffield. A brushholder to be used on dynamos and motors.

15,495. W. MORISON. New York. Improvements in battery lamps.

15,517. R. SAUERWALD and H. GRÜNE. London. Improvements in electric batteries.

July 14, 1896.

15,534. A. G. BROOKES. London. Improvements in the construction of armoured insulated conduits. (R. T. Elwell, United States.)

15,535. P. A. NEWTON. London. Improvements in and relating to writing telegraphs (The Gray European Telautograph Company, United States.)

15,595. F. J. BEAUMONT and F. HALLOWS. London. An improved electricity meter for registering the amount of current consumed on direct or alternating polyphase, triphase, or quadruple-phase circuits.

15,606. J. J. REIFGRABER. London. Improvements in printing telegraphy

15,614. W. S. SMITH and W. P. GRANVILLE. London. Improvements in electrical relays.

15,622. H. B. LITTLE. London. Improvements in alternators.

July 15, 1896.

15,677. J. G. DIXON. London. An improved electrical counter.

15,678. F. GRAY. London. Method and apparatus for utilising the mechanism of existing windmills for generating and storing electricity.

15,696. E. CASPER. London. Improvements in the manufacture of tubes by electro-deposition.

15,704. C. N. RUSSELL. London. Improvements connected with joint or like boxes and appliances or attachments to be used therewith for electric and like wires.

July 16, 1896.

15,768. H. H. LAKE. London. An improved electro-magnetic brake for vehicles. (Union Elektricitäts-Gesellschaft, Germany.

15,777. C. THÉRYC. London. Improvements in electrically actuated vehicle wheels. [Date applied for under Patents, &c., Act, 1883, sec. 103, 30th January, 1896, being date of application in France.]

15,779. A. A. PHILIPPE and G. SHENTON. London. A new or improved heat generator and accumulator.*

15,782. A. H. BRINTNELL and G. S. BAKER. London. Improve nents in or relating to electric railways.

July 17, 1896.

15,834. A. J. OUTHENIN-CHALANDRE. London. Improvements relating to the electrolysis of soluble salts specially applicable for the production of chlorine.

15,856. J. PALLWEBER and A. KOLBE. Liverpool. A new or improved electric clock.

July 19, 1896.

15,966. H. LEITNER. London. Improvements in or relating to electric arc lamps.*

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

10,308. DEFERT. Electric signalling.
11,708. PIPPETTE. Electric switch apparatus.
12,042. JANDUS. Globes for arc lights, &c.
13,091. DE FERRANTI. Electric switches.
14,065. PARSONS. Dynamos and electric motors.
14,739. HUISMAN and GOVER. Incandescent electric lamp holders.
14,902. FABBRIS. Secondary battery plates.
15,260. ROBINSON. Electro-magnetic separators.
15,338. BARNETT. Arc lamps.
15,442. FARADAY. Suspending electroliers, &c.
15,450. ROOS and others. Electric telegraphs.
15,826. HARDINGHAM (Felten and Guillaume). Insulating electric cables.
15,703. HARDINGHAM (Felten and Guilleaume). Electric cables.
15,863. STATIER. Dynamo electric, &c., machines.
15,880. JUNGNER. Electric accumulators.
16,700. SIEMENS BROS. AND CO., LIMITED (Siemens and Halske). Electrical tramways.
16,701. SIEMENS BROS. AND CO., LIMITED (Siemens and Halske). Electrical tramways.
16,737. PFLEGER. Electrical apparatus for extracting gold and silver from cyanide solutions.
23,515. BOREL. Electric cables.

1896.

7,834. KROTZ and others. Electric railways.
8,380. MERRITT and JOY. Printing telegraph instruments.
9,239. MCMURTRIE. Tools for stripping insulation from wires.
9,650. LANHOFFER. Electromotors and dynamos.
10,189. ROYCE and CLAREMONT. Electromotors and dynamos.
10,804. LAKE (Johnson and another). Electric railways.
10,818. DEVONSHIRE (Potter). Electric tramways.
10,603. THE EDISON AND SWAN UNITED ELECTRIC LIGHT CO. (LIMITED) and PROCTOR. Tumber electric switches.
10,816. DEVONSHIRE (Thomson). Electric measuring instruments.
10,846. THOMASON (Coffin). Electric arc lamps.
11,232. STENDEBACH and LINKER. Electric railways.
11,471. WISE (Fernald and Hubbell). Arc lamps.

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# COMPANIES' MEETINGS AND REPORTS.

## Chili Telephone Company (Limited).

An ordinary general meeting of this Company was held at Winchester House on Friday last, Mr. George Keith presiding.

The SECRETARY (Mr. Edmund Petley) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, you have all had copies of the report and accounts, and I suppose you will take them as read. You will be pleased to see that the business of the Company has made considerable progress during the past year. I think the statement of accounts, which we now submit for your approval, is the most satisfactory the Company has yet had. The gross revenue amounts to $619,826, or over 11 per cent. more than for the previous year. This gain is due principally to the increase of 237 in the number of subscribers, and in a lesser degree to an increase in the use made of the trunk line service. The total working expenses amount to $384,979, or 62 per cent. of the gross revenue, as compared with 65 per cent. of the previous year. The general expenses of the year show a marked reduction, which with the increased revenue is most satisfactory, and reflects great credit on our general manager for the economies he has effected. The adoption by Chili of a gold standard has practically rendered the exchange constant during the year at the mean value of 17¼d. to the dollar, which, as compared with 13·61d. of the preceding year, has considerably enhanced the sterling value of the net income in Chili. The net profit of the year amounts to £8,551, as compared with £6,013 of the previous year, an increase of £2,538, which enables the Board to recommend the payment of a dividend of 4 per cent. on the shares. The general bad state of business, which unfortunately still continues, has certainly lessened the satisfactory result of the year's working by increasing the movement in and out of subscribers and diminishing the actual increase. The telephone is different from other businesses, such as the telegraph. To them a change of customer does not matter, but to the telephone company it means additional expenditure without any increase of revenue whatever. During the year 792 new subscribers were connected up. Of these only 237 have added to the revenue, while the remaining 555 had to go to replace revenue lost by an equal number giving up their telephones; and, consequently, the expenses incurred in joining them up have added considerably to the expenditure, without any corresponding increase of revenue. During the year the Company's property has been considerably improved and extended. Besides the ordinary extensions due to the increase of exchange subscribers, a number of rural lines have been added to the Santiago centre; and the pole routes and trunk lines of Valparaiso have been increased in number and capacity, while the Iquique centre has had its city lines increased in capacity, and an additional trunk line built in the nitrate district. The property throughout is in very good condition, with the exception of some of the older lines, which, our manager reports, now require revision to put them in a perfect state of repair. The people of Valparaiso use the telephone very extensively, and, to meet the demand there for quick and increased communication, we have on order a multiple switchboard of large capacity, and of the newest pattern, and we hope to have it installed and in working order before the end of the year. Our object is to give our subscribers a complete and perfect service at the reasonable rates we are at present charging, and to secure to you a fair return for the capital you have invested. The opposition I alluded to last year opened an exchange in Valparaiso in October, but their operations have not affected us to any appreciable extent. We have lost none of our subscribers in consequence, and we have good reason to expect that the service we give will retain their full support, as any attempt to divide the service would be much against their interests, because subscribers of rival systems must either subscribe to both services or be unable to communicate with one another. With respect to the current year, the settlement come to between Chili and the Argentina, regarding the boundary question, has certainly done much to restore confidence; and the difficulties brought about by the change in the monetary arrangements of the country are likely to become gradually less, so that the course of events may soon be in favour of a revival of business, from which this Company would certainly derive great benefit. With these remarks I beg to move—

"*That the report of the Directors and the statement of accounts to March 31, 1896, now presented to this meeting, be approved and adopted.*"

Mr. FRANK W. JONES seconded the motion.

Mr. J. D. BONNER criticised the way in which the balance-sheet was made out, and also asked if there was any prospect of the Company receiving an additional payment from the Chilian Government in respect to the claim made for damages arising out of the revolution. He would also like to know if the Company could not now create a further issue of debentures at a lower rate of interest than Six per Cent., for the purpose of redeeming the existing debentures.

The CHAIRMAN, in reply, said: The accounts clearly show how much has been earned in the manner prescribed by the auditor, who held that we ought to lay aside a certain amount against depreciation. The way in which we formerly made out the accounts was to put down the net profit plus the reserve. The alteration was made by the auditor, who holds that the actual net profit for the year is £8,551. The amount put to the reserve comes out of the earnings of the year. With reference to the question of the compensation received from the Chilian Government, our general manager did not succeed in getting the amount that he expected; but he got a certain sum, and for the remainder he obtained the sole right of supplying telephonic communication to the Government. That is a very great privilege, and forms a nucleus to the Company, because many people will not take a telephone unless they can communicate with the Government offices. As regards the debentures I do not think we are yet in a position suitable for making any attempt to convert them into other debentures paying a lower rate of interest. When they become due, in the course of three or four years, it will be time to consider what should be done.

The motion was carried unanimously.

The CHAIRMAN next moved—

"*That a dividend of 4s. per share, as recommended by the Directors, be and is hereby declared, and that the same be payable at the Company's bankers on and after the 8th inst.*"

The Hon. HERBERT ALLSOPP seconded the motion, which was carried unanimously.

The CHAIRMAN having intimated that the Hon. Herbert Allsopp had been elected to fill the vacancy on the Board caused by the resignation of his brother, the Hon. Ernest Allsopp, moved the re-election of that gentleman as a Director.

Mr. FRANK W. JONES seconded the resolution, which was carried *nem. con.*

The auditor (Mr. Thomas A. Welton) having been formally reappointed,

Mr. BONNER proposed a vote of thanks to the Chairman, who briefly responded; and the proceedings ended.

## Central London Railway Company.

The ordinary half-yearly general meeting of shareholders of this Company was held on Tuesday at the Cannon-street Hotel, Mr. Henry Tennant presiding.

The SECRETARY (Mr. R. O. Graham) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, it now falls to my lot to move that the report for the half-year ending June 30th last be received and adopted. At this stage of the history of the Central London Railway there is not much to say; but it is a satisfaction to the Directors to be able to point to the fact that a good beginning with this great work has been made. Possession has been obtained of sites for the stations at Shepherd's Bush, Holland Park, Notting Hill Gate, Westbourne, Marble Arch, Oxford Circus, Tottenham Court-road, British Museum and Chancery-lane; and at Shepherd's Bush, Westbourne, British Museum and Chancery-lane the work of sinking the shafts has been commenced. I believe I may say the same as regards Marble Arch, although the beginning may not have been made more than a few days ago. Close by the Bank, where the station in the centre of the City will be constructed, a commencement has been made with the subways which the Company have undertaken to construct. As regards the stations at Queen's-road and at Newgate-street, the requisite property has not yet been acquired, although arrangements with that view are in progress. At Newgate-street, which will be the station for the district round the Post Office, it has been considered a wise arrangement to make larger provision for station purposes than was originally contemplated. That station will be a very important one, and is likely to contribute a large amount of traffic, and it has been thought desirable to make the addition now, because in the case of a railway constructed on the principle of the Central London, the cost of making additions or alterations after the line has once been opened would be very much greater. The station site between the Marble Arch and Oxford-circus has not yet been arranged for. The engineers report that satisfactory progress has been made with the preparations of the ironwork for the tunnel throughout the whole length of the line, and also with the shields and other appliances needful for the execution of the works. The outlay during the half-year has amounted to £273.812. 14s. 9d., which, added to the amount previously expended, makes the total outlay to June 30th £442.098. 0s. 11d. In the general balance-sheet you may observe a sum entered under the head "Mansion House Works Deposit Account." The City authorities were anxious for a practical assurance that the work at the Bank station, when it was commenced, should be prosecuted with diligence, and completed. As security for that the sum named has been invested in Consols, which has been so deposited, so as to meet their requirements, thus removing all objections to our taking possession of the site in front of the Exchange, which is necessary for the execution of the works. You will observe from the report that we are expecting the completion of an agreement with the Great Eastern and the North London Companies as to the Liverpool-street Station and the approaches thereto, in connection with which we anticipate no difficulty. The outlay already incurred, and the anticipated further payments for property and works during the next few months, has rendered it necessary that another call should be made; and accordingly notice of a call of £2 per share was given in June last, to be payable on September 1st next. Some of the shareholders have desired to pay up their calls in full, and since the issue of the report, in which a notice was given respecting the payment in full, we have received a number of applications, but not covering any large amount of money. On the whole, good progress has been made with all the preliminaries, and also with the actual works, so far as circumstances have permitted. The tunnel, for six miles out of the total distance of six-and-a-half miles, has been let, and the Electric Traction Company have shown every disposition to press on with the work as fast as possible. As regards the

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proposal for the division of the shares into two classes, namely, Preferred half-shares and Deferred half-shares, this is proposed to be done under the authority of the Central London Railway Act (1891). In some of the schemes for the division of stock which have been put forward, the nominal amount of the capital has been largely increased. In the case of the present proposal it is not intended to increase the nominal amount of the Central London capital at all. What we propose to do by the resolution which will be submitted, and which will be carried out if the shareholders approve, is to give to every holder of a £10 share the liberty, if he so decides, to have that £10 share divided into two £5 shares, one of which will entitle the holder when the line is open to a Preferential dividend over the other to the extent of 4 per cent. thereon. The shareholders will, of course, exercise their judgment as to whether they will retain their interest in the undertaking as holders of undivided or divided shares. The option of division cannot come into force until £6 per share has been paid upon each £10 share. He then moved—

"*That the report and accounts be adopted, and that the payment of interest at the rate of 3 per cent. per annum on the paid-up capital of the Company be, and the same is hereby, approved.*"

Lord COLVILLE OF CULROSS, K.T., seconded the motion, which was agreed to unanimously without discussion.

The SOLICITOR, at the request of the Chairman, then read the notice convening the special meeting, and the resolutions relative to the division of the shares.

The CHAIRMAN formally moved the resolutions as read.

Lord RATHMORE seconded, and they were unanimously carried.

A vote of thanks to the Chairman and the Directors brought the proceedings to a close.

## Liverpool Overhead Railway Company.

The ordinary half-yearly meeting of the shareholders of this Company was held at Liverpool on Tuesday, Sir William B. Forwood *presiding*.

In moving the adoption of the report and accounts, the CHAIRMAN said that the traffic was making steady progress, that the line was being more largely used by the commercial community of the port, and that it was extensively patronised by visitors and sightseers. During the past year they had earned £31,286, and had expended £19,694, leaving a profit of £11,592, out of which they had paid £2,500 as debenture interest. After adding the balance of £2,074 *brought forward*, there was a total sum of £11,166 available for dividend, and the Directors proposed to pay a dividend of 5 per cent. on the Preference shares, which would absorb £2,700, and a dividend of 2¾ per cent. on the Ordinary shares, which would take £5,568, and to carry forward £2,897. Last year they paid a dividend of 2¼ per cent., and carried forward a balance of £1,302. It might be thought that the amount carried forward was too large; but if they were able (as they hoped) to pay a dividend of 3 per cent. next year, they would have to make an additional contribution to the Tramway Company, and they thought it judicious to make provision for that extra expenditure. Their receipts had increased by £3,154, as compared with the corresponding period last year, and their expenses had increased by £1,141. £400 of that sum represented rates, which, he regretted to say, seemed to be increasing year by year. The extra revenue of £3,154 had thus been earned with an additional expenditure upon the lines of £600. The average receipts per passenger during the period under review had been 1·96d., against 1·92d. in the corresponding half-year of 1895, whilst the revenue per train mile had been 15·1Cd., against 14·38d. They had incurred an additional expenditure of £485 upon repairs to structure and opening bridges, and of £240 upon stations. They had now got the structure in an excellent state of preservation, and they hoped that in a year or two they would be in a position to relax their expenditure somewhat upon this item. They were employing their electric power for the purposes of painting. The outside of the structure was being painted by means of a machine which put on the paint with a spray, and the machine was worked from their electric conductor on the railway. In this way the cost of labour was reduced nearly one half, or from 20s. to 11s. 6d. They were also putting £175 more towards their renewal fund, which now amounted to £5,700. The cost of their locomotive power per train mile had been 3·40d., against 3·49d. last year. He regretted to say that the progress of the works at the south end had been somewhat delayed. They crossed the Cheshire Lines in tunnel, and the necessary works to make it an efficient crossing had been more difficult than was anticipated. It had also been found necessary to construct their bridge with one span instead of two, and this caused further delay; but he was happy to say that these difficulties were being rapidly overcome, and there was no doubt that the additional works would be open for traffic on November 1st.

The report and accounts were after some discussion adopted, and a vote of thanks to the Chairman brought the proceedings to a close.

## Bristol Tramways and Carriage Company (Limited).

The half-yearly meeting of this Company was held on the 7th inst. at Bristol, Mr. Wm. Butler presiding.

In moving the adoption of the report and accounts, the CHAIRMAN congratulated the shareholders on the progress made during the half-year and on the general position of the Company. The tramway receipts showed an increase of £11,651, but as compared with the corresponding period of last year there was an increase of £4,500 in the items for renewals and repairs. With regard to the lines which they had recently been constructing, these were inspected and passed by the Board of Trade Inspector last week. As to the question of the adoption of electric traction on the Eastville line, all the necessary arrangements for the additions to the plant and machinery at the St. George's power station, and also the erection of the overhead work, were made during the half-year. Provision had also been made for the extension of the line to the Fishponds district, which would be carried out immediately the necessary powers were obtained. The St. George and Kingswood electric line had received the universal approval of the public, and everything went to show that they were well pleased with their work in that locality. The Company was constantly getting inquiries from other districts in Bristol as to when the citizens might look forward to an extension of electric traction in their respective localities. Several deputations had waited upon them during the past half-year, and the Directors had told them that they were prepared to extend electric traction throughout the entire system, so satisfied were they that it met in every way the public requirements. They were preparing a scheme not only for the extension of electric traction over the other portions of their system, but also for the extension of the tramway lines in various other districts. They knew that they could serve the public by giving them a number of advantages which could not be obtained whilst animal power was used. They could extend the penny fare system, and give the public a quicker service; in fact, they could convey passengers on their various journeys in about half the time now occupied, especially on those portions where the gradients were severe. He believed that the Corporation conceded that they were *right* in all the advantages claimed for electric traction. The Directors would enter upon the negotiations with the Corporation with every desire to give to the public the maximum of advantages. They were perfectly aware that the working of the lines by electricity could be accomplished at a smaller expenditure than was the case with horse traction; but to introduce the system they would have to largely increase their capital expenditure, and, having regard to the date at which the Corporation might compulsorily acquire the whole of the tramways by purchase, it was absolutely necessary that the Company should be placed in a position to make additional profits in order that the portion of the capital outlay so to be made, but which, under the Tramways Act, the Corporation would not have to recoup the Company, should be written off. Unless they could see their way to earning a considerably increased profit to enable them to write off this large amount, they would be acting in an unbusinesslike manner in incurring such an outlay. The report and accounts were then adopted.

Afterwards a special meeting was held to consider the question of the creation of additional capital. The CHAIRMAN formally moved: "That the capital of the Company be increased to £500,000 by the creation of 25,000 new shares of £10 each." He said the Company's share capital and debenture powers were exhausted. They had creditors for over £20,000, and they still had to complete the works which he had already referred to. It was therefore absolutely necessary that the capital should be increased. The Directors had not yet determined on the exact mode or time of issuing. The motion was seconded and carried unanimously.

## Imperial Tramways Company (Limited).

The ordinary general meeting of the shareholders of this Company was held on Saturday at Bristol, Mr. George White (the Chairman of the Company) presiding. In dealing with the condition of the Reading tramways, the Chairman said they would shortly be compelled to expend additional capital on that undertaking, in order to put themselves in a position to meet opposition and to extend the system. He hoped that as a result of negotiations with the Corporation they would be able to report at their next meeting that arrangements had been made for carrying out the plans in regard to these extensions. They would remember that in the former history of the Company the Dublin Southern Tramways were always looked upon as the least important, as they certainly were the least profitable; but, as a matter of fact, this line proved to be a very valuable asset. The Company acquired, at a very small outlay, the Blackrock and Kingstown Tramway, which intervened between their two lines at Dublin, and, having secured a through run of eight miles, obtained powers to introduce electric traction throughout the whole system. As soon as the electric tramway had been opened and worked for a few weeks, they were able to demonstrate to the whole world that their opinion of the value of the property had been a correct one; and the contractors (the British Thomson-Houston Company), who held the Preference and Debenture capital, ultimately agreed to take over the whole of the Ordinary share capital from them for £130,000, subject to the payment of certain liabilities of the Dublin Southern Company. The British Thomson-Houston Company had since been able to effect a sale of practically the whole concern to the Dublin United Tramways Company at a sum sufficient to cover their outlay and the purchase price paid to the Imperial Company. They had received a cash deposit of £30,000 on account of the purchase price, and the balance of the purchase money was payable at the end of the present half-year. Between now and February next, when they would have received the balance, they hoped to be in a better position to suggest some mode of dealing with the money to be received, especially as the position would be somewhat affected by whether or not they disposed of one of their undertakings, about which they were in negotiation, and also as to the capital outlay necessary for carrying out the electrical extensions at Reading. Any shareholder anxious to anticipate that end could now readily dispose of his shares at par, viz., £6, at which amount they were quoted on the Bristol Stock Exchange. The gross revenue, omitting all credit on the Dublin account, amounted to a sufficient sum to pay Debenture interest, the Preference dividend at the rate of 6 per cent. per annum, and a dividend on the Ordinary shares at the rate of 2½ per cent. per annum, and to carry forward a small amount to the credit of the new account. The report and accounts were then adopted.

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## Cuba Submarine Telegraph Company (Limited).

The report of the Directors of this Company for the half-year ended June 30th, to be presented at the fifteenth ordinary general meeting of shareholders, to be held at noon on Wednesday next, the 19th inst., at the offices, 58, Old Broad-street, E.C., is as follows:—

The gross receipts amount to £36,186. 19s. 2d., and the gross expenditure to £9,425. 1s. 3d., leaving a sum of £26,761. 17s. 11d., which, added to the balance brought from the last account (£3,719. 2s. 5d.) leaves £30,481. 0s. 4d. at the credit of revenue account. The increased traffic, and the cost of working the five new stations of the Cienfuegos-Manzanillo cables, which were opened on January 1st, account for the increase in the stations expenses. The sum of £17,910. 9s. 4d. has been added to the reserve fund, which now stands at £98,000. after deducting the cost of the cables between Cienfuegos and Manzanillo. The dividend on the Preference shares absorbs £3,000, leaving a balance of £9,570 11s., out of which the Directors recommend the payment of a dividend on the Ordinary shares at the rate of 8 per cent. per annum, free of income tax, the balance, £3.170. 11s., being carried forward.

The cables have continued in good order since the date of the last report.

The Company's suit against the Spanish Government at Madrid has recently come before the Contencioso Court, which has declined to cancel the royal order complained of, on the ground that no injury has been done to the Company by the order. In the event, however, of injury arising in consequence of the order, the Company is free to take such action as may be necessary to protect its interests.

The retiring Director, Mr. Charles Woodbyne Parish, offers himself for re-election, as does the auditor, Mr. John Gane.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**ANGLO-FRENCH MOTOR CARRIAGE COMPANY (LIMITED).**—This Company was registered on July 29th, with a capital of £300,000, in £1 shares, to carry on business as manufacturers of and dealers in electrical, oil and gas engines, motors and dynamos, motor cars, cycles, &c., launch and boat builders, mechanical and electrical engineers, millwrights, wire drawers, &c.

**DAVIES MOTOR COMPANY (LIMITED).**—This Company was registered on August 7th, with a capital of £160,000, in £1 shares, to enter into an agreement with the Alternate-Current Electro-Motor Syndicate (Limited) for the purchase of certain patents and other rights and properties belonging to the said Syndicate, to carry on the business of commercially developing and obtaining contracts for the supply and sale of alternate-current motors, to be manufactured according to the said patents or any improvements thereof, and to carry on the business of electrical engineers, light and power contractors, electricians, electrical manufacturers and makers of dynamos, motors, apparatus and fittings. The subscribers, with one share each, are: G. W. de Tunzelmann, electrical engineer; C. E. Cree, barrister; A. W. Cree, solicitor; W. Langdon Davies, electrical engineer; Alfred Davies, electrical engineer; H. E. Cree, solicitor; J. W. Phillips, clerk. The first directors are: G. W. de Tunzelmann, Charles E. Cree, Arthur W. Cree, W. Langdon Davies and Alfred Soames.

**DE LAVAL ELECTRIC FURNACE.**—A Company, with a capital of 15,000,000 kroner (£827,815), has been formed at Stockholm for the purpose of acquiring and developing Dr. de Laval's patents relating to electric furnaces. The Company intends to use the water-power of the well-known falls near Trollhattan. Dr. de Laval, who already possesses some of these falls, recently acquired the largest of them, the Vestra Gullöfall, for £38,742, and this will most likely be taken over by the new Company.

**ELECTRICAL DEVELOPMENT AND FINANCE CORPORATION (LIMITED).** This Company was registered on July 31st, with a capital of £500,000, in £1 shares, to promote and facilitate the development of undertakings for electric lighting, traction, and power supply, electrical communication and other industrial purposes connected with electricity in any part of the world, and to acquire and hold shares, debenture stock and securities of undertakings for electric lighting, traction, power supply and communication. The subscribers are: the Duke of Newcastle, W. Crookes, F.R.S., and W. Claude Johnson, engineer (with 250 shares); and G. Newington C. T. Price, J. Steuart, and N. G. Newington (with one share each).

**"MOTORS" (LIMITED).**—This Company was registered on July 28th, with a capital of £5,000, in £1 shares, to enter into an agreement with Mr. Simeon L. Phillips, and to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity, and manufacturers of and dealers in all kinds of electrical apparatus. The first subscribers are: Bennett Pell, electrician (200 shares); Arthur Bergheil, electrical engineer (100 shares); H. Wilson Young, electrician (100 shares); and E. Somerset Eccles, electrician, F. Bennett Pell, electrical engineer, E. Forrest, electrician, and Stanley Smith, with one share each.

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**EVERSHED AND VIGNOLES (LIMITED).**—The annual return of this Company, to April 11th, has just been filed. 753 shares have been subscribed for out of a capital of £10,000, in £10 shares, and the full amount has been called and paid.

**F. H. ROYCE AND COMPANY (LIMITED).**—The annual return of this Company, to June 4th, has been filed. The nominal capital is £30,500, in 30,000 Ordinary and 500 Deferred shares of £1 each. 17,954 of the former and all the latter have been taken up, and 12,514 Ordinary have been issued as fully paid. The full amount has been called and paid on 5,440 Ordinary and the 500 Deferred.

**TELEGRAPH MANUFACTURING COMPANY (LIMITED).**—The annual return of this Company, to July 24th, has been filed. 3,661 shares have been taken up out of a capital of £50,000, in £10 shares, and 646 have been issued as fully paid. The full amount has been called and paid on the remaining 3,015 shares.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31½d. per oz. (Aug. 13th). Consols (2¾ per cent.) 112⅞—112⅞ for money, 112⅞—112⅞ for account; 2½ per cent. 108—108¼ (Aug. 13th). Stock Exchange Settling Days: Consols, Sept. 1st; Stocks and Shares Continuation Day, Aug. 26th; Ticket Day, Aug. 27th; Pay Day, Aug. 28th; Mining Share Carry-over Day, Aug. 25th.

**ALUMINIUM COMPANY (LIMITED).**—The ordinary general meeting of this Company was held at the Cannon-street Hotel, E.C., on Friday. The Chairman (Sir Henry E. Roscoe, F.R.S.) moved the adoption of the report and accounts, and said that the result of the year's trading was satisfactory. The effect of the sales of patents during the year had been that the Company had received a net cash profit of £33,523, in addition to being in possession of shares of the nominal value of £119,000, and the actual market value of which, he thought, was not less than that sum. The trading profit at Oldbury amounted to £16,281, which, added to the profit from the sale of patents, and after the deduction of expenses, gave a gross profit of £50,681. After deducting debenture interest and other fixed charges, there remained a sum of £38,003., which, with £2,076 brought forward, left a net profit of £40,079. The Directors recommended the payment of a dividend at the rate of 15 per cent., that £20,000 be written off the works and patents accounts, and that £11,079 be carried forward. The earnings of the Company would not in future be dependent on the profits on the Oldbury Works, as their revenue would be enhanced by dividends from the shares in the Castner-Kellner Alkali Company, the Mathieson Alkali Company, and also the Niagara Electro-Chemical Company. They would also receive, as from January 1, 1897, a fixed minimum royalty of £4,000 per annum from the Mathieson Alkali Company. This sum would suffice to pay a dividend of between 6 and 7 per cent. on their capital, and as the maximum payment was fixed by the output, the actual payment might ultimately represent a very important revenue. It had lately been ascertained that the Company's sodium patents were being infringed in Germany, and the Directors had instituted proceedings to stop such infringements. Should the Company prove successful in these proceedings, it is anticipated that the profits of the Oldbury business would be much increased, as this year they had to contend with improper competition. The negotiations respecting the British and Continental patents corresponding to those sold to the Niagara Electro-Chemical Company were soon likely to be brought to a satisfactory issue. The report and accounts were then approved, and a dividend at the rate of 15 per cent. declared.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The traffic returns of this Company for the week ended August 9th were £895, against £860 in the corresponding period of last year, an increase of £35. The total receipts for the half-year amount to £5,419, against £5,084 in the corresponding period of 1895, an increase of £335.

**CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).**—The gross revenue return of this Company for the quarter ended June 30th, 1896, is as follows:—Sale of current for public lighting, £3,189, against £3,202 in the corresponding quarter last year; private lighting, &c., £16,564, compared with £12,283; and estimated revenue from other sources, £650 against £200. Total, £20,403 compared with £15,685, an increase of £4,718. There was an equivalent of 215,559 8 c.p. lamps connected on June 24th last, there having been an increase during the quarter of 10,656 against an increase during the corresponding quarter last year, of 8,291.

**ELECTRIC CONSTRUCTION COMPANY (LIMITED).**—The transfer books for the Ordinary and Preference shares of this Company will be closed till the 27th inst., inclusive.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 9th inst. amounted to £1,700. The amount for the corresponding week last year was £1,578, an increase of £122.

**MANCHESTER EDISON-SWAN COMPANY (LIMITED).**—The annual meeting of this Company was held on Friday at Manchester. The Directors' report stated that the net profit, including last year's balance, amounted to £2,041. 18s. 1d. Out of this it was proposed to pay a dividend at the rate of 5 per cent. per annum, which would absorb £1,500, and to carry forward the balance, amounting to £541. 18s. 1d. Mr. V. K. Armitage (Chairman of the Company), in moving the adoption of the report, referred to the keen and even unscrupulous competition to which the Company was subjected by its rivals in its efforts to obtain business. The Managing Director (Mr. W. P. James Fawcus) seconded the motion, and explained that the installation at Altrincham, on which there was last year a loss of £400, had now begun to pay its way. There was a fair demand for electric current, and the number of customers was steadily increasing. The Altrincham Electric Supply (Limited) had also got a Provisional Order for supplying the electric light to Ashton-on-Mersey, and it was probable that they would start laying the electric light mains in a month or two. At a comparatively small outlay they would be enabled to tap another populous district, and to increase the profits of the Company. The report was then unanimously adopted, and the dividend recommended by the Directors was declared payable.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended August 7th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,711.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price August 5. | | Price Wednesday, August 12. | | Rate per Cent. Yielded. | Dividend Due. | Business Done during Week ending August 8. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 52 | 54 | 52 | 54 | 4 12 7 | Jan., Apr., July, Oct. | 53 | 52½ |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 97½ | 98½ | 97½ | 98½ | 5 1 6 | " " | 98½ | 97½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 | 9½ | 9 | 9½ | .. | .. .. | 9½ | 9⅜ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 | 104 | 100 | 104 | 3 17 4 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ | 9½ | 8½ | 9½ | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15¼ | 15½ | 15½ | 15⅝ | 4 8 11 | Mar., June, Oct., Dec. | 16⅛ | 15½ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 | 116 | 112 | 116 | 4 6 7 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | 160 | 170 | 160 | 170 | 4 2 9 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ | 13½ | 12½ | 13½ | 5 18 6 | February and August | 13 | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20 | 21 | 20 | 21 | 4 5 3 | " " | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ | 4½ | 3½ | 4 | 5 0 0 | April and October | 4½ | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 | 10½ | 10 | 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% | 110% | 107% | 110% | 4 2 0 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9⅞ | 10¼ | 9⅞ | 10¼ | 4 3 0 | Jan., Apr., July, Oct. | 9⅞ | .. |
| 400,000 | 10 | 5/6 | Eastern | 17⅞ | 18¼ | 18 | 18⅛ | 3 10 3 | " " | 18¼ | 17⅞ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ | 19½ | 18½ | 19½ | 3 1 6 | " " | 19 | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 | 134 | 131 | 134 | 3 0 3 | May and November | .. | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 | 107 | 104 | 107 | 4 13 6 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 | 18½ | 18 | 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅜ | 18⅛ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 | 133 | 130 | 133 | 3 0 2 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900 | 100 | 104 | 100 | 104 | 4 16 7 | January and July | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 100 | 104 | 100 | 104 | 4 16 7 | .. .. | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 | 108 | 105 | 108 | 3 14 1 | February & August | 106 | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% | 114% | 111% | 113% | 3 11 5 | May and November | .. | .. |
| 180,227 | 10 | 3/0 | Globe Telegraph and Trust | 11¼ | 11⅝ | 11¼ | 11⅝ | 3 15 7 | Jan., Apr., July, Oct. | 11⅛ | 11⅛ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17⅞ | 18¼ | 18 | 18⅛ | 3 5 9 | " " | 18¼ | 18 |
| 150,000 | 10 | 5/0 | Great Northern | 23½ | 24½ | 23½ | 24½ | 4 1 8 | Jan., April, and July | 24½ | 23⅝ |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 105 | 108 | 105 | 108 | 4 14 4 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 53 | 55 | 53 | 56 | 4 9 3 | May and November | 54 | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | .. | .. | .. | .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 111 | 114 | 111 | 114 | 5 7 7 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel.4% Guar. Debs."Red"1942 | 103 | 111 | 108 | 111 | 3 12 5 | .. .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 7 | 8 | 7 | 8 | 5 0 0 | April and October | .. | .. |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 140 | 145 | 140 | 145 | 4 2 9 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 | 6 | 5 | 6 | 5 0 0 | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 104 | 107 | 104 | 107 | 4 15 3 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 | 2 | 1 | 2 | .. | January and July | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 99 | 104 | 99 | 104 | 7 15 0 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1⅛ | 1⅜ | 1⅛ | 1⅜ | .. | .. | 1⅛ | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11½ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ | 10½ | 9½ | 10½ | 5 14 3 | " " | 10⅜ | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 | 111 | 108 | 111 | 4 10 6 | June and December | .. | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8¾ | 9⅛ | 8¾ | 9⅛ | 4 17 4 | May and November | 9⅛ | 8⅞ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 7 | 7½ | 7 | 7½ | 5 0 0 | .. .. | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2¼ | 2⅝ | 2¼ | 2⅝ | .. | .. | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 107 | 103 | 107 | 5 12 2 | February & August | 106½ | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 | 107 | 103 | 107 | 5 12 2 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 | 115 | 110 | 115 | 6 3 7 | May and November | .. | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 104 | 107 | 104 | 107 | 5 14 10 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 44,000 | 5 | 2/6 | Chili Telephone (fully paid) | 3½ | 4 | 3½ | 4 | .. | .. | .. | .. |
| 224,850 | 10/0 | 1¼d. | Consolidated Telephone Const.& Manufacturing | 1/16 | 1/8 | 1/16 | 1/8 | .. | May and November | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅜ | ½ | ⅜ | ½ | 5 14 3 | Yearly | .. | .. |
| 484,597 | 5 | 3/0 | National | 7¾ | 8 | 7¾ | 8 | 3 8 9 | June and December | 8 | 6 |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 | 19 | 17 | 19 | 3 3 2 | " " | 17½ | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 | 18 | 17 | 18 | 3 8 7 | " " | 17½ | 17⅛ |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅞ | 7⅛ | 6⅞ | 7⅛ | 3 10 2 | .. .. | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 | 110 | 107 | 110 | 3 3 9 | January and July | .. | .. |
| 58,000 | 5 | 4/0 | United River Plate | 3¾ | 4¼ | 3¾ | 4¼ | 4 14 2 | July | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 101 | 106 | 101 | 106 | 4 14 9 | January and July | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 15 | 16 | 15½ | 16½ | 3 0 7 | February & August | 15⅛ | 16⅜ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 16½ | 17½ | 17 | 18 | 3 6 8 | January and July | 17⅜ | 17 |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 133 | 137 | 133 | 137 | 2 13 3 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. | .. | .. | .. | .. | .. | .. | .. |
| £30,000 | £5 | 3/0 | Charing Cross & Strand Electricity Supply Corp. | 8¼ | 8¾ | 8¾ | 9¼ | .. | .. | 8⅜ | 8⅛ |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. | .. | .. | .. | .. | .. | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 | 9 | 8 | 9 | .. | .. | 8⅞ | .. |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 13½ | 14 | 13½ | 14 | 4 5 9 | .. | 14 | .. |
| 8,322 | £5 | .. | House-to-House Electric | .. | .. | .. | .. | .. | .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. | .. | .. | .. | .. | January and July | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | ⅜ | 1½ | ⅜ | 1¼ | .. | .. | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13¼ | 13⅜ | 13¼ | 13⅛ | 2 18 2 | .. | 13⅜ | 13⅛ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 119 | 123 | 119 | 123 | 3 13 4 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 11 | 11½ | 11 | 12 | .. | .. | 11⅛ | 11⅜ |
| .. | .. | .. | Rand Electric | 1/16 | 1/16 prem. | 1⅛ | 1⅛ prem. | .. | .. | .. | .. |
| 19,980 | £5 | 2/6 | St. James and Pall Mall | 12½ | 13½ | 13½ | 13½ | 2 17 5 | .. | 13 | 12⅞ |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 | 11 | 10 | 11 | 3 6 8 | .. | 10⅛ | .. |
| 59,900 | 5 | 4/6 | Westminster Electric Supply (fully paid) | 11 | 12 | 11 | 11½ | 3 0 10 | .. | 11⅜ | 11⅛ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1 | 1½ | 1 | 1½ | .. | .. | 1 | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1½ | 1½ | 1½ | 1½ | .. | .. | 1/16 | 1⅛ |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 112 | 115 | 112 | 115 | 3 19 9 | March & September | 113 | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref | 2 | 2½ | 2 | 2½ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1⅞ | 2¼ | 1⅞ | 2¼ | 6 13 4 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 | 106 | 103 | 106 | 4 5 1 | January and July | .. | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 110,000 | 2 | .. | Electric Construction | 1⅞ | 1⅞ | 1⅞ | 1⅞ | .. | .. | 1⅛ | 1⅛ |
| 12,845 | 2 | 2.9⅜ | Do. 7 per Cent. Cumulative Pref. | 2⅛ | 3 | 2⅛ | 3⅛ | 4 6 2 | September | .. | .. |
| 91,195 | 2 | 10.0 | Elmore's Patent Copper Depositing | ⅝ | ⅞ | ⅝ | ⅞ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. | .. | .. | .. | .. | .. | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 22 | 23 | 22 | 23 | 4 6 11 | February & August | 22⅝ | 22⅛ |
| £200,000 | 100 | .. | * Do. 4 per Cent. Debentures | 108 | 109 | 106 | 109 | 3 13 5 | March & September | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ½ | ⅝ | ⅝ | 1 | .. | .. | .. | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 39 | 42 | 39 | 42 | 4 5 9 | March and July | 42½ | .. |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 | 105 | 102 | 105 | 4 15 8 | January and July | .. | .. |
| £100,000 | 10 | 8/0 | W. T. Henley's Telegraph Works Ordinary | 17½ | 18½ | 17½ | 18½ | 4 10 1 | March & September | .. | .. |
| £30,000 | 10 | 5/0 | Do. 7 per Cent. Preference | 17½ | 18½ | 18 | 19 | 3 13 8 | " " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 | 114 | 109 | 114 | 4 0 4 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | | | |
| £680,000 | Stock | 1⅝% | City and South London Railway Con. Ordy. | 45 | 47 | 46 | 48 | 2 12 0 | January and July | 46½ | 46 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ | 15 | 14½ | 15 | 3 6 8 | " " | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 | 138 | 136 | 138 | 2 18 0 | May and November | .. | .. |
| 37,500 | £10 | 3½% | Liverpool Overhead Railway | 13⅜ | 13⅞ | 13⅜ | 13⅞ | 2 3 0 | .. | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 17⅜ | 17⅝ | 17⅜ | 17⅝ | 2 17 7 | .. | .. | .. |
| 125,000 | Stock | 4% | Do. 4% Debenture | 112½ | 114½ | 112½ | 114½ | 3 9 10 | January and July | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest but *not* for redemption.

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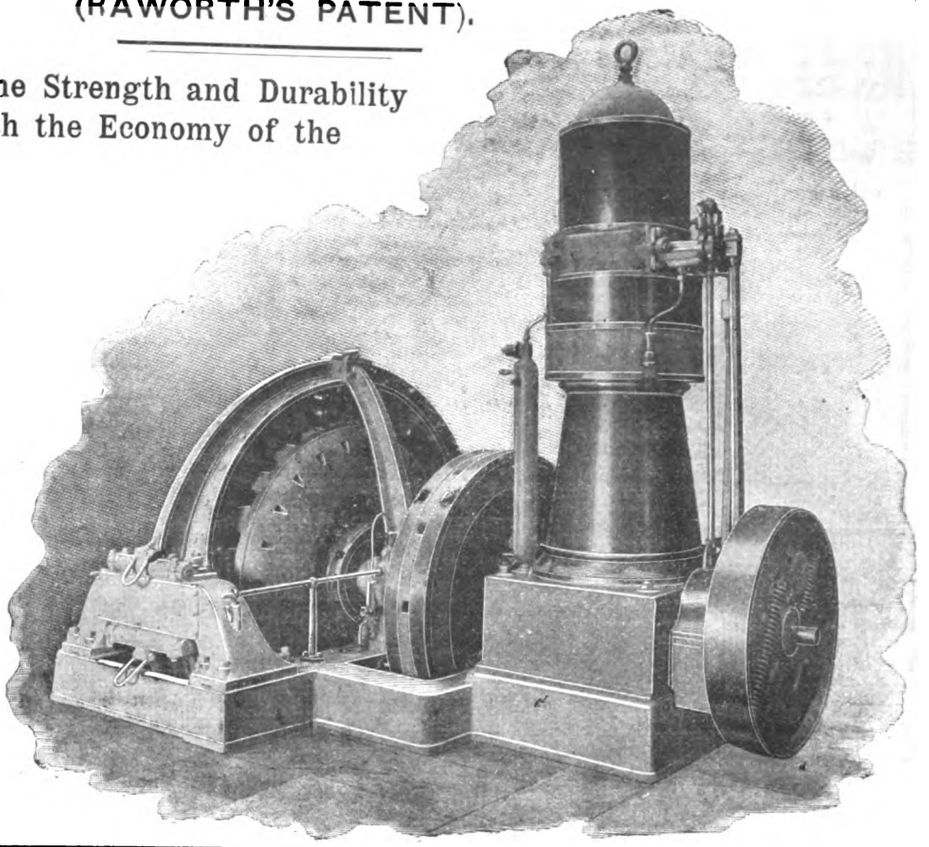

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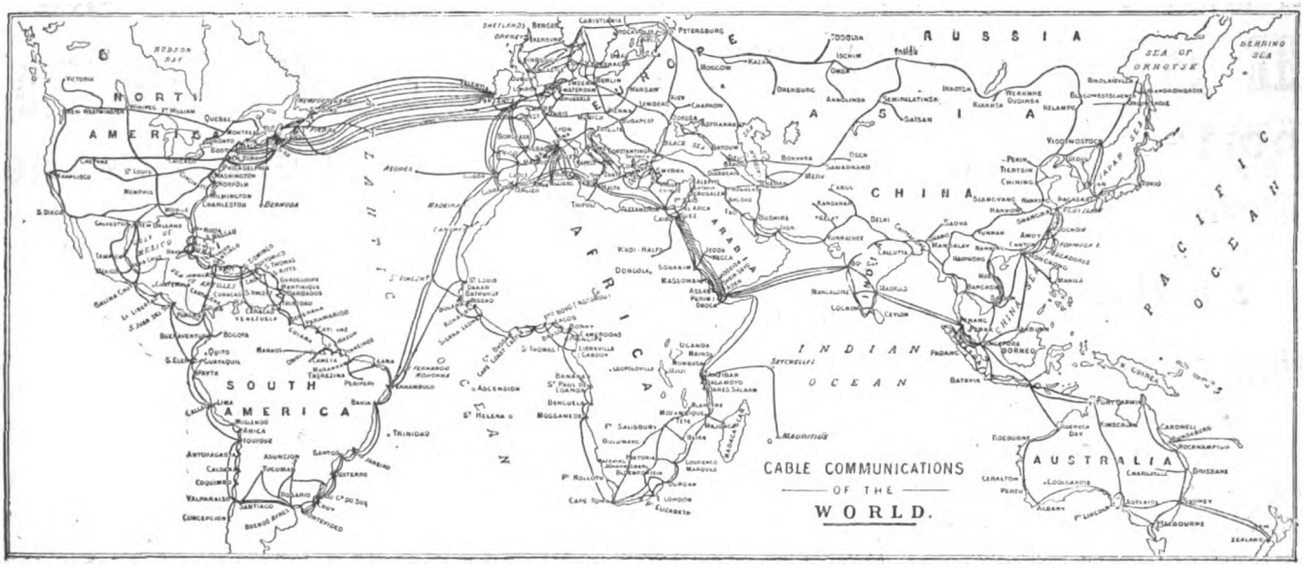


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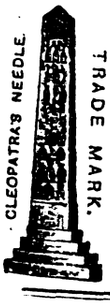


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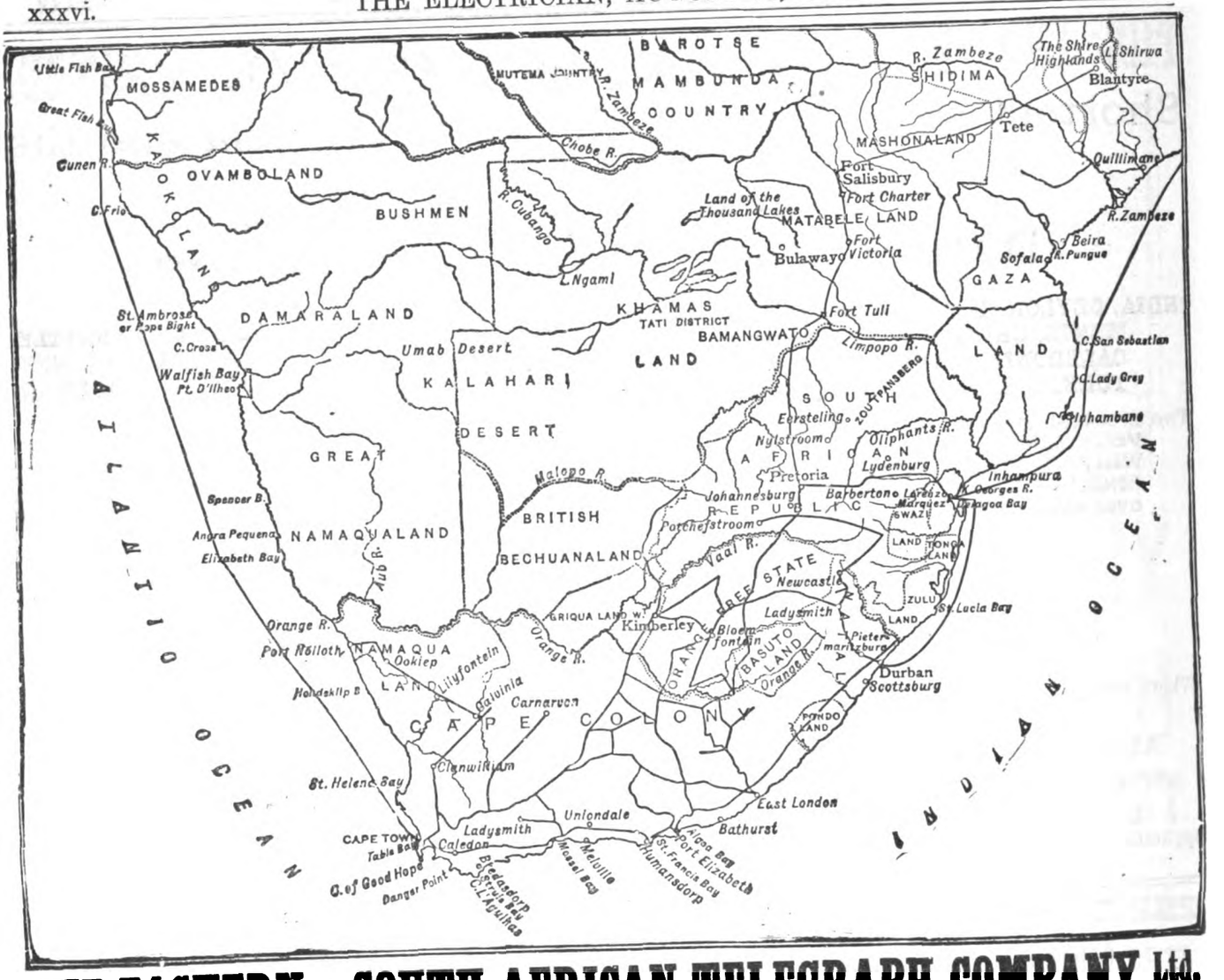


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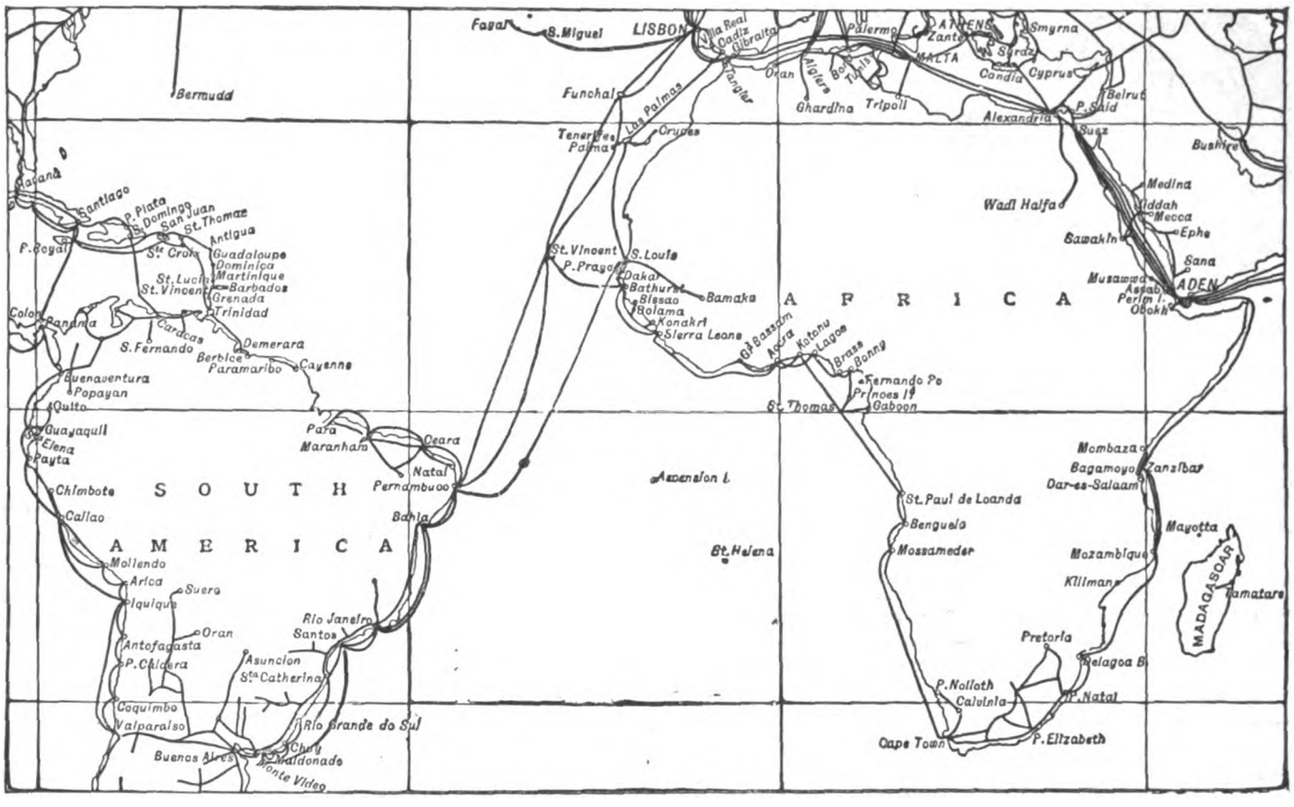


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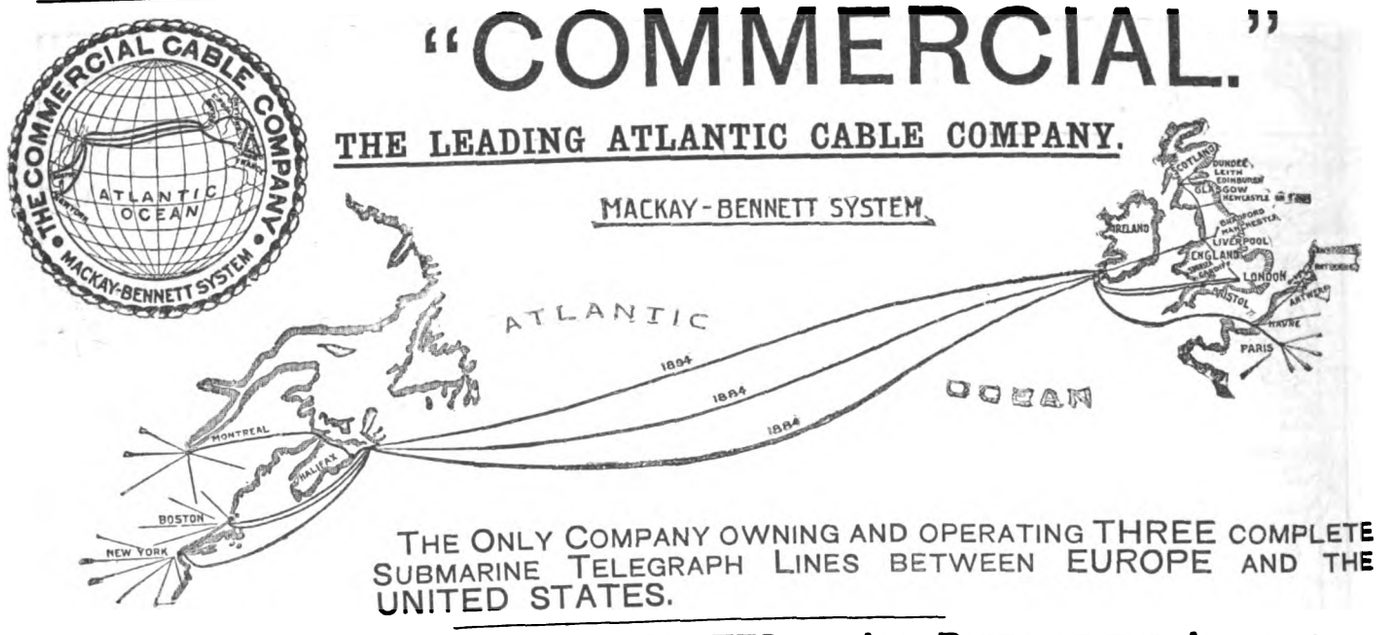


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The Mayor, Aldermen, and Burgesses of the City or Borough of Cork invite TENDERS from Persons or Companies willing to carry into effect the powers conferred upon the Corporation of Cork by the Electric Light Provisional Order of 1896.

The Corporation of Cork have made arrangements with a Tramway Company who propose installing an Electric Tramway system in Cork, whereby the supply of current for the tramways must be taken by the Tramway Company from the Assignees of the Electric Light Provisional Order, and the advantages of this arrangement are specially pointed out to the intending Tenderers.

A Copy of the Conditions under which the Order may be transferred and Form of Tender prepared by Messrs. Kincaid, Waller and Manville may be obtained from the undersigned on payment of one guinea, which sum will be returned on receipt of a *bona fide* Tender.

The Corporation do not bind themselves to accept the lowest or any Tender.

Sealed Tenders endorsed "Application for Transfer of Electric Light Provisional Order," to be sent on or before Twelve o'clock Noon on FRIDAY, the 11th September, 1896, to ALEXANDER M'CARTHY, Town Clerk, Municipal Buildings, Cork.

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The CORPORATION of GLASGOW are prepared to receive TENDERS for the ELECTRIC LIGHTING of the St. Andrew's Halls.

Specifications and Forms of Tender may be obtained on application to Mr. William Arnot, Electrical Engineer, 75, Waterloo-street, Glasgow; and Sealed Tenders, marked "Tender for Electric Lighting of St. Andrew's Halls," must be lodged with the Subscriber by Ten o'Clock a.m. on FRIDAY, 28th inst.

The Corporation do not bind themselves to accept the lowest or any Tender.

J. D. MARWICK, Town Clerk.

City Chambers, Glasgow, 19th August, 1896.

## APPOINTMENTS VACANT.

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ELECTRIC LIGHTING.

RESIDENT ENGINEER.

The VESTRY of the Parish of Hammersmith Hereby Give Notice that they will be prepared at their meeting, to be held on Wednesday, the 2nd day of September, 1896, to receive APPLICATIONS for the appointment of RESIDENT ENGINEER, to supervise under the Consulting Engineer the Erection of the Electric Lighting Plant and other works in connection therewith, and afterwards to undertake the management and control of the Electric Light Department.

The person appointed will be required to reside in the parish, and must give the whole of his time to the duties of his appointment.

Applicants must have had a thorough mechanical training and well versed in the erection and running of boilers, engines, and electrical machinery.

The salary will be £200 per annum during the erection of the works, &c., to be increased to £250 when the installation is completed and in working order.

Forms upon which applicants must send in their application may be had from the undersigned at the Vestry's Temporary Offices, 57, Fulham Palace-road, Hammersmith, on and after the 20th day of August, and any further information may be obtained on application to Mr. A. H. Preece, Consulting Engineer, 39, Victoria-street, Westminster.

Applications, marked on the outside "Resident Engineer," must reach me not later than Four o'Clock on the 2nd September.

Canvassing, both personal and otherwise, will disqualify candidates.

Applicants will not be required to attend on the above-mentioned day, and no travelling or other expenses will be allowed.

By order,

W. P. COCKBURN, Vestry Clerk.

Temporary Offices, 57, Fulham Palace-road,
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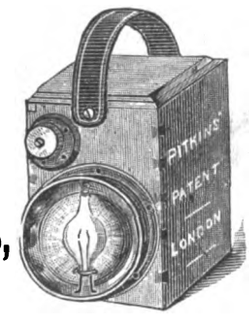

FIG. 1A.

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***Five issues of the original Vol. I. were made and exhausted between September, 1889, and March, 1896.***

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**CHAPTER VI.—The Induction Coil and Transformer.**

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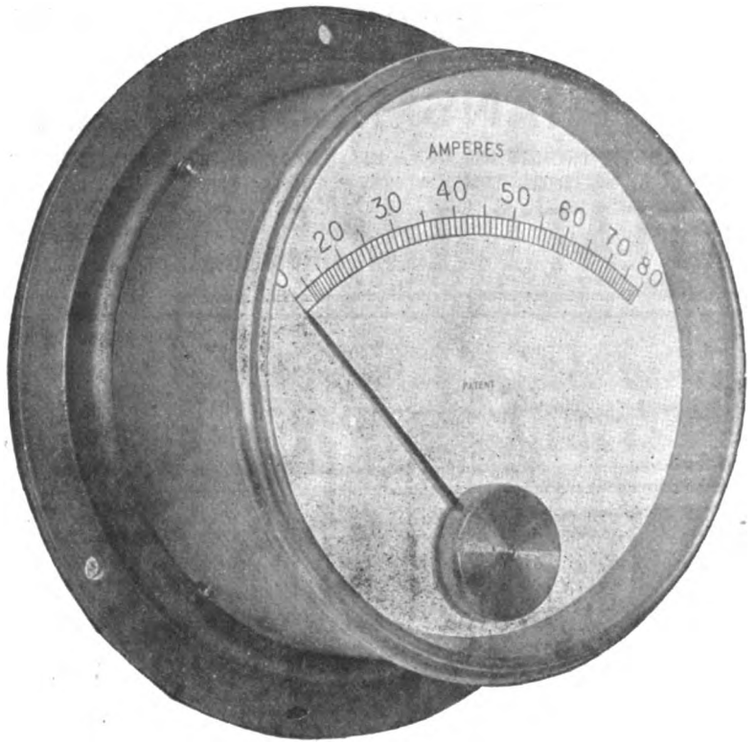


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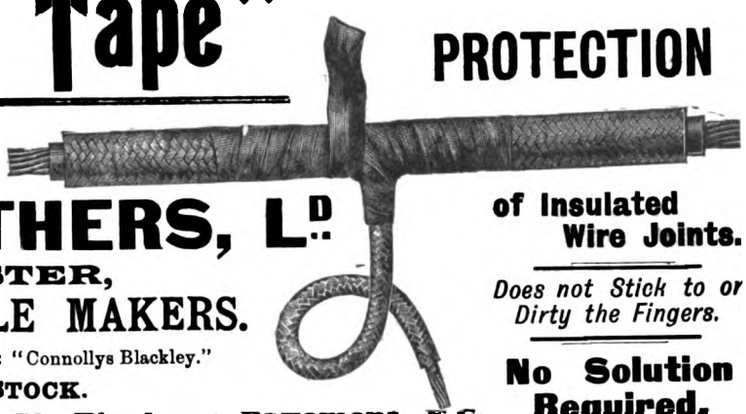

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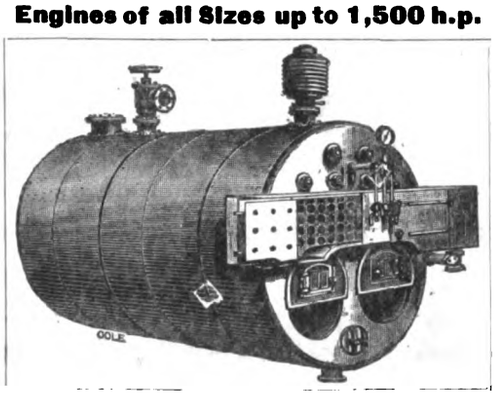

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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## NOTES.

THE legalisation of the metric system of weights and measures cannot be considered, even by the most sanguine, as being to-day within the shere of practical politics; that is to say, there is no likelihood of an Act making its use obligatory on and after 19... passing both Houses of Parliament and receiving the Royal Assent by August next. But that is no valid reason why those who look forward to the adoption, sooner or later, of a more scientifically satisfactory system should not discuss, in anticipation of the hatching of their little chicken, what name or names they shall give him. Indeed, seeing how little genuine deliberation there is in our deliberative assembly, it is absolutely necessary that all details should be settled by the experts before any wide-reaching scheme attains that high altitude.

So far as we are aware, Mr. OLIVER HEAVISIDE is the first to raise this question of nomenclature (see *The Electrician*, August 7th, p. 489); everyone else would appear to have thought, not unnaturally, that the units, decimal notation and names all hung together. Mr. HEAVISIDE, however, has his doubts about the possibility of forcing "Latin and Greek combinations and polysyllables" into the mouths and the minds of our new masters, though he admits it would be "probably more satisfactory in the long run" than his own masterpiece of confusion, which rules that we are to call a metre a yard, and so on. Surely the only statesmanlike and practicable plan is to officially adopt the international name for each international unit, and let the man in the street please himself as to whether he talks of a decimetre or a "dessy." As an anonymous correspondent points out this week, this plan works well in the home of the metric system. We *can* drum into the youthful mind of the nation the proper names and the exact values of the international units; and although no earthly power can compel a youth when he comes to man's estate to use either the one or the other in fond familiar intercourse, that is no reason why one of the main advantages of this momentous change should be foregone. That would, indeed, be a *reductio ad absurdum* of the system of counting heads without weighing them.

THE concentration of sulphuric acid by the heating effect of a current passed through platinum wires immersed in the liquid has been suggested and investigated with somewhat discouraging results. It was found that the drop of voltage from one part of the wire to another was sufficient to cause an appreciable amount of electrolysis to take place, a loss of energy and a contamination of the acid being incurred. It is now claimed by ASKENASYS in a recent German patent that the intentional electrolysis of concentrated sulphuric acid can be usefully performed. The chief products are said to be ozone, finely-divided sulphur and sulphuretted hydrogen. The first-named serves to oxidise any dissolved organic impurities and to decompose chlorides (both ends, it may be remarked, would be equally well reached by boiling the acid). As to the sulphur and sulphuretted hydrogen, their *rôle* is set down as the reduction of oxides of nitrogen and the precipitation of metallic impurities as sulphides. The process is carried out at a pressure of 6 volts and with a current density of 1 to 2 amperes per square decimetre. Lead electrodes are used, and the liquid is at first allowed to be at rest, and after electrolysis has proceeded for some time, is agitated. The acid after treatment is heated to agglomerate the sulphur and entangled sulphides, or, as an alternative plan, may be diluted to aid the separation of metallic impurities by dissolved sulphuretted hydrogen. The product contains a small quantity of lead as an impurity. This fact and the alternative method quoted above, are not without significance. It is clear that in concentrated acid the separation of metallic sulphides—save possibly arsenic—is not to be expected, and if the acid be diluted and thus needs reconcentration the advantage of the electrolytic method over those chemical modes of purification which are at present in use, is not obvious. In short, the whole process may be criticised by saying that it is a device to do imperfectly and at great cost what is already done perfectly and cheaply by well-known means.

THE valuable and instructive experiments of Messrs. SEVER MONELL, and C. L. PERRY, with regard to the effect of temperature upon insulating materials, which were reported in our issue of July 31st, are interesting, as affording a further example of the application of Mr. W. A. PRICE'S "guard-wire" to eliminate the effect of leakage upon the galvanometer readings. The general arrangement of the testing apparatus, however, seems open to some objection, chiefly because of the uncertainty of the contact-area and contact-pressure between the dielectric sheets and their electrodes. The outer electrode consists of a closely wound helix of bare copper; and it is

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clear that each turn as it is applied must partly embed itself, so that it is impossible to compute either the pressure, thickness, or active area of the dielectric under test. Changes of temperature must necessarily alter the diameter of the helix, and thus vary the pressure and active area; and we should expect that the galvanometer would respond to the temperature changes even though the specific resistance of the dielectric remained constant. This defect could have been partly avoided by making the inner tubes of copper instead of brass; but the only certain way of ensuring definite contact is to use mercury electrodes, kept in position with india-rubber washers between metal plates. The objection to such a method is that it finds out the pores of the dielectric; this, however, is only a theoretical objection, in practical tests it is a positive advantage.

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THE secluded borough of Colchester would appear to have hit upon a very obvious and, at the same time, very satisfactory solution of the standing quarrel between contractor and consultant. Their adviser aired no "fads," as manufacturers are apt to call ideas good or bad that don't square with their own. He merely issued, it would appear, a sketch map of the town, fixed the capacity of the required plant, and added, perhaps, a few particulars with regard to the early-rising or late-retiring habits of the good people of Colchester, and then left the contractors to do their best, only reserving to himself the arduous task of deciding which firm had propounded the most suitable scheme. The part played by the consulting engineer would thus seem to be reduced to an irreducible minimum, and the greatest happiness of the greatest number, of contractors and consultants, secured. One step more and the consultant would be totally effaced: no doubt a consummation devoutly to be wished, by contractors, but not by bewildered town-councillors or their electors the ratepayers. A golden rule for young doctors is to cultivate a good bedside manner, and to this end a solemn sympathetic voice, a gray hair or two or a depilated patch, will be more profitable than accurate knowledge and varied experience. Electrical practitioners likewise would do well to cultivate a good consulting manner. We feel sure that the real or simulated irritation which some consulting electrical engineers arouse in the breasts of representatives of engineering firms is merely due to the desperate youthfulness of some of these advisers of town councils. It has been decided by the world that what is matured wisdom at forty is extreme unwisdom at forty minus fifteen.

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**Electric Lighting in Malaga.**—Messrs. Siemens and Halske, of Berlin, have acquired the small central station at Malaga, and are about to greatly extend it.

**Ohm Monument.**—It is proposed to erect a monument over the grave of Georg Simon Ohm. Subscriptions will be received by the Königliche Filialbank, Munich.

**A New Belgian Electrolytic Company.**—A company has just been formed in Brussels, with a capital of £24,000, to be known as the Société l'Oxhydrique pour l'Exploitation des Procédés Electrolytiques Garuti.

**Cable Interruptions and Repairs:—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique ..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Para—Maranhao..... | Aug. 6, 1896 ... | — |

**Chicago and the Trolley System.**—The Chicago City Council, the other day, passed an ordinance preventing the tramway companies from introducing the overhead electric trolley system into the central business streets of the town.

**Electric Traction and Electrolysis.**—In Richmond (Va.), a regulation has been put in force according to which any current leakage from electric tramway lines will be taken as "sufficient evidence that corrosion of the gas and water pipes is being caused by the tramway company."

**A Lavoisier Monument.**—In 1894 the Académie des Sciences opened an international subscription for a statue to Lavoisier, who met his death in 1794. The Committee now report that some £1,900 have been received, including £129 from English societies, and that subscriptions are still coming in. The execution of the statue has been confided to M. Barrias.

**Errata.**—On page 504 of our last issue the last five lines of "Two Sermons on Science" should read as follows, and not as rendered by the printer:—"but for all that we do not think the smart writer of 'The Superstitions of Science' would stake such reputation as he has on a reasoned denial that the next ethical 'revolution that really counts' will be *profoundly affected* by the discoveries and applications of science."

**Energy Losses in Electric Machines due to the Armature Current.**—Mr. Otto T. Bláthy writes us as follows under date, Rome, August 17th: "I have just seen *The Electrician* of August 7th, and am sorry that a very disagreeable printer's error has crept in, *i.e.*, in the footnote, where the word 'not' should be eliminated. Of course, the variations of the armature resistance in consequence of increase of temperature have always been taken into account, though the influence of this factor was very slight indeed."

**An American Bar-Contact for Electric Tramways.**—A current collector for electric traction purposes somewhat after the Siemens-Halske pattern has recently been put upon the market in America. In this device there is a roller about 3ft. long and 1¾in. in diameter. This roller is made of seamless drawn steel tubing, and is case-hardened. At each end of this tube is a cone made of case-hardened steel. The bearings consist of twelve ¼in. steel balls at each end of the roller, bearing between the two cones. The current is taken from the rod by means of small copper brushes secured to short pieces of brass tubing which revolve on the rod, thus preventing the current passing through the ball bearings and pitting the latter.

**Telephone Translators.**—In a short article in a recent issue of *l'Electricien*, M. E. Piérard has something to say about telephonic translating apparatus. The constitution of the magnetic circuit in such apparatus would seem likely, the author remarks, to play an important part; but it is not so, at any rate from the point of view of the transmission of speech. If we take two totally dissimilar translators, such as the "Van Ryssel-berghe" (consisting of two distinct coils at right angles, mounted on a soft-iron core), which has a primary resistance of 160 ohms and a secondary resistance of 600 ohms and the "Bennet," with its 150 and 300 ohm coils, and closed magnetic circuit, and if we telephone by their aid over, say, a 100-kilometre line, using the same transmitter, there is no appreciable difference in the result. On short lines, where, however, translators are not needed, a closed magnetic circuit instrument is found to be the better. M. Piérard, however, points out one advantage in using closed magnetic circuit translators: they are much superior for the purpose of transmitting magneto calls over interurban and long lines generally.

**Insulation of Grooved Armatures.**—The difficulties that have been experienced in insulating grooved armatures, and which have, in some measure, deterred manufacturers from using them, are held by Mr. William Baxter, jun., in the *American Machinist* of June 11th, to be not as formidable as has been imagined. It simply requires a recognition of what are really the weak points, to enable manufacturers to overcome all the difficulties, and to make the insulation as substantial and permanent with the grooved type as with the smooth core; and this without materially increasing the cost of construction. A U-shaped piece or trough of mica accurately fitting the groove for machines working with an electromotive force of more than 110 volts, and of proper thickness, is the best insulator for the sides and bottoms of the

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grooves. Sheet fibre rendered waterproof by saturation with paraffin will, however, answer well for machines used in buildings. The mica troughs can be made of thin plates of mica stuck together with copal varnish, tempered with raw linseed oil to make it tough. Other ways of using mica are described and illustrated in Mr. Baxter's article. He points out that the insulation is most likely to give out at the ends of the grooves, and presents a practical way of obviating this difficulty, closing with a statement of the necessary thicknesses of mica for machines working under different voltage.

**Electric Motors and Ventilation in Warships.**—Our contemporary, the *Engineer*, commenting in a recent issue on the antiquated methods of ventilating usual on our warships, makes the following remarks:—"The fan ought to be placed where room can be found for it low down in the ship—far below the water-line—and driven by electricity. The use of electricity in this way enables us to do what could not be accomplished before. We can place our fan where we like; the distribution of the air subsequently is but an affair of wind trunks. Until electricity was available each fan had to be provided with its own steam engine, and, to say nothing of the circumstance that the engine took up a good deal of space, there were dozens of situations quite suitable for a fan alone, but most unfit for a steam engine. An electrically-driven horizontal fan, with its motor, can be got into the thickness of a deck with its beams, if need be; and, indeed, small fans are used now to excellent purpose in various places on board ship. . . . We live in the hope that wiser counsels will prevail, and that by degrees the ludicrous and objectionable cowl will become as obsolete as the spritsail yard."

**Glasgow.**—The Glasgow Corporation Committee on Gas Supply and Electric Lighting have issued their annual report. The report, dealing with the fourth year of the Electric Lighting Department, stated that the gross revenue for the past year amounted to £25,862. 8s. 6d., and the gross expenditure to £11,589. 19s., and that, after accounting for depreciation, interest on loans, and additions to the sinking fund, there remained a surplus on the year's operations of £2,380. 19s., as against a deficiency of £1,527 last year. In view of that favourable balance the Committee recommend a reduction in the price of current, and charging on the Wright system, at the rate of 6d. per unit for the first hour of the maximum demand, and 4d. per unit afterwards. The Committee also recommend the discontinuance of the charge for meter hire, and that the price charged for each arc lamp should be reduced from £26 to £20 per annum. The number of consumers at May 31st last was 855, being an increase of 269 over the number at the same date in the previous year. The quantity of electricity sold during the past year to private consumers, irrespective of public lighting, was 866,606 Board of Trade units, being an increase of 24·11 per cent.

**Calcium Carbide.**—We learn that the Acetylene Illuminating Company have concluded arrangements with the British Aluminium Company, by which they will be able to erect works of several thousand horse-power for the manufacture of calcium carbide—using water-power. Pending the construction of such works, the Acetylene Company have obtained the use of a considerable portion of the spare water-power of the existing works of the British Aluminium Company at Foyers, and a carbide plant is now being erected there, which, it is expected, will be in full work during the month of October next. It is stated that the Acetylene Company have been making calcium carbide in this country on a fairly large experimental scale since the early part of 1895; but, as so much had to be learnt in the details of manufacture and as to the behaviour of acetylene gas under various conditions, they have not, until now, felt justified in erecting large works. Having now succeeded in regularly making a crystalline metallic carbide, free from dangerous impurities (such as exist in some specimens of foreign carbide which found their way to this country), and having satisfied themselves as to the gas being no more poisonous than coal gas—in fact less so—and that there is no danger of explosive compounds being formed in contact with metals, they have decided to go ahead with the manufacture on a large scale with water-power.

**Boiler Makers v. Fitters.**—In our issue of July 24th we commented upon the dispute then raging between the boiler makers and fitters engaged at Messrs. Thornycroft's works at Chiswick. The battle is now over, Sir Benjamin Baker, the arbitrator mutually agreed upon by the parties, having just given his award. Thirteen points were submitted to the arbitrator, but of these the crucial points were practically two. They related to the testing of the boilers; and in reference to this, Sir Benjamin Baker has decided that, while the work of fitting the boilers on to the testing apparatus shall be done by the fitters, the boiler makers shall be responsible for the testing. Thus, on these two points each side gains one. On the other eleven the decision is in favour of the boiler makers, but these were not seriously in question. The effect of the present arbitration is, it is stated, likely to be far-reaching. Not only have the points in dispute been settled, but an agreement has been arrived at between the two societies, setting forth the lines upon which all disputes as to demarcations of work shall in future be adjusted. It is proposed that certain shop delegates, duly elected, shall be in readiness when such questions arise to give them consideration, and to lay them before the firm or firms affected, the firm being allowed to make such arrangements as it may think best pending the settlement of the questions at issue. The two societies in the meantime will decide upon an arbitrator, whose decision shall be binding. All's well that ends well.

**Contemporary Electrical Science.**—*Il Nuovo Cimento* for July contains some very interesting contributions. A. GARBASSO writes about the discharge of a cathode by flame gases. The products of combustion of a candle give rise to exactly the same phenomena in the spark-gap as those produced by Röntgen rays and by ultra-violet light. They promote the discharge when impinging upon the cathode, but produce no effect upon the anode. If a glass plate is brought between the knobs so that the discharge can only just pass round the edge, a candle placed below the cathode on one side of the plate produces a shower of sparks, while when placed under the anode it stops the discharge altogether, if anything. This action is not due to the heat of the flame. The gases can be led up to the knob through a tube 40cm. long, and the tube can be immersed in cold water, without altering the effect. Besides, a current of hot air does not produce the effect described, whereas it may be brought about by the smoke from a cigarette. Signor GARBASSO suspects that the discharge produced by ultra-violet and X-rays may be a secondary effect, and may be due, as in the case of a flame, to the action of electrified particles in the shape of dissociated molecules.——Dr. MAIORANA gives the results of his studies of the effect of light upon the resistance of selenium. He finds that the effect is anything but "instantaneous." The resistance of a piece of selenium, with a normal resistance of 258,100 ohms, was lowered in the first second of illumination to 224,000, in the second to 212,000, and after that it gradually approached a limit of about 200,000 ohms. The recovery proceeded equally gradually.——We also find a description of the new system of electrical distribution patented by Profs. FERRARIS and ARNÒ. The system is to provide for the case when the same current has to be used for lighting and power to nearly the same extent. The ordinary alternate current is sent through the lamps, and the power portion is transformed so as to suit the requirements of polyphase motors. This is done by the "phase-difference transformers" designed by the inventors. These have primary and secondary coils, like ordinary transformers, but have, in addition, an intermediate rotating part, the motion of which is maintained in the same manner as that of the armature of an asynchronous single-phase motor. The principle utilised is that of two-phase motors, consisting of two coils crossed at right angles; or an armature returning upon itself. If an alternate current is sent through one of the coils, and the armature is made to revolve, the other coil gives an E.M.F. the phase of which is displaced with respect to the primary. Any desired displacement may be obtained by a suitable adjustment of the number of turns in each coil. The rotation only requires starting, and then maintains itself. This sounds suspicious, but it is easy to see where the energy comes from.

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## THE CAPILLARY ELECTROMETER IN THEORY AND PRACTICE.*

BY GEORGE J. BURCH, M.A.

(*Concluded from page 517.*)

I propose with a special apparatus to continue the investigation. Meanwhile, these experiments bid fair to lead to results of practical as well as scientific importance. Now that the familiar use of the telephone inclines us to regard its shortcomings in a more critical spirit, few persons would deny that it caricatures rather than reproduces the tones of the voice. The reason is not far to seek. We are dealing with an instrument capable of responding to a large number, but not all, of the vibrations concerned in speech-sounds. More-

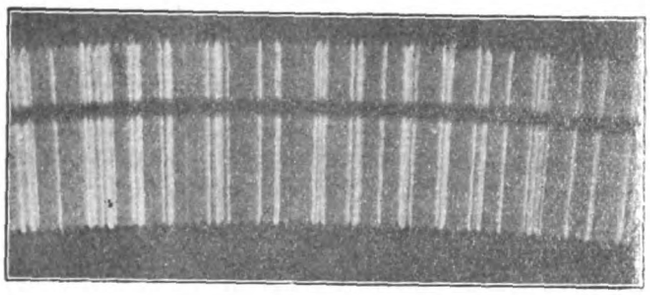

FIG. 21.—Curves given by a small Inductor Alternator making 400 complete periods per second.

over it reproduces them, not with the same, but with different relative intensity. As in the Jew's harp we reinforce by resonance certain harmonics of a fundamental tone, so in the telephone—and also in the phonograph—we bring out the harmonics of the diaphragm. These experiments suggest the possibility of improving the telephone by the use of several diaphragms of different dimensions. They have an interest also to the student of phonetics. The curves obtained by my method differ from those of Prof. McKendrick and Prof. Hermann in the relative amplitude of the slow and rapid vibrations. In the present stage of the investigation it is not possible to say which is nearer the truth, but, unquestionably, such work are not great in a laboratory devoted to physiology, but I was able to do sufficient to convince myself of the possibility of using the capillary electrometer for this purpose.

In Fig. 21 are shown the curves given by a small inductor-alternator with a frequency of 400 per second. Such curves are, of course, too small to be analysed individually, but the maximum E.M.F. of each could be easily measured. But the electrometer would stand currents a good deal stronger; and even without putting any greater pressure upon it, by increasing the velocity of the plate, which in this particular instance was only 60cm. per second, a curve could easily be produced

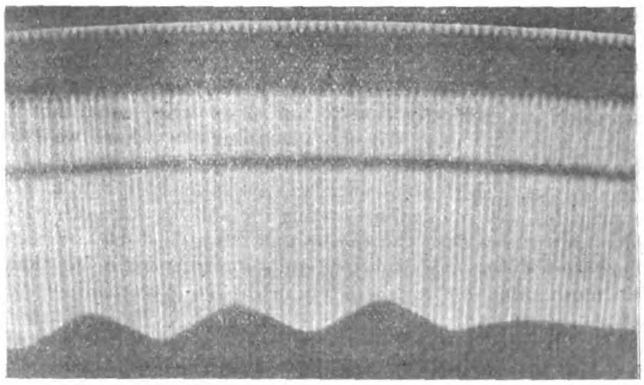

FIG. 23.—Inductor Alternator running slowly and making 30 periods per second.

on which eight or ten determinations of P.D. could be made for each period, as in the case of the photograph of microphone currents reproduced in Fig. 20.

The next example, Fig. 22, is taken from a very poor photograph, but an exceedingly interesting one. It was taken after altering the adjustments of the inductor-alternator so as to throw it a little out of truth. The change was very slight, but it is recorded with unmistakable plainness upon the plate, a periodic rise and fall of potential, corresponding to a complete revolution of the armature-shaft, being superposed upon the more rapid alternations due to the passage of the pole-pieces past the magnets. The importance of this result can

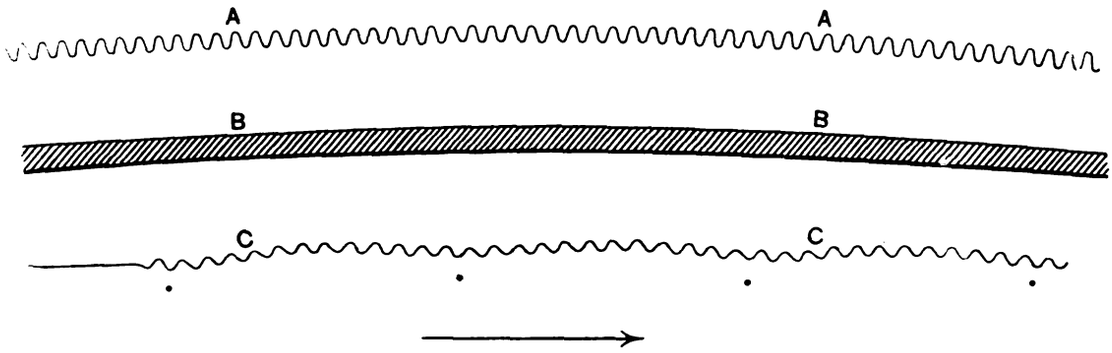


FIG. 22.—Enlarged Reproduction of Curves given by the Inductor Alternator with the Armature Shaft set so as not to run true. Shows a rise and fall of potential corresponding to each revolution, in addition to the rapid alternations due to the passage of the pole-pieces past the magnets.
A is the time record given by a tuning-fork making 500 double vibrations per second. B is the shadow of the signal-key. C is the outline of the electrometer curve. The dots mark the completion of each revolution.

in all such researches it will be necessary to take into account the characteristics of the recording apparatus to a greater degree than has been done hitherto.

But the main interest to myself is the proof they afford of the extraordinary rapidity of the response of the capillary electrometer to alternating currents. Evidently the limit of its capabilities has not yet been reached, and these results, even though they should have no further application, imply that confidence may be placed in the photographic records of less rapid changes.

The success of the experiments with the telephone induced me to photograph some dynamo currents. The facilities for hardly be over-estimated. It confirms the evidence afforded by the experiments with the telephone, particularly that in which the wavering of the voice when fatigued was recorded (Fig. 16). But whereas in that case the degree of correspondence between the variation of the sound and of the photographed curve could only be judged by memory, in this photograph of alternating currents it can be tested by observing that the number of serrations in each period corresponds precisely with the number of field magnets in the cycle.* I am continuing my experiments in this direction, and will for the present confine myself to the expression of my conviction

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MSS. received October 17, 1895

* Fig. 16 illustrates the interference of two vibrations of nearly equal period, but Fig. 22 is the result of compounding two cycles of P.D., one slow and the other rapid.

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that this use of the capillary electrometer will be of great service in dynamo investigations.

Fig. 23 shows the current curves of the same inductor-alternator driven at a slower speed, and giving about 30 double alternations per second. Were it not for the imperfection of the photograph, due to the spitting of the arc lamp, which was a very poor one, these curves could easily be measured and the E.M.F. determined for each two-thousandth part of a second. The electrometer was kept on short circuit until after the plate had reached the slit, and the interval between the fall of the signal and the commencement of the curve is due to the delay of the auxiliary magnet, by which the key was opened and the current thrown in. It should be noticed that the *average level of the mercury in the capillary is not altered* by the action of an alternating current not too powerful for the instrument to bear with safety.

This is not the case with the next photograph (Fig. 24), taken with an ordinary lecture-table dynamo fitted with a Siemens shuttle armature, and driven by a water motor. The current was sent through a non-inductive resistance, and a derivation led to the electrometer, which was kept on short circuit until the plate had reached the slit. The result shows the effect of suddenly throwing in a pulsating direct current. The curves look very much like those of the alternator, but a closer inspection shows that the descents are not so steep as the ascents for the first few periods, and that consequently the meniscus *mounts*.

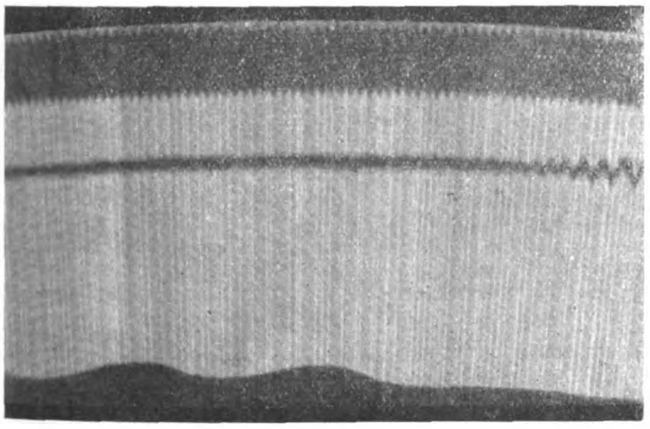

FIG. 24.—Curves given by a Shunt wound Dynamo with Siemens Shuttle Armature, making about 10 revolutions per second.

In Fig. 25, in which the plate was driven more slowly, this is shown better. The mercury column rises steadily through a distance depending on the average P.D. between the ends of the derived circuit, and continues oscillating about this new level. At first sight this might seem to indicate that the E.M.F. never falls to zero, but on analysing the curves by the method I have described it is found that at a certain point on the descent of each the downward velocity of the meniscus indicates an E.M.F. exactly equal and opposite to the P.D. corresponding to the height of the mercury above the zero line, showing that the current actually falls to zero twice during each revolution of the armature.

It remains to describe briefly a method of observation which I had in view, but which Prof. Wedensky had quite independently discovered and perfected before I put my own idea into execution.

It is not always convenient, or, indeed, possible to use the photographic method. Prof. Wedensky has supplied us with a means of observing the phases of a rapidly recurring cycle of electromotive changes without recording them. His apparatus, which was designed for physiological work, is equally applicable to the study of dynamo currents. It is an adaptation of the familiar principle of the zoetrope. The microscope used for observing the capillary electrometer is illuminated by a series of flashes, nearly, but not quite synchronous with the cycle of electromotive changes under observation. Thus, although the meniscus is in rapid motion, the observer sees it only during a definite small period of each excursion. The stroboscopic disc, by which the illumination is interrupted, may be either driven at a slightly slower speed, or fitted with an arrangement by which it can be given a definite amount of lag, variable at will. In this way, by a series of separate observations, the electrometer curve for the entire cycle can be plotted down. But it must not be forgotten that in this case, as with the photographic records, the distance through which the mercury is observed to have moved above or below its zero-point is *not* proportional to the actual P.D. between the terminals at the instant of each flash. To ascertain the true variation of P.D. with Prof. Wedensky's apparatus, it would be necessary to plot a curve from a large number of observations, and then analyse it in the manner described in this Paper. And the analysis of a plotted curve is neither easy nor satisfactory. Still, I have no doubt that the stroboscopic method will prove of service in cases where photography may not be practicable.

In conclusion, I would recommend the capillary electrometer to the notice of electricians for two reasons. It is the cheapest form of electrometer that can be made. When it has received the attention it merits, I have no doubt it will become as familiar an instrument as the thermometer. The construction is so simple that even if it should be broken a new one can be made, unless the operator is very unfortunate, in less than an hour. It is essentially the instrument for those who have to think twice before spending a shilling. But it has qualities of its own distinct from those of any other form of electrometer or galvanometer, and these will make it a valuable addition to the most perfectly appointed laboratory. I have described the method by which these special properties may be utilised, and some of the apparatus I have designed for the purpose during the nine years I have worked with the instrument, in order if possible to bring it into general use. For the same reason I have refrained from patenting any part of it, preferring to present my discovery and invention to the scientific public. The same method may be applied not only to the capillary electrometer, but to any form of electrometer or galvanometer, or thermometer, or other measuring instrument, the movement of which is either dead beat or governed by a known law. The motion of the recording surface may be rectilinear or circular. The surface itself may be flat or developable. It may be propelled with uniform velocity or with uniform acceleration by any of the devices used for such purposes and known to scientists. The motion of the plate may be continuous, and the exposure may be given by opening and closing the shutter during the passage of the whole or a part of the sensitive surface. Several methods are available for determining with the requisite accuracy the exact moment of the experiment. For slow speeds diffused daylight or a lamp will serve, while for higher velocities the limelight, or magnesium, or the electric arc or sunlight must be employed; in short, the methods and apparatus by which labour is lessened and improved results obtained in other

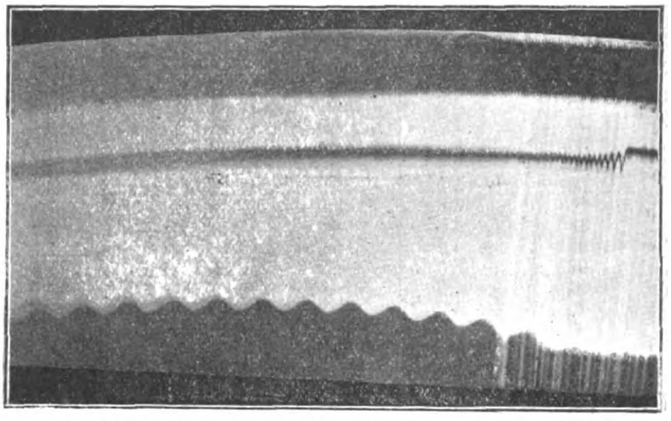

FIG. 25.—Curves given by a Shunt-wound Dynamo with Siemens Shuttle Armature, making about 10 revolutions per second, taken on a slowly moving plate. Note the rise of the meniscus, which does not occur when an alternating current is used.

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branches of photography are applicable to this. From the records so obtained the derived curve may be calculated or drawn either in the way I have described, or by means of any known device for differentiating curves, and for certain purposes the same process may be repeated on the derived curve itself. The apparatus has already done good service in physiology, and it now remains to extend its application to other departments of science.

*Note added July 2, 1896.*

The following detailed analyses of the photographed curves of two dynamos, one giving an alternating and the other a pulsating current, will illustrate both the practice of the method and its applicability to the study of motors and generators. By far the greater number of curves I have measured relate to the physiology of muscle and nerve. Most of them are as yet unpublished, but several are discussed by Prof. Burdon Sanderson in the *Journal* of Physiology, Vol. XVIII., pp. 117-159.

*No. 52, B.—Analysis of a Portion of the Curve given by the Inductor Alternator, while making 24 periods per second, with the armature-shaft set as in Fig. 22 so as not to run true. The values of* $N+k\,\Delta R$ *in the last column are directly proportional to the E.M.F.*

| T. | ΔR. | $k\Delta R$. | N. | $N+k\Delta R$. |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 68 | +10·0 | +2·0 | - 1·0 | + 1·0 |
| 70 | + 8·5 | +1·7 | - 12·0 | - 10·3 |
| 72 | + 7·5 | +1·5 | - 18·0 | - 16·5 |
| 74 | + 5·5 | +1·1 | - 19·8 | - 18·7 |
| 76 | + 3·5 | +0·7 | - 19·2 | - 18·5 |
| 78 | + 1·5 | +0·3 | - 18·7 | - 18·4 |
| 80 | - 0·5 | - 0·1 | - 17·5 | - 17·6 |
| 82 | - 2·0 | - 0·4 | - 15·5 | - 15·9 |
| 84 | - 3·0 | - 0·6 | - 11·5 | - 12·1 |
| 86 | - 3·8 | - 0·8 | - 8·5 | - 9·3 |
| 88 | - 4·5 | - 0·9 | - 3·0 | - 3·9 |
| 90 | - 4·5 | - 0·9 | + 2·0 | + 1·1 |
| 92 | - 3·8 | - 0·8 | +15·0 | +14·2 |
| 94 | - 2·5 | - 0·5 | +15·4 | +14·9 |
| 96 | 1·0 | - 0·2 | +16·0 | +15·8 |
| 98 | + 0·3 | +0·1 | +16·0 | +16·1 |
| 100 | + 1·5 | +0·3 | +16·5 | +16·8 |
| 102 | + 3·5 | +0·7 | +16·0 | +16·7 |
| 104 | + 4·8 | +1·0 | +15·5 | +16·5 |
| 106 | + 6·0 | +1·2 | +14·5 | +15·7 |
| 108 | + 7·5 | +1·5 | + 7·5 | + 9·0 |
| 110 | + 8·0 | +1·6 | + 2·0 | + 3·6 |
| 112 | + 7·5 | +1·5 | - 12·0 | - 10·5 |

The portion given includes a complete period. The photograph is similar in appearance to Fig. 23, which was taken on the same day, viz., August 15, 1895. Owing to the spitting of the arc lamp, the negative is ribbed, making accurate measurement impossible. In this, as in the next example, $\Delta R$ is measured from the position of zero-potential. With the alternating current $\Delta R$ changes sign, as does also N, although not simultaneously.

The curve of which the analysis is given in the next column was a duplicate of that reproduced in Fig. 24, and was photographed on August 15, 1895. The electrometer employed for these dynamo experiments was not the same as that referred to in the earlier part of the Paper, so that different constants are used in the calculation. The nominal E.M.F. of the dynamo was about 4 volts. The current was sent through a non-inductive resistance, from which a derivation led to the electrometer. As the exact value of this derivation was not ascertained, I have not reduced the subnormal readings to volts, but roughly 1cm. on the subnormal $=0{\cdot}25$ volt at the brushes.

In both cases the first column shows the time, T, in thousandths of a second, from an arbitrary zero.

In the second column, $\Delta R$, the distance of the meniscus from the position of zero-potential, is given in units of a scale of which 50 divisions $=14{\cdot}1$mm. on the photograph. This scale, which was ruled on glass, was fixed close to the wire G of the measuring apparatus (Fig. 13). The zero of its image was made to coincide with the position of zero-potential on

*No. 54, B.—Analysis of Curves given by a Shunt-wound Dynamo with Siemens Shuttle Armature, making about 700 revolutions per minute, and generating a pulsating current.*

| T. | ΔR. | $k\Delta R$. | N. | $N+k\Delta R$. |
|---|---|---|---|---|
| 0 | 35·0 | 7·00 | 0 | + 7·00 |
| 2 | 35·0 | 7·00 | + 2·3 | + 9·30 |
| 4 | 35·4 | 7·08 | + 3·7 | +10·78 |
| 6 | 35·9 | 7·18 | + 6·7 | +13·88 |
| 8 | 36·8 | 7·36 | +10·5 | +17·86 |
| 10 | 37·8 | 7·56 | +14·0 | +21·56 |
| 12 | 39·3 | 7·86 | +14·7 | +22·56 |
| 14 | 40·6 | 8·12 | +13·5 | +21·62 |
| 16 | 41·4 | 8·28 | + 9·5 | +17·78 |
| 18 | 42·3 | 8·46 | + 7·0 | +15·46 |
| 20 | 42·8 | 8·56 | + 4·7 | +13·26 |
| 22 | 43·2 | 8·64 | + 2·5 | +11·14 |
| 24 | 43·4 | 8·68 | 0·0 | + 8·68 |
| 26 | 42·9 | 8·58 | - 2·5 | + 6·08 |
| 28 | 42·3 | 8·46 | - 7·0 | + 1·46 |
| 30 | 41·0 | 8·20 | - 8·2 | + 0·0 |
| 32 | 40·3 | 8·06 | - 8·0 | + 0·06 |
| 34 | 39·9 | 7·98 | - 7·5 | + 0·48 |
| 36 | 38·9 | 7·78 | - 6·6 | + 1·18 |
| 38 | 38·4 | 7·68 | - 5·0 | + 2·68 |
| 40 | 38·0 | 7·60 | - 4·0 | + 3·60 |
| 42 | 37·9 | 7·58 | - 2·0 | + 5·58 |
| 44 | 37·9 | 7·58 | 0·0 | + 7·58 |
| 46 | 38·0 | 7·60 | + 3·0 | +10·60 |
| 48 | 38·5 | 7·70 | + 5·6 | +13·30 |
| 50 | 39·2 | 7·84 | +12·0 | +19·84 |
| 52 | 40·4 | 8·08 | +15·4 | +23·48 |
| 54 | 41·9 | 8·38 | +16·5 | +24·88 |
| 56 | 43·5 | 8·70 | +12·6 | +21·30 |
| 58 | 43·9 | 8·78 | + 8·5 | +17·28 |
| 60 | 44·6 | 8·92 | + 3·5 | +12·42 |
| 62 | 45·0 | 9·00 | 0·0 | + 9·00 |
| 64 | 44·9 | 8·98 | - 1·5 | + 7·48 |
| 66 | 44·7 | 8·94 | - 2·7 | + 6·24 |
| 68 | 44·4 | 8·88 | - 4·0 | + 4·88 |
| 70 | 43·9 | 8·78 | - 6·3 | + 2·48 |
| 72 | 43·3 | 8·66 | - 8·0 | + 0·66 |
| 74 | 42·5 | 8·50 | - 8·5 | + 0·0 |
| 76 | 41·6 | 8·32 | - 7·5 | + 0·82 |
| 78 | 40·9 | 8·18 | - 6·7 | + 1·48 |
| 80 | 40·4 | 8·08 | - 5·5 | + 2·58 |
| 82 | 39·9 | 7·98 | - 4·5 | + 3·48 |
| 84 | 39·4 | 7·88 | - 2·2 | + 5·68 |
| 86 | 39·1 | 7·82 | - 0·2 | + 7·62 |
| 88 | 39·4 | 7·88 | + 3·0 | +10·88 |

N.B.—Here $\Delta R$ (and $k\Delta R$) remains continually positive, but fluctuates in value, while N not only fluctuates, but changes sign.

the plate, and the value of $\Delta R$ was read off upon it as each successive point on the curve was brought over the wire for the determination of the subnormal. I find this method more accurate and more convenient than that previously described.

The third column shows the value of $\Delta R$ in terms of the subnormal. The constant multiplier ($k=0{\cdot}2$) is found by taking the ratio of the difference between any two values of $\Delta R$ and the difference between the corresponding values of N upon the normal excursion (Fig. 11). This ratio is constant if the electrometer is a good one.

The fourth column gives the subnormals N at the points measured, reckoned as positive if the meniscus is rising and negative if it is falling.

The last column is directly proportional to the E.M.F., and shows how it falls to zero twice in each revolution of the armature, although the photographed curve remains continually above zero. It is interesting to note in No. 54 B, the way in which the negative value of the subnormal balances the positive E.M.F. indicated by the position of the meniscus on both occasions, and how the actual zero lags behind the zero of the subnormal. On examining the machine I found that the armature was not centrally situated between the field-magnets, and that its poles were not symmetrical, so that once in each revolution it came very near to one of the horns. Something of this kind is indicated by the curve of the E.M.F., which is more peak-shaped in one half than in the other. On plotting this curve I find that the areas of the two halves corresponding to the two faces of the armature coils are in the proportion of 195 to 206. This divergence from equality may be due to the fact that the brushes are not

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exactly 180deg. apart, and the two halves of the commutator are not quite equal. The smaller area belongs to the steeper curve.

I am at present engaged upon a modification of this method. The sensitive plate is mounted as a disc upon the armature shaft, or a shaft revolving synchronously with it, and the image of the capillary is projected upon it, as in my pendulum machine, the whole being enclosed in a camera with an automatic arrangement for exposing the plate at any given time during a single complete revolution. I propose to employ various well-known ways of connecting the whole or part of the armature coils with the electrometer circuit, with a view of obtaining polar diagrams of E.M.F. by analysing the photographic records.

## THE NIAGARA FALLS ELECTRIC LIGHT AND POWER STATION.

BY ORRIN B. DUNLAP.

It is doubtful if another electric-light station in this country possesses the novel features found in the plant of the Buffalo and Niagara Falls Electric Light and Power Company, of

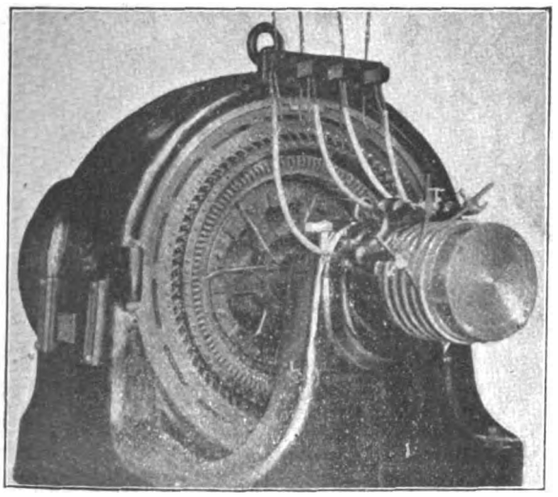

FIG. 1.—One of the two 300 H.P. Two-Phase Westinghouse Motors in the Niagara Falls Lighting Station.

Niagara Falls, N.Y. This name is apt to mislead some people to believe that the Company has to do with the lighting of the city of Buffalo; but the fact is, Buffalo capital is interested in the plant, and they have tacked on the name of their city to

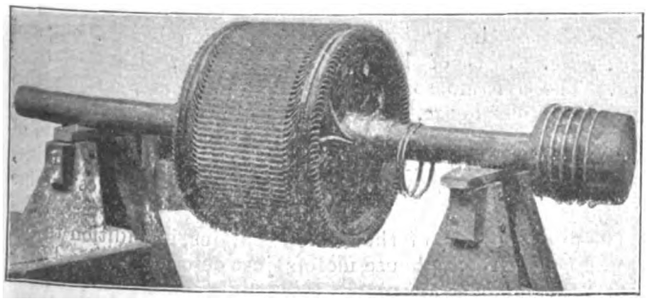

FIG. 2.—Rotor of 300 H.P. Two-Phase Westinghouse Motor.

that of the name of their Company, their franchise giving them rights in Erie and Niagara counties.

The especially novel feature of this plant consists in the fact that the controlling Company buy current as well as sell it. This is so, because they purchase electric power from the Niagara Falls Power Company, both for the operation of their plant and also for distribution to their customers. This arrangement is made especially advantageous, because the electric-light station in question is located at the back of Buffalo Avenue, almost opposite the power house of the Niagara Falls Power Company.

The two-phase alternating current purchased comes to the electric-light station over four cables, each about 1in. in diameter, laid in a tile conduit about 8ft. underground. Three manholes are placed along the course of this conduit on Buffalo Avenue, and there are also other manholes on the Company's

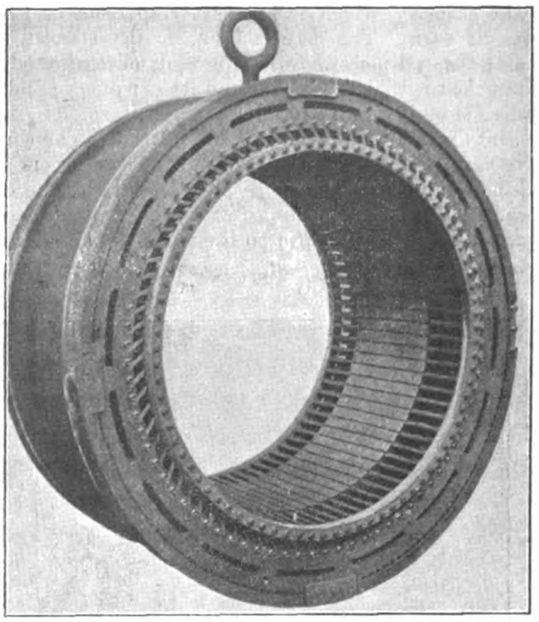

FIG. 3.—Stator of 300 H.P. Two-Phase Westinghouse Motor.

lands. As it extends along Buffalo Avenue the conduit is composed of several 3in. tiles, to provide for other cables as the future may demand; but on the Company's land the conduit is formed of one 8in. tile, in which the cables are laid. These

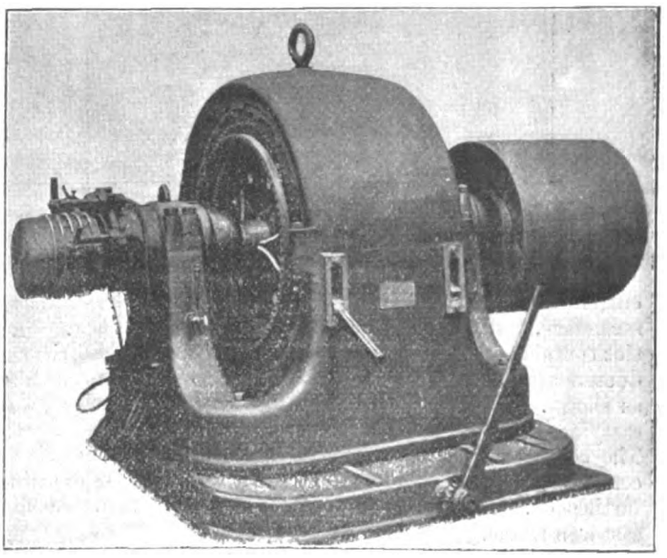

FIG. 4.—General View of 300 H.P. Two-Phase Westinghouse Motor.

cables enter the lighting station on the east side, and immediately after passing the wall are brought to the surface, and extend up the wall, across the ceiling, through a second wall, into the dynamo room, where they descend to the switchboard. This switchboard has recording kilowatt-hour meters, and is in direct connection with the power house of the Niagara Falls Power Company.

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The switchboard controls the current supplied to the 300 H.P. motors in use in this station, which are truly wonderful machines. These are two in number, and were made by the Westinghouse Electric and Manufacturing Company of Pittsburg, Pa., which Company also built the large generators for the Niagara Falls Power Company that supply the current. Standing in the station, these motors attract much attention. Fig. 1 shows one of them in the station. The motors are of the self-starting induction type, designed to operate at a speed of 500 revolutions per minute when supplied with current of 3,000 alternations per minute and 2,000 volts pressure. In Fig. 2 the primary, which is the revolving element in these machines, is seen. The core is 36in. in diameter, and 14in. long inside the end plates. It is built of laminated steel; each disc is punched with 120 slots around its periphery; and these discs, when superimposed one upon another, form longitudinal grooves, into which the conductors are placed. The core contains five ventilating ducts, $\frac{3}{8}$in. wide. The conductors consist of machine-wound coils, separately insulated with fuller-boards and mica. The winding is tapped at suitable points, and the leads pass through the shafts to the rings, which receive the current from the brushes. In Fig. 3 is displayed the stationary secondary, which is also built up of slotted steel discs. Each slot contains one rectangular copper conductor, and all the conductors are secured to an iron ring on each side of the machine, as shown. Outside the iron rings are two copper rings, each carrying 82 small copper brushes, one for each conductor. The copper rings are rotated so as to either connect or disconnect the brushes and the conductors, as is explained further on. Fig. 4 shows the two elements mounted in a cast-iron frame.

The machine is started as follows:—The copper brushes mentioned above being disconnected from the conductors in the secondary, the switch through which current is supplied to the collector rings is closed, and the motor starts. As soon as a fair speed is attained one side of the secondary is short-circuited through the copper ring by connecting the copper brushes with the secondary conductors. This is accomplished by means of a ratchet movement and the handle shown in Fig. 4. Then the other side of the secondary is short-circuited in the same manner. The object of the short-circuiting device is to limit the flow of current when starting. The iron ring, being of comparatively high resistance, prevents the induction of very large currents in the secondary, which, when the primary is at rest, acts precisely as the secondary of a transformer; and therefore if the secondary conductors were short-circuited by the copper rings when the switch was thrown in, the primary current would be excessive. It will readily be seen that these motors are one of the novel features of the Niagara Falls lighting station.

It was in October, 1893, that the Brush Electric Light and Power Company was succeeded by the Buffalo and Niagara Falls Electric Light and Power Company, the plant then being located on the lands of the Niagara Falls Hydraulic Power and Manufacturing Company. In March, 1892, the two former villages of Niagara Falls and Suspension Bridge had been merged into one incorporation—the City of Niagara Falls—and the new Company prepared to give a service such as befitted the Power City of the world. The present fine station was erected in the summer of 1894. This was operated by steam until March 22, 1896, when current was first taken from the Niagara Falls Power Company.

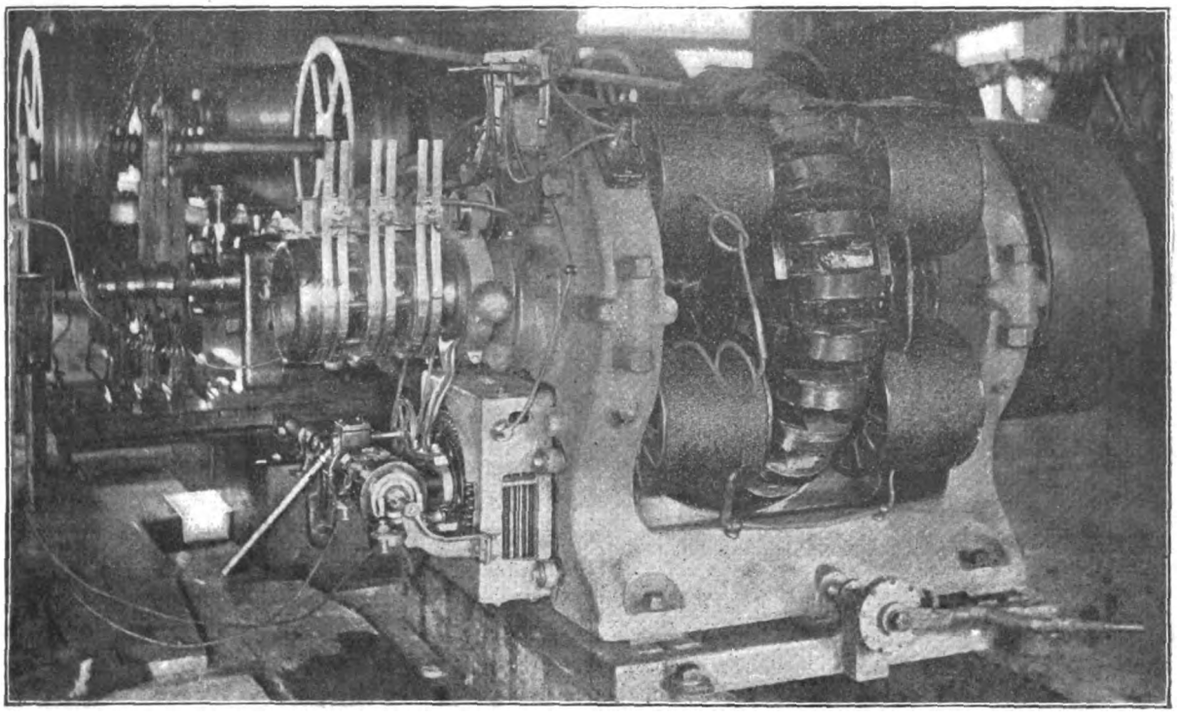

FIG. 5.—Brush Arc Light Machine at Niagara Falls (100-lighter).

The size of the station at the foundation is 95ft. long and 62ft. wide. It is of brick, one story high, with steel truss roof. The dynamo room is 60ft. by 60ft., and besides this there is a boiler house, office quarters, oil room, machine shop and store rooms. The steam plant of the station consists of two boilers of 175 H.P. each, one 350 H.P. Corliss engine, 24ft. by 43ft., and one 12ft. by 12ft. John T. Noyes' engine of 100 H.P.

The dynamo room of the station contains, in addition to the two 300 H.P. Westinghouse motors just described and a 4,000-light Westinghouse alternator, also four steam-driven 100-light Brush 5,000 volt machines (*see* Fig. 5), one 60-light Brush machine and an additional switchboard for the city circuits. These Brush machines are all new, having but recently been installed. The addition of these machines, together with the Westinghouse motors, places the equipment of the station on a very modern basis. These Brush machines are of the open coil variety, built on the general lines of the old type designed by Mr. Brush in 1877 and 1878. However, instead of being two-pole these later machines are four-pole, having 24 bobbins on the

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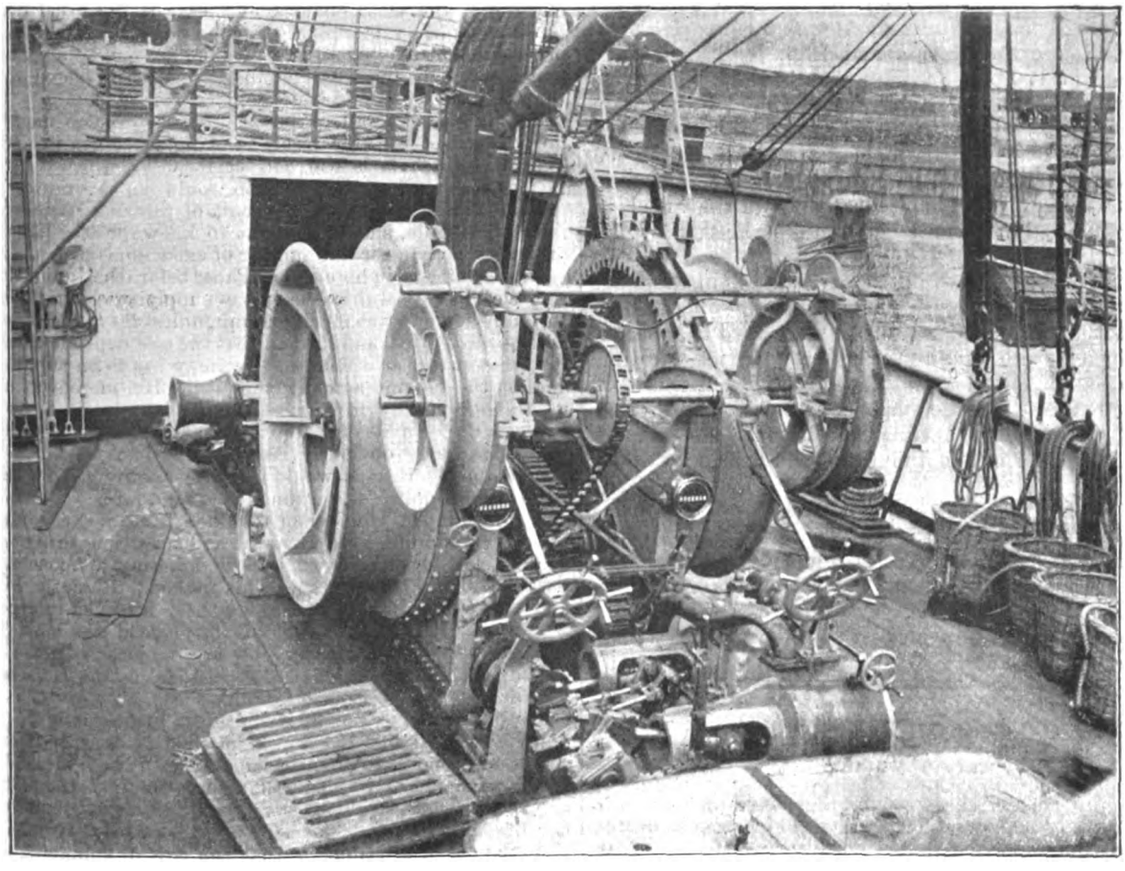
armature, the armature being connected in a manner permitting the use of two brushes instead of four to a ring. The machine has 12 shaft wires, four bobbins being connected in series to two segments. The commutator is composed of three rings, each ring having eight segments. The commutator body is of iron, surrounded by insulating material covered with mica. Thus it is impossible for any portion of the commutator to become charred unless the mica is destroyed. The body of the armature is built up on a solid cast ring. The field spools are eight in number, and placed over the steel magnets in the ordinary manner.

Besides the alternating current used for the big motors in their station, the Buffalo and Niagara Falls Electric Light and Power Company buy direct current from the Niagara Falls Power Company. This is explained by the fact that the first-named Company are the distributing agents of the last-named Company, and control the distribution of power beyond the limits of the Power Company's lands in and about Niagara Falls. The direct current so bought is sold for operating motors in machine shops, planing mills, bicycle repair shops, running fans in hotels, ice-cream establishments, &c.

## THE "TUTANEKAI."

The above-named vessel, which was built for the owners by Messrs. Dunlop and Co., of Port Glasgow, is designed for several purposes, the most important of which is the repairing of the New Zealand Government cables; and Messrs. Johnson and Phillips, of Charlton, who have supplied us with the following particulars, were entrusted with the complete outfit of apparatus, accessories and stores for this purpose.

The machine is built on two frames, made of steel plates with steel angles inside and outside, with welded corners; the drum shaft, which has large collars welded on for attachment to the frame, ties them well at the top; the forward bottom ends are tied by a steel plate and also by a flanged shaft, which carries the fleeting knives and takes the eyes of the main brake straps; there is also a T bar stay at the bottom after end, as well as diagonal stays at each end of the frames, thus making a very stiff job, and allowing of the whole of this part of the gear being lifted out in one piece, without fear



S.S. "Tutanekai" Paying-out and Picking-up Gear.

A novelty in the design of all the deck cable machinery and fittings is that it can all be easily removed, so that when the ship is not required for cable repairing the whole of it can be taken away and put into store, leaving the decks free. All the holding down bolt-holes are provided with sockets, into which plugs can be screwed so as to leave the deck perfectly watertight when the gear is removed.

The picking-up and paying-out machine (*see* illustration) is decidedly compact, though it is a double machine, and is designed to pick up cables under a strain of 20 tons; it only weighs 9¼ tons, and only occupies a deck space of 8ft. 3in. by 11ft. 6in. It is very similar in design to the gear recently fitted by the same firm on the Japanese Government steamer, except that it is not so powerful, and has horizontal engines instead of vertical.

of the shafts or bearings getting out of line. The machine is designed for two speeds, which can be geared on to either drum; but the port drum only is intended for the heavy lift of 20 tons, for which purpose it is built in steel, whereas the starboard drum is of cast iron. These drums are 6ft. 7in. diameter by 2ft. wide over all. They are internally geared, and have a rim cast on for the main brake, and so combine main drum, brake drum and gear wheel. These drums are arranged to run loose on the shaft, and are capable of many combinations with the gearing as follows:—(1) Both drums can work loose without the engine; (2) both drums can work at the same speed with engine; (3) one drum can be driven by engine, while the other runs independently; (4) one drum can be held by brake, while the other is being worked by engine; (5) power of both brakes can be put on to one drum.

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All wheels are arranged to draw out of gear where possible when not required for driving, so as to avoid rattling. In the case of the pinion which gears with the large drums, this necessitated cutting large holes in the frames, so that the pinion could pass right through them. The frames at these parts are provided with large circular cast-iron pockets, which carry bearings at each end, so that when the pinion is in work it is close up to a bearing, thus ensuring a very sound job. The brakes consist of steel straps with elm blocks attached, the ends of the straps being fitted with steel castings which carry nuts, with right and left hand threads to take the brake screws. The screws and rods are taken down to the after end of the machine, so as to be worked from the main deck. The lower part of the brake strap is fitted with a large cast-iron eye, which transmits the strain to the lower part of the machine frames by means of a steel shaft, which is secured to the frames by large cast-iron flanges.

The hauling-off gear is driven by chain from intermediate shafts, so that its speed is always proportionate to that of the drums. For holding-back purposes the sheaves have a brake rim cast on them, and on these rims a steel strap with screw adjustment is fitted, so that the amount of "drag" put on the cable can be adjusted minutely. The sheaves can slide along on their shaft to suit an inside or outside lead. A small Worthington pump is fixed between the frames to supply the main and holding-back gear brakes.

The engine has cylinders 9in. and 16in. by 10in. stroke, suitable for steam 160lb. per square inch, and it is complete with automatic bye-pass valve, steam valve, and link-motion reversing-gear, all of which, with the main and holding-back brakes, are within reach of one man at the after end of the machine. The gear was run under steam pressure at Messrs. Johnson and Phillips' Works, and also on board the vessel, to the satisfaction of the consulting engineers, Messrs. W. H. Preece and W. R. Culley.

The bow gear consists of two steel sheaves, 3ft. 2½in. diameter by 11½in. wide, which run loose on a steel shaft supported in cast-iron brackets, attached to three steel girders. Each sheave is provided with cast-iron whisker guards to prevent the cable getting off the sheave. The girders are fitted with eyes and bollards to secure the stoppers. A davit is provided between the sheaves for launching mushrooms, &c., and is arranged to fold down out of the way when necessary to let go the "bight."

The vessel is fitted with the usual dynamometer, lead wheels, deck leads, troughing, &c., and is fully equipped with a complete outfit of stores and accessories, including grapnel and buoy ropes, grapnels, mushrooms, buoys, chains, sounding shot, steam-sounding machine, steam-hauling gear, &c., and the testing room is provided with a set of first-class instruments.

## COST OF ELECTRICITY SUPPLY.*

BY ARTHUR WRIGHT.

No manufacturing undertaking can be considered to trade on a sound commercial basis unless it has ascertained to some degree of accuracy the cost of supplying the commodity it produces. That the electricity supply business at present can hardly be said to pass this criterion of commercial soundness the author thinks will be generally admitted, when it is remembered that although electricity has been regularly supplied for over five years from many large undertakings in quantities exceeding a million units annually, yet at the present time no very definite basis has been agreed upon by which the cost of energy wasted in feeders, transformers, shunted meters, &c., can be estimated, or on which to arrange tariffs for such varying classes of consumers as street lamps, motors, business premises, electric tramways and other industries consuming the electric current.

To illustrate this great diversity of tariffs and presumably the uncertainty as to the true basis for cost calculations, the author points out that in many towns discounts are given in proportion to the amount of electricity consumed, thus assuming that the cost of supplying electricity depends mainly on the quantity taken. In other towns rebates are given on the basis of the time of the day during which the electricity is consumed, or on the lengthened use of the lamps or plant consuming or producing the electricity. Again, in others, the electricity consumed in motors is charged at a different rate to that consumed in lamps, implying thereby that it costs less in the one case than in the other. Curious instances of the uncertainty of opinion on this subject, which is of the first importance to central-station managers, are afforded by the varying and often quite arbitrary figures charged for the electricity consumed in public street lamps, and by the compiler of electricity works costs in a largely circulated technical journal, who, in estimating the profit or loss made on the supply to public street lamps, has actually to assume the cost of the electricity to these is the same as the average cost of all the electricity supplied from the central station.

A commercial undertaking supplying only one commodity such as electricity, ought surely to be able to show from its books where and how the profits or losses are made. Hitherto, however, central stations have had to be judged as to whether they are successful or not, solely on the net results of the year's trading, irrespective as to whether the profits or losses were made from all the consumers or from only a portion of them, because no proper method of keeping the profit and loss account has been as yet agreed on among central-station managers.

The question now naturally arises, is there not some easy and practical method for doing away with the continued guess work at the cost of supplying electricity to the varying classes of consumers which is so often resorted to, and with the present great diversity of systems of tariff?

Of the many proposed methods devised for arriving at a solution of the complex problem of determining the cost of supplying electricity, the most obvious and easy is the usual one adopted by most of us—viz., that of dividing the total annual expenditure or the amount debited to the revenue account of a central-station undertaking by the total number of units delivered to the consumers, and to accept this actual average cost per unit as a sufficient guide for all purposes. Many business men, however, now recognise that this result is of no more use in deciding the question of which is the correct tariff by which to charge the various classes of consumers than would be, to a railway manager, the knowledge of the average cost of carrying passengers on his railway per mile, should he want to know for how little he could profitably carry a certain number of excursionists on a given day.

Dr. Hopkinson, in his classical Paper before the Junior Engineers,* very clearly proved that the cost of supplying electricity cannot be correctly defined at so much per unit, unless *the rate of supplying* that unit be also stated, and showed that the cost depends much more on the greatest rate at which the electricity has to be supplied than it does on the amount actually supplied. He, moreover, urged that it was both morally unjust and commercially inexpedient to always charge a uniform rate for a manufactured commodity which in one case might very obviously require ten times as much plant for manufacturing it as it would in another, owing to its having possibly to be supplied at ten times as great a rate.

The results Dr. Hopkinson obtained from the very bold method of analysis adopted were so novel and surprising that perhaps this may account for so many of us still ignoring his conclusions, and partly doubting the accuracy of his method. Recently, Mr. Edison and Mr. W. J. Greene, in America, have attacked this problem in a very practical spirit; and the last-named gentleman has still further developed the theory on the subject, with the result of arriving at practically the same conclusions as Dr. Hopkinson as to the correct basis on which to frame electricity charges. As far as the author is aware, no one has hitherto made public the results of applying the original Hopkinson method to actual accounts. He therefore proposes to describe modifications of the method, and the results of analysing by them the figures obtained from the central-supply station with which he is most conversant, namely, that of the Brighton Corporation.

At the onset, he stipulates that the cost of supplying electricity shall be understood to be the sum of all the items necessarily debited to the undertaking's net revenue account, or that it is equal to the amount of revenue the undertaking must earn per annum for it to be considered self-supporting. In the next place, it must be understood that the methods adopted are only really applicable to stations which have got into full working order and which are not either over-capitalised or much too large for the actual business done, but which can be extended as soon as the increase of demand will warrant same; and in such a business as that of electricity supply, it is essential for commercial reasons to assume the supply is taken by all classes of consumers for at least one year, when estimating the total cost of supplying these classes. If monthly or quarterly statements be made of the total expenses and charges debited to the revenue account of a central-supply station, the most careless observer cannot fail to notice how very slightly the total expenditure varies during the different months of the year, although the output or sale of units during the different months may vary as much as threefold. A comparison of these monthly or quarterly statements during a period when the output

* Paper read before the Municipal Electrical Association, June, 1896.

* See *The Electrician*, November 11, 1892, Vol. XXX., p. 29.

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has considerably varied furnishes, in the opinion of the author, the most correct and simple method for determining those portions of the total cost of supplying electricity which vary with the number of units sold, and which are conveniently called "running costs" in contra-distinction to the "standing-by cost," and the method by which the cost of supplying any class of consumers can be approximately ascertained.

In the first place it may be observed that, as regards the above divisions of the total expenditure into the two classes of running and standing-by costs, in actual central-station practice only the following items can be properly included under the head of *running costs*—coal, oil, water and a few other engine stores, besides those repairs to the steam and electricity generating plant which are caused by the continued supply of electricity to consumers.

Under *standing-by costs* must be included all coal and oil used in getting up steam and in keeping the machinery and mains in a position to supply electricity to the consumers at any time, also all other stores used in the station or on the mains, all the wages debited to revenue account, as in practice these do not vary from month to month with the output of electricity, repairs to buildings, mains, meters, and those repairs to plant, &c., which are due to it having to be kept in a position to supply electricity, all rates and taxes, management expenses, insurances and all provisions for redemption of capital and interest on same, and for the creation of any reserve or depreciation fund it may be decided to form for the purposes of preventing any cessation of the supply at any future time.

Of the above items constituting the running and standing-by costs, the only ones which are not capable of being at once debited to the proper division are the coal, stores, and repairs of plant, but the two first of these can be very fairly divided by the use of the following simple method, which its accompanying formula will explain and justify. Let T represent the total expenditure on these items during one month or period of time when the sale of electricity U is great, and T′ that for another period of preferably the same year when the sale U′ is much less. Let S be the cost of the two items coals and stores which have to be used during each of the two periods on account of having to get ready and to stand by, and R the running cost per unit it is desired to determine.

Then by the definition, as $T = S + R \times U$

and $$T' = S + R \times U'$$

then $$T - T' = R \times (U - U')$$

therefore, $$R = \frac{T - T'}{U - U'}$$ and $S = T - R \times U$ or $T' - R \times U'$,

or the average cost per unit of continuing to supply electricity during these two periods is the difference of the total expenditures divided by the difference of the sales in the two periods.

With regard to the item of plant repairs due to continued supply, as these repairs are of an accumulative nature, it is advisable to divide the total of all items of repairs obviously due to having to continue generating electricity from the commencement of the supply by the total number of units since supplied, the quotient will be then a fair valuation of the running cost per unit for plant repairs.

To illustrate the above method of apportioning items involved both on account of running and standing-by, the following statement referring to the figures of the Brighton undertaking will be of use:—

| — | The amount spent in coal. | Engine stores. | The units sold during these months. |
|---|---|---|---|
| In the three months of October, November and December, 1895... | £990 | £201 | 366,040 |
| In the three months of May, June and July ..... | 365 | 133 | 109,662 |
| The differences between the figures are ..... | £625 | £68 | 256,378 |

Therefore, by the above rule the running cost for coal during these six months was $$\frac{625 \times 240}{256,378} = 0{\cdot}584\text{d. per unit.}$$

For oil and stores $$\frac{68 \times 240}{256,378} = 0{\cdot}063\text{d. per unit,}$$

and from the total amount spent on running-cost repairs, during the four years the central station had been in full working order, the author finds the running-cost repairs averaged at the end of 1895 0·063d. per unit sold. Then, as the running costs of the remaining six months of 1895 were about the same as the above values, by this method it is possible to arrive at a very fair division into running and standing-by costs of the items on the debtor side of the revenue account of 1895.

Division of the debtor side of the Brighton 1895 revenue account into running and standing-by items:—

| Item. | Rate per unit for running costs determined by above method. | Total running costs for the 867,500 units sold. | Total standing-by costs. | Total amount spent on the items during 1895. |
|---|---|---|---|---|
| Coal ..... | 0·584d. | £2,111 | £485 | £2,596 |
| Stores ..... ..... | 0·063d. | 230 | 302 | 532 |
| Repairs to plant ..... | 0·063d. | 230 | 147 | 377 |
| „ to buildings ..... | ... | ... | 59 | 69 |
| „ to meters ..... | ... | ... | 69 | 69 |
| „ to mains..... | ... | ... | 463 | 463 |
| Wages ..... ..... | ... | ... | 1,719 | 1,719 |
| Rates and taxes .. ... ..... | ... | ... | 327 | 327 |
| Management ..... | .. | ... | 1,838 | 1,838 |
| Insurance..... ..... | .. | ... | 69 | 69 |
| Interest and sinking fund | ... | ... | 7,777 | 7,777 |
| Totals ..... | 0·71d. | £2,571 | £13,255 | £15,826 |

As the annual maximum load on the station is generally increasing, the mean of the two consecutive years' annual maximum load is taken to be the demand on the station, in calculating the standing-by cost per kilowatt; this in 1895 was £17·9 per kilowatt as thus defined.

The above obtained values for the running and standing-by costs at Brighton in 1895 are closely confirmed by quite a different method to be presently described, based on the analysis of the different years' expenditure curves into the different terms of an equation obtained empirically.

If the total monthly expenditures as above defined from soon after the starting of the undertaking be plotted in the form of a curve, such as the dotted one shown in Fig. 1, and the corresponding sale of units be plotted alongside this, no very obvious connection between the two curves will be discernible, at all events certainly nothing like the uniform price system of charging implies ought to exist. If, however, the maximum annual load taken off the mains be plotted on the same diagram, as shown by the crosses, with a suitable scale, and these points or crosses be connected by straight lines, a very obvious tendency becomes apparent after the first or second year for the monthly total expenditure to follow this line joining the points representing the annual maximum loads, and the slight deviations from this line will be found to be roughly proportionally to the monthly sales of electricity.

The author, after studying this monthly expenditure curve of the Brighton station, which he thinks may claim to be one fairly representative of economically run undertakings, feels convinced that the chief governing factor in determining the monthly expenditure in any central station will probably be found to be the maximum annual load which the station has to be prepared to meet every succeeding year, and that after the first year or two the total of the standing charges will be found, for all practical purposes, to be fairly proportionate to this maximum annual load.

Mr. W. J. Greene, in the paper alluded to, has pointed out that the standing charges ought theoretically to be divided into the three following distinct classes of expenditure:—No. 1. Those due to the preliminary expenses in starting the undertaking, which may be called Basic expenses. No. 2. Those depending on the cost of connecting the consumers, called Connection costs. No. 3. Those proportional to the total maximum simultaneous demand of the consumers on the mains, and conveniently called Demand costs.

With regard to these three groups into which the standing charges may be divided, the author finds that the following is the percentage each of the three classes bore to the total annual expenditure incurred after the Brighton undertaking had been worked four complete years:—The Basic, or those due to the original unproductive outlay incurred in starting the undertaking, constituted 6·3 per cent. of the total. Connection costs, or those due to the cost of connecting the consumers, 11 per cent. The Demand costs, or those due to having to be ready to supply the annual maximum load, 66·4 per cent.; and the running costs, or those due to having to continue to run the machinery after it has been started, 16·3 per cent.

The most important point to be noticed in connection with these ratios is that the very small percentage that the running costs bear to the total in such a town as Brighton, viz., only 16·3 per cent., would obviously be very much smaller if coal be there obtained at say 10s. per ton, the price paid for an equivalent quality in some of the northern and midland towns; and in that case, instead of annual standing charges being about five times the running costs, as they are now at Brighton, they would probably be quite eight and a half times. Hence, *there is obviously the greater necessity for a differential tariff in towns where coal is cheap than where it is dear*, as at Brighton.

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In view of the great expense of connecting consumers and of this being practically independent of their demand or consumption, Mr. Greene strongly advocates the system of making a minimum charge per annum on this account, as well as on account of their demand. The author's experience, however, tends to prove that the sum total of the three classes of standing-by expenses follow, as a rule, the rising line connecting the annual maximum demands on the mains.

This near proportionality of the standing charges to the plant capacity of a fairly economically run station may be a surprise to many who think, as the author was formerly inclined to, that the cost per kilowatt demanded on the station would diminish rapidly as the station increased in size; it must be remembered, however, that the above rule does not only include the standing charges due to the central station alone, but it includes all expenses due to mains, meters, service lines, &c., and that the statement does not by any means imply that two stations can be as economically run as one of the same capacity as the two.

The above tendency seems capable of explanation after the following considerations:—

That although the original basic charges become less and less in proportion to the total expenditure, as the undertaking grows larger, other charges of a similar pioneering character continue to be incurred from year to year; such, for instance, as those on account of the cost of extending supply mains into new districts, running or building from time to time expensive feeders and sub-stations; increased office and engine-house accommodation which are generally built many years before their full capacity is wanted, and moreover this class of expenditure is not generally all incurred simultaneously, but is spread over a great many years after the starting of the undertaking. Also, as regards the connection expenses, as the business grows larger, the average individual demand of the consumers on the station tends to become smaller for the two following reasons:—No. 1.—Because the class of consumers generally requiring to be connected soon after the commencement of the undertaking are the larger business premises, shops and hotels, which do not cost for connection so much per kilowatt demanded as do the succeeding classes of smaller shops and private houses. No. 2.—As the number of consumers supplied increases, a greater variety of classes are included among them, and the diversity of the hours at which they use their maximum loads tends to increase, so that a smaller kilowatt capacity of the plant and mains is thus required than if only one class, such as shops, whose maximum demands would be more simultaneous, were supplied; this and the former cause both obviously must tend to make the connection cost per kilowatt *demanded on the mains* increase with the growth of the supply undertaking.

The above reasons appear to the author quite sufficient to account for the observed near proportionality of the standing charges to the maximum load on the mains of a station in full working order.

The other method referred to, which can be made use of in determining what effect the varying output has on the various items constituting the total cost of supplying electricity, especially with stations that have been running for three or four years, is that of analysing graphically curves of monthly total expenditure, output and maximum demand; although this is more tedious and of more theoretical than practical value, the close agreement between the Brighton actual with the monthly costs calculated from the empirical formula thus obtained is another proof that the cost per unit for running expenses is not now more than 0·8 of a penny.

The formula from which the full line on Fig. 2 is calculated is the one found to most nearly fit the last three years' curves, and is as follows:—

Total monthly expenditure in £

$$= £190 + 1{\cdot}25 \times D + \frac{\text{Units sold per month}}{300}$$

Where D is the value in kilowatts of the gradually increasing maximum load line of Fig. 1.

From the near agreement of the two analyses of 1895 revenue account of the Brighton undertaking, the author feels justified in assuming that the cost of continuing to run the machinery after it is once in a position to supply has not varied very much from ¾d. per unit during the last three years, and that the annual standing charges can now be taken to be about £17·9 per annual maximum kilowatt taken from the mains.

The question next arises, how is each consumer's proper proportion of the annual total standing charges, as determined in the manner previously described, to be properly apportioned? Theoretically, it might be said that the standing charges ought to be divided into amounts proportionate to the maximum demand of each consumer, at the day and at the very time the maximum load occurred on the mains each year. This, however, it is obviously impossible to determine in practice, and would not be, moreover, necessarily equitable to the consumers who might or might not have used their maximum demands at the exact moment in question. In practice some arbitrary definitions, more or less equitable, of what constitutes a consumer's call on the plant have to be made. At Brighton, for instance, instead of taking a consumer's maximum demand to be the greatest rate of taking current during the year, it has been considered fairer to the consumer to take the mean of six winter months' readings of a maximum current indicator, which, by its very nature, takes quite ten minutes to fully register the passing current. For the purposes of calculating the cost of supplying any individual consumer, it is then assumed that the mean demand as above defined bears to the total of all the consumers' demands the same proportion that the plant and mains necessary to supply this one consumer bears to the total plant, &c., required for all the consumers; therefore a proportion of the total annual standing charges is debited to each consumer in proportion to his mean demand. In the opinion of the author, this method gives as nearly as possible the fairest division of the standing charges, and it makes substantial allowance for the fact, that the demands of the different consumers do not all coincide in point of time of day. Opportunities are also given for preventing any unusual maximum demand being registered, so as not to penalise the consumers for having parties, &c.

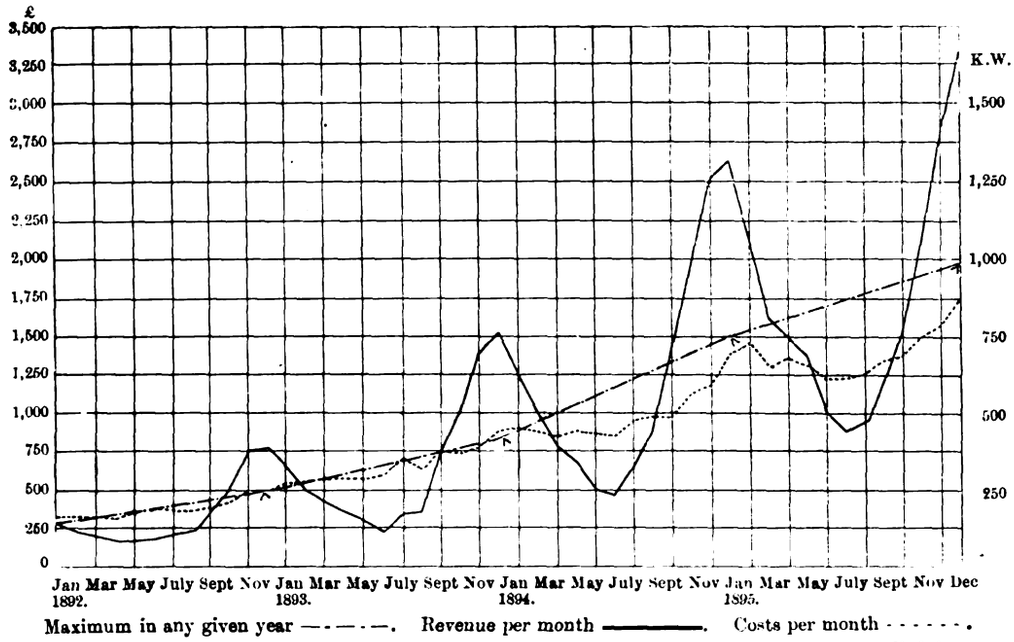


FIG. 1.—Curve showing how monthly expenditure is related with the maximum rate at which Electricity is supplied in any given year, rather than with the monthly sales.

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Owing to the varying time of day at which the different consumers' heaviest loads are taken from the mains among the fairly large and representative number of consumers at Brighton, the maximum load of the station is now only 66 per cent. of the sum total of the consumers' maximum demands. This want of coincidence in point of time of the consumers' maxima thus means a considerable saving in plant and mains, consequently in the standing charges of the undertaking; therefore the consumers are entitled to the benefit of this, which they get by the Corporation assuming that each kilowatt demanded by a consumer only costs 66 per cent. of the above mentioned £17·9 a year, or £11·8 per annum, which works out to nearly 7¾d. per day per kilowatt demanded by any consumer. This figure of 7¾d. per kilowatt, and the previously determined figure of ·71d. per unit for running expenses, enables the cost of supplying electricity to any consumer in Brighton this year to be very closely ascertained, and from this data the curve of costs, Fig. 3, has been drawn. The solid line gives the average cost of supplying each unit to a consumer at Brighton in 1895, who used his demand so many hours or fractions of an hour per day on the average throughout the year. The hyperbolic line of dashes shows how rapidly the charge to cover the standing cost falls as the time of daily use of the demand is lengthened; the total cost curve is obviously obtained from this by adding ·71 to it vertically.

As it was thought impolitic to charge consumers on the true theoretical method of so much per maximum kilowatt demanded, and so much for the running costs of the units registered by their meters, on the ground that this tariff might possibly have the

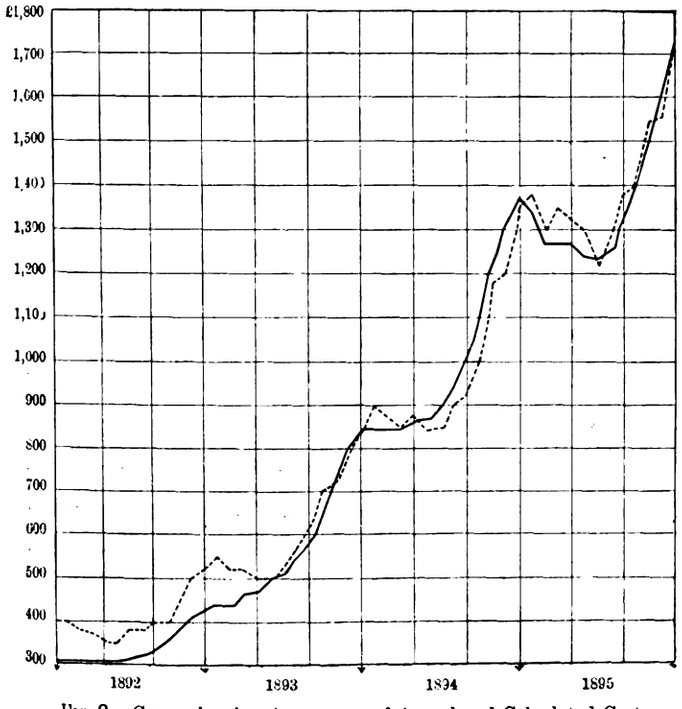


FIG. 2.—Curve showing Agreement of Actual and Calculated Cost.
Actual Money Costs ·····. Calculated Monthly Costs ———.

effect of preventing consumers installing any other lamps than those likely to be constantly used, it was suggested that nearly as fair a charge could be made by refusing to reduce the highest permissible price per unit consumed until the individual consumer had paid off all his proportion of the year's standing charges, as determined by the demand indicator, in the manner above described. This system has worked out very well during the last three and a-half years, and naturally tends to encourage profitable consumers to use electricity.

From the above calculations it follows, provided all consumers paid 8½d. per unit for the first 365 hours in the year they used their demand, and ½d. for all units consumed afterwards in that year, the whole of the annual expenditure would be covered, and the Brighton undertaking would be considered in a self-supporting condition. However, there will always be a considerable number of consumers who do not use their demand on the average one hour per day throughout the year, among whom, of course, must be included a great many of those connected during the year in question, and as the maximum price chargeable at Brighton is fixed at 7d. per unit, it is impossible to charge on this equitable basis. The tariffs adopted for the last three years have been something therefore less fair to the long-hour profitable consumer, and by the one now in force each consumer pays 7d. per unit for the first 365 hours in each year he uses his demand and 3d. afterwards. This tariff will, doubtless, produce sufficient profit during this present year from the units charged at 3d. to people using their demand, say slightly more than 1½ hours per day, to justify a reduction in the 3d. units being very soon made to 2d. per unit.

The small dotted curves show the average price paid by the Brighton consumers on the present and proposed future tariffs according to the average daily number of hours they individually use their demands. From an inspection of the tariff and cost curves in Fig. 3, it will be seen that loss was incurred on supplying all consumers at Brighton during 1895 who used their demands less than 600 hours per annum. In connection with these unprofitable consumers, it may be quite reasonably asked how with a given plant and set of mains it can be said that the undertaking can lose money by having to supply one set of short-time consumers while it is making a profit on supplying others with the same commodity, or why selling units at 7d. can be less profitable than not selling them at all. The answer is, that in growing stations, as the author premised should alone be considered, the same expensive extensions and the consequent increase of standing

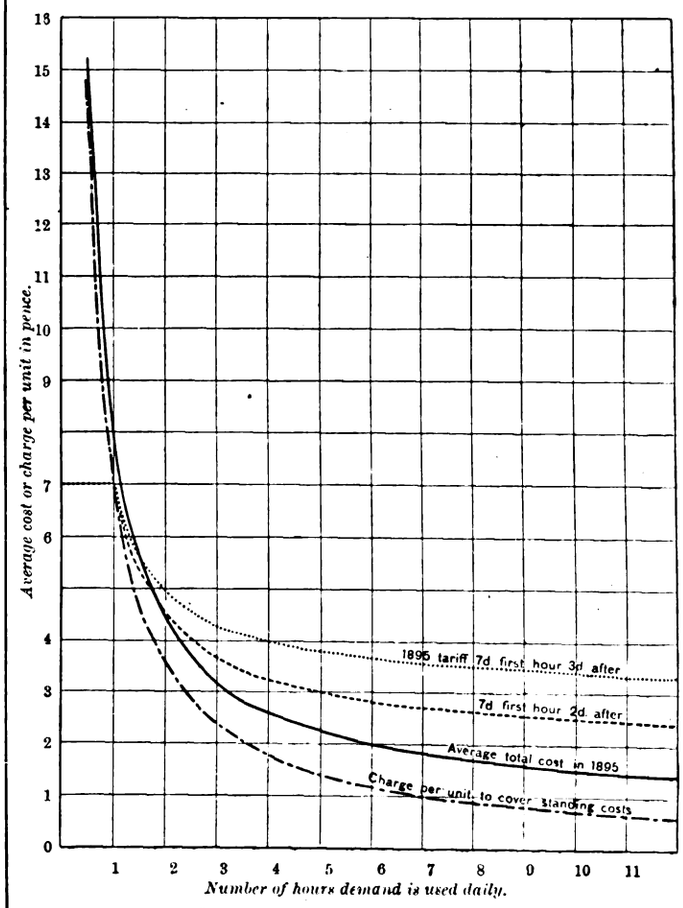


FIG. 3.—Curve of Average Cost and Charges.

costs are necessitated by having to supply the short-time consumers as if they were long-hour users, although they probably only use their proportion of the plant say three months out of the twelve; thus they not only cause fresh capital to be spent, the interest, &c., on which they cannot pay off themselves, but they necessitate their unpaid share of the standing charges being paid by the better class of consumers, who could have been supplied from the station in the condition it was in at the end of the year without further extensions having to be made for many years to come; therefore, actually this short-time class increase the charges to the profitable, and this is surely only another way of stating that there is loss incurred by having to supply them.

Given the cost of the standing charges per kilowatt demanded by the consumers, the running costs per unit and the individual demands of all the consumers, it must be obvious that it is then possible to make out an annual profit and loss account showing what profit or loss is made from any class of consumers. The author has prepared such a one for the Brighton undertaking in 1895. He has taken the running costs at 0·8d. per unit, and has divided the classes of consumers in the four following:—

1. Those who were connected during the year, and of which a great many therefore could not naturally have had enough time to pay off their proportion of the standing charges incurred during the year in providing sufficient additional plant for their probable demands.



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*Profit and Loss Statement, 1895.*

Class 1.—Consumers connected during 1895. Class 2.—Consumers using demand less than 1 hour per day on the average throughout the year. Class 3.—Consumers using demand from 1 to 1½ hour per day on the average throughout the year. Class 4.—Consumers using demand over 1½ hour per day on the average throughout the year.

| Class. | Total of the demand in kilowatts of each class. | 7d. Units. | | | | | | 3d. Units. | | | | Net result of supply to each class. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. of units charged at 7d. | Standing charges based on 7¾d. per day per kilowatt. | Running costs based on ·8d. per unit. | Total costs. | Revenue. | Loss. | No. of units charged at 3d. | Running costs at ·8d. per unit. | Revenue. | Profit. | Loss. | Profit. |
| 1 | 175 | 32,608 | £2,080 | £110 | £2,190 | £951 | £1,239 | 25,682 | £86 | £321 | £235 | £1,004 | ... |
| 2 | 162 | 39,006 | 1,929 | 130 | 2,059 | 1,138 | 921 | ... | ... | ... | ... | 921 | ... |
| 3 | 118 | 45,564 | 1,410 | 149 | 1,559 | 1,329 | 230 | 10,873 | 45 | 136 | 91 | 139 | ... |
| 4 | 635 | 254,443 | 7,540 | 831 | 8,371 | 7,422 | 949 | 459,318 | 1,490 | 5,741 | 4,251 | ... | £3,302 |
| Totals . | 1,090 | 371,621 | £12,959 | £1,220 | £14,179 | £10,840 | £3,339 | 495,873 | £1,621 | £6,198 | £4,577 | £2,064 | 3,302 |
| | | | | | | | | | | | Deduct losses ..... | | 2,064 |
| | | | | | | | | | | | Resultant annual net profit ..... | | £1,238 |

2. The consumers who did not consume sufficient electricity to be equivalent to the use of their demand 365 hours or one hour per day on the average.

3. Those who were a source of loss to the undertaking owing to their using their demand less than 1½ hours per day, which was about the minimum time necessary on the present tariff to pay off all the cost of supplying them for that period.

4. The profitable class who used their demand more than about 1½ hours per day on the average throughout the year.

From the foregoing profit and loss account it will be seen that in consequence of the highest price allowable being fixed at Brighton at 7d. per unit, it was necessary to charge the longer users of electricity at a substantial profit to recoup the losses incurred in having to supply the unprofitable, although this was nothing approaching the rate of profit that would have been charged to them had all consumers paid the uniform price per unit necessary to produce the same revenue.

The results of the above presumably correct methods of analysis being applied to existing electricity works accounts appear to so thoroughly confirm Dr. Hopkinson's startling conclusions, and to warrant so many fresh departures from the usual methods of attempting to develop the business of electricity supply, that the author sincerely trusts the Convention will carefully criticise the principles enunciated, and either frankly combat, refute, or accept the following far-reaching conclusions the author has been forced to realise.

1. It is the duty of municipalities to charge a uniform rate of *profit* on the cost of supplying electricity rather than a uniform price to all consumers, and much more so in the case of electricity than with gas, because of the much greater percentage standing charges bear to the total cost in the former than in the latter case.

2. To charge the same amount for the electricity consumed by 100 lamps burning four hours a day as that by 400 lamps burning one hour per day is manifestly unjust to the longer user, as only a quarter of the plant and copper are required to produce and supply it as are required by the shorter user.

3. The practice of charging profitable and unprofitable consumers the same price per unit must necessarily have the effect of keeping the average cost and price higher, consequently the supply business smaller, than by charging a uniform rate of *profit* to all consumers, because, having to charge the profitable consumer in order to recoup the loss incurred in supplying the unprofitable must tend to prevent the former using it as liberally as if he had not to pay such a high rate of profit. Therefore electricity can be produced at a lower price on an equitable sliding scale of charges than on a uniform price.

4. The extremely low price at which electricity can be profitably supplied to consumers after they have paid off their proportion of the standing charges much more than compensates for the difficulty of understanding a uniform rate of profit tariff, as shown by the increasing rate of receiving applications for electricity in towns where differential charges and low prices to long users are in vogue.

5. It is in every sense advisable to retain the initial charge per unit at the *highest permissible* figure and the charge for current after the standing charges are paid for at *as low a figure* as is compatible with making a safe annual net profit, as experience proves that consumers judge their electricity accounts solely on the total amount, and those consumers who are always charged the highest price are naturally the least worth having, and the only ones likely to complain of the equal-profit system of tariff.

6. It is erroneous to suppose that by increasing the size of the business the loss on supplying the ordinary short-hour user will diminish as time goes on; as offices and similar short-time consumers generally light up at dusk, an increased number of such can only aggravate the peakiness of the load curve, and cannot therefore reduce the standing charges per kilowatt demanded, on which the cost of supplying them mostly depends.

7. It is much fairer to the ratepayers to try to limit the supply to consumers who are willing to pay their share of the costs than to have to rapidly extend the supply works in order to take on more unprofitable as well as profitable consumers, or, in other words, it is more justifiable for a municipality to lose the unprofitable consumers by raising the initial price, and to take in their place more profitable ones, than to extend the works directly their capacity is reached.

8. The enormous cost of getting ready to supply electricity, compared to the cost of continuing to supply when ready, can be best realised by remembering that *it costs two and a half times as much to supply a unit to a consumer who uses his lights on the average only one hour per day as it does to another who uses them three hours.*

9. With coal at the price paid in Brighton, the same reduction can be made in the average cost of producing electricity by so arranging the tariff as to improve the load factor 3 per cent. as if the coal bill had been reduced 15 per cent. Although the author does not wish it to be understood that he discourages the attempt to save coal, he desires to point out that it is much more worth while trying to improve the load factor than to reduce the coal bill. Since the differential tariff has been adopted at Brighton, the load factor has improved 50 per cent., showing the improvement wanted is not difficult to attain. In the Midlands, where coal is half the price paid at Brighton, probably the same reduction in the average total cost of electricity would be made by improving the load factor 3 per cent., as if the coal bill had been reduced 30 per cent.

10. The difference in the financial results of central-supply stations are more due to the different load factors, and the varying economy in standing-by costs, than by any great differences in the amount of running costs.

11. The rapid fall in the cost of supplying electricity as the average time of use increases makes the small householder a much more profitable class to supply, both in his residental and shopping districts, than the residences and shops where the wealthy dwell and deal, owing to the frequent absence from home of this class and the early closing of their shops.

12. One of the most important consequences of the fact that electricity can be profitably supplied from central stations to consumers at the rate of 8½d. per unit for the first 365 hours in each year they use their demand, and for something between ½d. and 1d. (according to the price of coal) for any electricity consumed afterwards in the same year, is that street lighting and that of basements or dark buildings lighted all day long, can be more cheaply done by electricity than by any other form of artificial light as in those cases where the use is on the average eleven hours per day, or 4,000 hours per annum, *the inclusive cost for the electricity consumed will not generally exceed 1½d. per unit.*

The fact that up to the present only the very fringe of street lighting has been touched by the electricity supply undertakings appears to the author a sure sign that Dr. Hopkinson's conclusions have been hitherto ignored by most of the responsible managers; and to again direct and urge them to give their closest attention to them has been the author's object in writing this lengthy Paper.

## DISCUSSION.

Mr. H. MAVOR said he had had some experience with the method of charging adopted by Mr. Wright, and had come to the conclusion that it was not practicable; and though Mr. Wright had since proved that it was practicable, he (Mr. Mavor) still thought the method was unnecessarily expensive and complicated for the supply station. The method he would

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suggest was this. Take, for instance, a consumer who had 1,000 lights upon his premises, and give him a supply at the rate of 500 amperes per hour. If they put an ordinary recording meter on to the consumer's premises, they would find that at the end of the year a certain number of ampere-hours was recorded. If they divided that total by 500 they would have the average number of hours during which a lamp had been used, and if the charge were based on that, they could then differentiate the valuable consumer from the consumer who was not a profit to the station. With regard to street lighting, that was also a very important question. If anyone attempted to go in for street lighting with the idea of making any profit whatever, it would be found that only in the best regulated stations was this possible.

Mr. H. M. SAYERS (Bournemouth) said the question had interested him very much during the last few years, and after giving a considerable amount of attention to it, he had recommended his company to adopt the system which was first used by Mr. Wright. This was put in operation in 1895, and he must say that the increase in the number of units sold to the consumers, who were favourably affected by the change, showed that they took a great deal more current than they did before. He found a little difficulty in making them understand how they were going to get the benefit.

Mr. ALEXANDER SIEMENS said he did not agree with the idea of charging for so many lights installed. He had electric light in his own private house, in every room, and he paid 8d. per unit, and he used to pay 3s. for gas, and he found the bills almost alike, and of the two the electric light came out a little cheaper, and then he had a much more convenient light than gas. He thought it was not a good plan to put the switches on the fittings. They ought to be put in a handy place, so that anyone on entering the room would know just where to put his hand on them.

Mr. ARTHUR ELLIS said when he first started at Southport the customers were all supplied on the same basis—that is, they all had some rate of discount on the total charges. But the people grumbled so much that in 1895 they decided to adopt the demand system, and they found that by the end of the year the result was so satisfactory that nearly 30 per cent. of the consumers were getting the electric light at the lower cost—that is, they charged 7d. per unit for the first two hours, and after that the charge was 4d. per unit. They found their best customers were the small shops, such as tobacco and small grocers' shops. His Committee were afraid the income would be reduced by the lower charge, but it was found that for the same number of consumers they had an increase of 18 per cent. in the receipts.

Mr. C. H. WORDINGHAM (Manchester) said he thought there was no question that the system adopted at Manchester was the right one. They made a fixed charge of £12 a year per kilowatt demanded, and then 2d. per unit actually consumed. He said, this in principle was exactly the same as Mr. Wright's method, but Mr. Wright's method had one most important advantage. Some of the previous speakers had referred to it; it was that when they charged for the maximum number of lamps fixed, instead of the number of lamps alight at one time, they were discouraging the fixing of lamps, which was a very important point. He thought the course suggested by Mr. Mavor was a very bad one. He had tried to work out a system like Mr. Mavor had suggested, but found that a consumer had only to burn a few more units to reduce his bill, and that was bad for the system. One great advantage of an indicator was that it did away with the trouble about a consumer altering the number and the candle-power of his lights. He knew of a consumer who had done so, and when he knew the inspector was coming round had put in 16 c.p. lamps instead of 32 c.p. lamps. The indicator would do away with this altogether.

Mr. R. A. DAWBARN said that in Mr. Wright's Paper there was no indication of the load factor, or what was the equivalent according to Mr. Wright's system. Mr. Wright had given them some very valuable information, but it rather made him long for more. If all other towns were to collect their information in the same way as Mr. Wright had done, in the course of a few years one would be able to give a very accurate tale of any particular class of consumer.

Mr. W. GEIPEL said there was one question in the Paper which had a very great interest for him, which did not seem to have been dealt with so fully as he would have expected, considering the importance of the subject—that was the question of first cost. On page 8 the author stated that although he did not wish to discourage the attempt to save coal, he desired to point out that it was much more worth while trying to improve the load factor than to reduce the coal bill. He (Mr. Geipel) thought it was even more important to try and keep down the first capital cost. He had found a very large variation in this question of capital outlay per kilowatt. At Brighton it was £125, whereas at Leicester and Bradford it was about £50. Applying these figures to Mr. Wright's method of calculation of the working expenses of the station, they would find that instead of his total standing costs being £13,000, they were reduced to £8,000, and instead of the stand by cost, as Mr. Wright very properly called it, being £17 per kilowatt, it would be reduced to £11·6 per kilowatt. Carrying this further the total maximum charge per diem per kilowatt would be reduced from 7¾d. to 5d.

Mr. FARADAY PROCTOR said he should like to go back to the question of the methods of charge. Mr. Wright contended that it cost less to generate current for three hours per day than it did for two hours. He contended that it cost less to generate current for two hours per day if the consumer took his current in the daytime. Mr. Sayers had commented on the proportion of his maximum demand as compared to the number of watts installed, the proportion having very much improved, and he attributed this to the introduction of a demand meter. He might say that the figures at Bristol had improved in the same way without any alteration in the charges.

Mr. HAMMOND said he thought the system that Mr. Wright had laid down was one which, if it could be thoroughly extended, would make the electric light not the light of the rich at all, but entirely the light of the poor. He was very much struck when he first went to New York to see how very largely the electric light was used in the Bowery district. Electric light would compete price for price with gas among the poor people. The poor man, the man who occupied one or two rooms, always lit up, was a very much more important customer than the man who, like Mr. Siemens, carefully turned his lights out as he roamed through his palatial dwelling. The principle which Mr. Wright laid down was this: Do not divide your total cost by your total number of units, and rely on the tables which are found in some technical papers. He did not wish to detract from the value of these tables, but, of course, they were simple reproductions of Board of Trade returns. With regard to the question of arc lighting, Mr. Wright showed that in working out the cost they must take into consideration the number of hours of burning, and that it might be quite possible to produce electricity for arc lighting purposes for several thousand hours at a cost of 1½d. per unit. The principle the President laid down was this. A certain amount of coal had got to be used whether they had any lights or not, and they must have a certain amount of repairs, and they must have a certain number of men there whether running or not. Therefore they must charge the whole of the wages bill not to running expenses or cost of production, but to the standing charge account of the station. Certainly a proportion should be placed under this head, but the classification of the whole wages account as a "standing charge" was indefensible. It was the same with the management expenses; the whole of this item could not be attributable to the "standing charge" account. With regard to interest and sinking fund payments, he was quite of the opinion of the author that no portion of these should go to "running expenses."

Mr. ANDREWS (Hastings) said he could not entirely agree with all Mr. Hammond had said. With regard to the system of charge they had had some difficulty at Hastings. They could not make their customers understand the new system. The Directors had almost made up their minds to throw up the demand system and go back to the old one of charging a fixed sum per unit.

Mr. WRIGHT, in reply, said with regard to what Mr. Siemens had said that 8d. per unit was practically an equivalent to 3s. for gas, he would venture to say that gas would be utterly out of market when electricity was at 4½d., which would very soon be the average price per unit. With regard to the wages account, he did not know what to do with his men. He could not send them away as the load went off. Mr. Hammond seemed to imply that the wages load varied with the ampere load. His experience at Brighton was that for three years their wages had not diminished in May as compared with January. His own salary was not less in May than January, nor was that of his clerks; and the men were paid by the day, and not by the time the load was on. Their wage load did not decrease with their ampere load. In reference to Mr. Geipel's remark, he (Mr. Wright) quite agreed with the principle of keeping down the capital cost; but in comparing Brighton with Leicester Mr. Geipel had lost sight of the fact that the mileage of mains must be taken into consideration. Brighton had 85 miles of mains, a figure which he did not think they had reached at Leicester. The item should be—

$$\frac{\text{Capital cost}}{\text{Kilowatts} \times \text{street mileage}} = x$$

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## COLONIAL ELECTRICAL ENGINEERING.

The electrical industry in England has many reasons to be thankful that CHRISTOPHER COLUMBUS discovered America—or, rather, the West Indies. Without the previous large-scale experiments of our transatlantic friends, it is doubtful if we should to-day be in full enjoyment of the innumerable blessings that flow from the existence of some hundred fully-fledged central stations; and it is more than doubtful if the trolley would have been tolerated, even in the industrial quarter of our ugliest manufacturing town, unless America had led the way—and survived the experience. Not that, in electric lighting at any rate, English electrical engineers have borrowed overmuch from the United States; on the contrary, the electric lighting work out there has mainly served as an admirable object-lesson in what to avoid in England. The unconscious service really rendered by American engineers is, that their electrical enterprises enabled us to point a moral, if not exactly to adorn a tale. The cult of the accomplished fact has many followers in Great Britain; and American electric lighting, and American electric traction, were two very big accomplished facts, that could be safely appealed to whenever an electro-capitalist or a vestryman wavered. Our Colonies, on the other hand, although the climatic and other conditions in Australasia or South Africa resemble in many respects those which obtain in the United States, have not assisted in the slightest degree, as young children are apt to do, in overcoming parental inertia. Mr. J. A. DAWSON, in an article published

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in our issue of June 12th. evidently thinks that electric lighting in Australia has a great future; that may be, and we devoutly hope will be the case. On the other hand, if we may judge from Mr. SPENCER'S article appearing in the present issue, Australian electric lighting has no part, or next to none. Perhaps the cause of this "conservatism" lies in "the fearful examples" of which he tells us; perhaps in inability to turn first-class machinery, and unwillingness to let in any; perhaps in geographical, climatic, and social conditions: to be situated at the Antipodes, thousands of miles away from the stress and turmoil of Europe, in a fine climate, and to hold the doctrine that anything which saves labour is tabu, are not conditions conducive to vigorous enterprises of any sort. Mr. DAWSON certainly gave excellent reasons for his faith in the future of electric lighting in Australia, where circumstances are such that the cost of fuel is comparatively moderate and the price of gas extremely immoderate; where the somewhat torrid nature of the weather makes a cool light distinctly welcome; and where, we may add, the latitude is such that the duration of daylight does not vary in so violent a manner as it does at home. But a question quite as important as the lamentably small amount of Colonial electric lighting in the past, and the probability of an increase in its bulk in the immediate future, is the question, Have we secured our fair share of what has been done, and are we likely to increase that share in the future? Even in South Africa, where German methods have of late been found so congenial, English engineers, English methods and English plants are well to the fore; and with the introduction of stringent rules and regulations, it is more than likely that the Mother Country will increase her lead; for whatever conduces to sound, honest work conduces to the victory of English engineering—at least such is the touching faith Englishmen are brought up in. And now Australia has followed the example of the Cape. Victoria has an Act, dated February, 10, 1896, "to facilitate and regulate the supply of electricity for lighting and for other purposes," an Act nine-tenths of which is transcribed straight from our own familiar Acts of 1882 and 1888; and Queensland has appointed an Electrical Inspector hailing from the Mother Country, and well versed in English ways. So long as free-and-easy methods are the order of the day, it must be confessed that English engineers are at a disadvantage. Firms accustomed to central stations with "architectural pretensions," high-speed direct-connected engines, and costly underground conduits, are not quite at home with corrugated-iron huts, belts, counter-shafting, and jarra-wood pole work. But with the advent of Acts, Regulations, and Inspectors, we may reasonably expect that the style of Colonial electrical engineering will more closely approximate our own; and then plant suitable for Perth in Scotland will be equally suitable for that other Perth of which Mr. SPENCER speaks.

Although the Victorian Act differs in letter and in spirit but slightly from our own two instruments of legal torture, the few points of difference that do exist are worthy of some notice. Notwithstanding that Australia is the home of municipalisation and legislative paternalism, it is curious to note that the terms upon which a municipality may purchase an electrical undertaking are identical with those to be found in the English Act of 1888. The period which elapses between the granting of an Order and the exercise of the municipal right of purchase is, however, reduced to 30 years; and in the case of a concern in existence at the time of the passing of the Act, to which an Order has been granted "as of course," the term is only 25 years, and that with qualifications. Concerns receiving an Order "as of course" *may* be bought out after two years or twelve years, being paid in that event an additional sum amounting respectively to 10 per cent. and 5 per cent. of the "then value" of their lands, buildings and plant. By Section 52 dividends are limited to a maximum of 10 per cent., "provided that whenever throughout any half-year any company shall charge for electricity supplied to consumers a less price than the maximum charge fixed by the Order authorising the undertaking, such company may increase such rate of dividend for such half-year by one-half per centum on the paid-up capital for each and every reduction of one farthing per unit in the price of electricity." The unit to which reference is here made is, we may remark, nowhere defined in the Act. Another curious and somewhat onerous proviso, to be found in Section 18, is that the annual statements of accounts are to be "published in a newspaper circulating in the area within which the undertakers are authorised to supply electricity." In Section 38, Subsection 2, house-wiring receives that solemn legislative notice that many would like it to receive in this country: "If it be reported to the Minister that the wiring or fitting up of any building is so carried out that it would be dangerous to supply, or to continue to supply, electricity to such a building, the Minister may direct some officer to make an inspection of such building and its premises." At the Antipodes the maxim *de minimis non curat lex* evidently does not hold. Imagine every piece of jerry-wiring in the United Kingdom being officially reported to the President of the Board of Trade or to Sir COURTNEY BOYLE, and Major CARDEW travelling about the United Kingdom like DIOGENES with a lantern looking for a perfectly insulated installation. For our own part we much prefer Rules 41-42 of the Board of Trade Regulations for securing the Safety of the Public. On the whole, however, when we consider the totally different circumstances of the case, the Victorian Act is an astonishingly close copy of the home-made product, the most striking general difference being a tendency to lay down in the Act fixed rules about details which are left by our own Parliament to the flexible sway of the Board of Trade, and which are in our opinion better so left.

## ELECTRIC LIGHTING IN AUSTRALIA.

BY HENRY J. SPENCER.

The phenomenal progress made by the Australian colonies from a commercial and social point of view is well known, and it is perhaps surprising that electric lighting is not more in vogue there; but after seeing the fearful examples of electric lighting still in existence in some Australian towns, one ceases to wonder at their conservatism in this respect. A number of small installations on the mining fields have been at work for upwards of 12 years, but as they are confined to the mine buildings and underground workings, residents in the district are hardly aware of their existence. It is a common idea among the general populace in these country towns that the only electric light is the arc lamp; incandescent lamps being regarded as some form of gas light. I remember, when viewing the machinery on a large gold mine where a small 50-volt dynamo was installed for lighting purposes, being warned by the engineer "not to touch that dangerous machine." It is true there was a considerable earth on it.

Beginning with Queensland, Rockhampton owns probably the best Central Station there at present. The concern is in the hands of the local gas company; a low-tension direct-current system is employed for the central portion of the town, with underground network; Chamberlain and Hookham supply meters being used. For suburban districts the high-tension alternating current with overhead wires is adopted.

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There is a single alternator of the well-known Mordey type, giving 12·5 amperes at 2,000 volts, and driven from counter-shafting. I am unable to give fuller particulars of this and several other stations, having unfortunately lost many of my notes on the subject. Charters Towers, one of the most important mining centres in Queensland, also owns a central station, and another is in course of construction at Bundaberg, in the sugar-growing district. Several small installations are at work in remote bush towns, and in most of the coast towns a few enterprising tradesmen have private plants for illuminating their business premises. Coming to the capital, Brisbane, the pioneers of electric lighting in this city were Messrs. Barton, White and Co., the local agents for Messrs. Crompton and Co. They own a small station in Edison-lane, consisting of a 40 H.P. horizontal engine, and two Crompton dynamos (driven by belting) of 25 kilowatts and 10 kilowatts output respectively. These machines run at 110 volts, supply being on the simple parallel system, the cables being run overhead on adjacent buildings. Current is charged for by contract, with discounts. Several hotels and shops in Queen-street are lighted from this station. The South Brisbane Municipal Council have recently had a central station erected for public and private lighting; but this I have not seen. The Houses of Parliament and railway terminus have had installations at work for eight or ten years; but the gas interests here, as elsewhere, have delayed its advent in the city streets.

In Sydney (N.S.W.) progress has also been very slow, only one of the boroughs so far having adopted electric lighting in their streets. In 1890 the borough of Redfern decided to adopt electric lighting for their streets in place of gas, which was costing them £2,000 per annum. The contract for the work was placed with the Williamson Electrical Engineering Company, of Sydney, and the services of Prof. Threlfall (of Sydney University) were secured as electrical adviser to the Council. In June, 1892, about 12 months after work had been commenced, the station was completed, and electric lamps took up the work of the old street gas lamps. Having been in charge of this station for the first two years of its operation, I am able to give a detailed account of its construction and working, with ground plan of the building showing engine and boiler rooms (*see* Fig. 1). I should mention here that the decision of the Council was to a great extent due to the exertions of Mr. Erskine, manager in Australia of the Crompton Electric Supply Company, who was engaged by the Council to report on the electric lighting of their borough before tenders were called for the work.

The station itself is a substantial brick building faced with cement, arches being built in the side and rear walls to allow for opening in case of extension. The engine room is 50ft. by 45ft. and 18ft. in height. The floor consists of solid granolithic blocks, except on the machine foundations, which are of concrete. The upper floor is supported on massive iron girders, strengthened in the centre by cylindrical iron pillars. The upper portion of the building is divided into store and testing rooms. Adjoining the engine room is the boiler house, 45ft. by 20ft. and clear to the iron roof. The floor is of concrete, with iron footplate along the front of the boilers. This boiler house is comfortably cool even during the hottest months of the year. The coal store opens on to the boiler house, and is 60ft. long by 13ft. in width. The usual lavatories and outhouses are provided, these being built over a large underground tank adjoining the boiler house, which was provided as a reserve in case of any failure in the supply from the main, the down pipes from the station roof being led into this. The boiler house contains two multitubular steel boilers by Tinker Brothers, of Hyde, each capable of developing 130 H.P. at a steam pressure of 120lb. per square inch. These are fed by two Worthington duplex pumps mounted on the wall near the boiler furnaces, and convenient to the stoker, injectors also being provided in case of accident to the pumps. At the rear end of the boilers, near the main flue, are the two feed-water heaters into which are led the exhaust pipes from the engines. These are supplied with cold water from the main, and are fitted with automatic valves and overflow pipes. The pumps are so arranged that it is possible to feed either from the heater or with cold water direct from the main. The chimney shaft is 100ft. in height and 8ft. internal diameter at the base. There is but one main steam pipe from the boilers, with a T-joint between the two

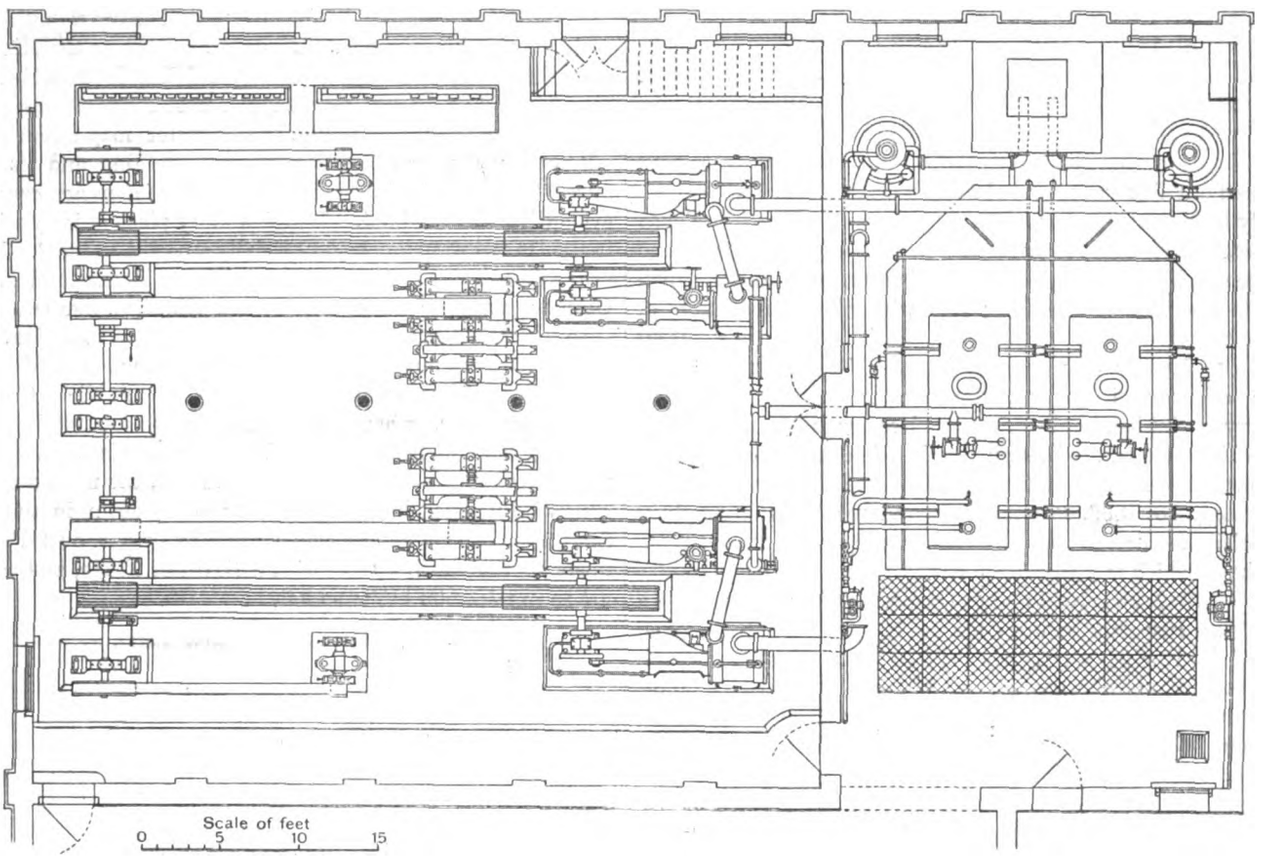


FIG. 1.—Plan of Engine Room and Boiler House, Redfern, N.S.W.

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engines, an expansion joint being provided between one of the engines and the T-joint. The steam and exhaust pipes are of cast iron, lagged with asbestos compound. There are two horizontal compound engines by Goodfellow, of Manchester, of 130 I.H.P. each, the high-pressure cylinders being 13in. and the low-pressure cylinders 23in. in diameter. The stroke is 24in., and the normal speed 90 revolutions per minute. The governors (which were designed by a Sydney engineer) are of imposing appearance, but totally unfit for the work, steady running being only obtained by careful working of the boilers. They are of the ordinary centrifugal vertical type, of very heavy design, driven by three ropes from the engine shaft; the sliding collar is connected by means of two vertical rods to a rocking-bar on the expansion-valve-rod, the leverage on which can be varied by means of a hand-wheel, which operates a slide-block, to which are pivoted the ends of the vertical rods. Both steam and exhaust pipes are carried overhead by means of iron rods attached to the girders and supporting the pipes by means of iron saddles. The engine fly-wheels are 10ft. in diameter, and grooved for seven 1½in. ropes. These ropes drive a counter-shaft extending across one end of the engine room, arranged in two sections with a central coupling, so that the alternators can be driven from either engine. The alternators and exciters are driven by belting from the counter-shaft. Friction clutches are provided for throwing alternators and engines in or out of gear when necessary.

There are two alternators by Mather and Platt of the well-known Hopkinson type, each capable of giving 100 amperes at 1,000 volts at a speed of 300 revolutions per minute. At full load the watts absorbed in exciting the fields of these alternators amount to only 0·6 per cent. The two exciters are also by Messrs. Mather and Platt; they are much too large for the work, having been originally designed for lighting the station in addition to exciting the alternators. The switchboards were made by Dean and Co., of Pitt-street, Sydney. They are of 1in. cedar, strengthened by a backing of 1in. pine and mounted in a strong pine frame ornamented with cedar mouldings. The instruments were fitted in the station after the boards were erected, and are all mounted on enamelled slate bases. The private lighting board contains the main switches, exciter and regulator switches, main ammeters, change-over switches for private lighting circuits, main cut-outs, and voltmeters. On the street lighting board are three change-over switches, street-circuit switches, lamp indicators, and cut-outs. The lightning arresters are arranged on a separate board on the upper floor, just below the leading-insheds.

All the mains are carried overhead on machine-turned wooden poles; the heaviest cable used being 19/18. The street lighting is carried out on the series system, with Thomson-Houston incandescent lamps of 25-c.p. each. These lamps are mounted on special cast-iron brackets of ornamental design attached to the poles at a height of 15ft. from the ground. There are 11 separate street circuits having three common returns, with a total of 410 lamps. The private lighting is carried out by means of transformers placed on the poles or on the balconies of buildings. The lamps connected are equivalent to 1,000 8-c.p. The price charged for current is 5½d. per unit by meter, or by contract. Elihu Thomson and Shallenberger meters are used. The hours of running are from sunset to sunrise, and as street lighting and private lighting are both supplied from the one alternator the load factor is a good one. The total costs per unit generated do not exceed 1·9d.

During my stay here we had on several occasions serious trouble with lightning. At several street crossings we had the mains placed underground to avoid telegraph wires, lead-covered cables placed in bitumenised wooden culverts being used for this purpose. During a severe storm, which occurred one evening shortly after starting up, a lightning discharge broke down a pair of house-lighting mains which supplied the bulk of our customers. On opening up the ground we found that water had penetrated the culvert, the joint between the drawing-in box and culvert being defective. To avoid future trouble we raised the two poles at this crossing, and placed the mains overhead—a unique instance, as far as I am aware, of underground lines being abandoned for aerial ones. Perhaps the strangest incident in this connection was an event which occurred during a peculiar dry storm early one afternoon. The balloon-shaped cloud appearance on this occasion was considered so remarkable that numbers of photographs of it were afterwards sold in Sydney. We started shortly after the storm had ceased, and, when attempting to switch on the street circuits, found that seven of them showed signs of a dead short. It took myself and assistant eight hours to remedy the mischief; no pleasant work on a wild night. Out of the 410 street lamps, 120 were short-circuited. The discharge had penetrated the paper film in the socket, but not a single lamp was injured. This was the only occasion on which lightning affected the street-circuits. The street lighting was at first a great disappointment to many of the ratepayers, who had expected to see arc lamps erected; but as their streets are obviously better lighted than those of surrounding boroughs where gas is used, and at lower cost, the satisfaction is now general.

Street lighting with incandescent lamps in series has found little favour in England; but I fail to see any justification for the prejudice existing against it. It can be made as reliable as parallel working, and is certainly much more easily controlled from the generating station. The average life of the lamps, in my experience at least, is longer than that of high voltage lamps, and their appearance can be made quite equal to that of the latter. I have only known the short-circuiting device to fail on one occasion, and that through the gross negligence of an attendant. But even in this instance the circuit was restored in a few minutes.

The city and several local boroughs have had a scheme of electric lighting in contemplation for some years past; but their progress in the matter, as with some local authorities in England, is painfully slow. Five years ago a company was formed for supplying Sydney with electric light and power by means of water-power from the river Grose, but their Enabling Bill was thrown out by the Assembly, blocked by the Labour Party, forsooth.

Rather an amusing incident occurred in connection with a small installation of which I had temporary charge in Sydney. The boiler we used had been previously installed for other purposes, and before we took steam from it the owners had it overhauled by an old mechanic. On completing his job, the mechanic told me that he had tested the boiler by filling it with water from the main, and considered that it would not be safe to work over 40lb. No doubt he was on the right side, but in working I found the old boiler stood nearly 80lb. without sending us up. Another boiler in the same shed, which we were working through from the first-mentioned, blew through a joint at 40lb.

One of the most important plants in New South Wales is that at Hillgrove, where water-power is used, the works being five miles from the township and mines where power and light is required. The head of water is 500ft. and the horse-power available for driving the Pelton wheels about 530. There are three Crompton continuous-current generators for power purposes and two Crompton-Brunton alternators (each of 400 light capacity) for lighting purposes. The continuous-current distribution is carried out on the three-wire system, at a pressure of 1,500 volts; the mains, which are of bare copper, being run overhead on fluid insulators supported on wooden poles. The alternate-current distribution is carried out on the simple parallel system. Some 250 horse-power is supplied for driving motors on the Baker's Creek, Eleanora, and other gold mines.

There are several private plants of considerable size in Sydney, the largest being that in the great establishment owned by Messrs. Hordern and Sons in the Haymarket. The total capacity of this plant amounts to nearly 200 kilowatts, several different types of machinery being installed, comprising Fowler horizontal engines driving Manchester dynamos from counter-shafting, Chandler's silent engine coupled direct to an Edison-Hopkinson dynamo, and three sets of Davey-Paxman vertical engines coupled direct to Crompton dynamos. A most interesting plant is that constructed by Messrs. H. H. Kingsbury for lighting the Town Hall, Sydney. A substantial stone

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building was erected to provide accommodation for the plant, adjoining the Town Hall. The plant comprises two multitubular boilers, two horizontal, compound, non-condensing engines (each of 100 I.H.P.) fitted with Marshall governors, and two Manchester dynamos of 50 kilowatts capacity each, the entire plant being in duplicate. The engines were made by the Mort's Dock Engineering Company, of Balmain, Sydney, and the working of the whole plant has been highly creditable from the commencement. There are about 1,200 lamps of 16-c.p. wired in the Town Hall and offices, besides several Brockie-Pell arc lamps. A battery of accumulators has recently been added in order to make the light available at all hours. Other important private plants are those at Darlinghurst Gaol, the Hotel Australia and Hotel Metropole, the City Bank, Sydney University, Government Offices, Railway Terminus, Circular Quay, but these are only a few of the large number now in existence.

With regard to country towns, very few, so far, have adopted electric lighting. I have seen the installations at Newcastle, Lambton, Penrith and Enfield, the system in use being, in each case, the alternating-current with overhead mains, and, with the exception of Enfield, American machinery being employed.

The Government plant at the Dyke, Newcastle, used for coaling the steamers at night, is worthy of notice. Steam is obtained from the boilers used in connection with the hydraulic plant. There are two Westinghouse high-speed engines, each

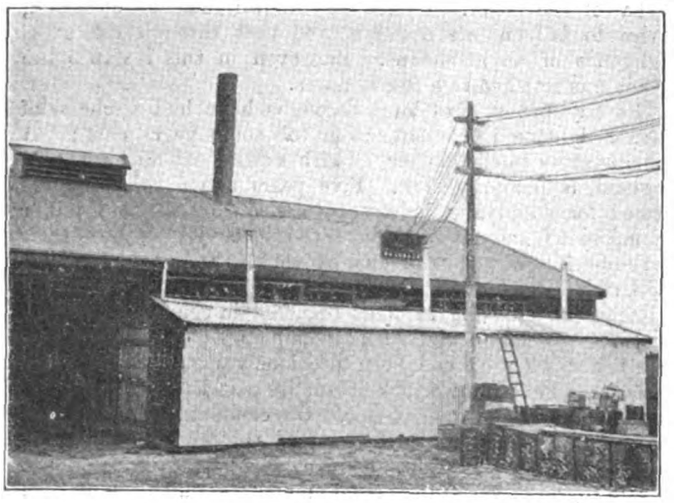

FIG. 2.—Perth (West Australia) Central Station.

of 50 I.H.P., driving by belting two Mather and Platt dynamos of similar pattern to the well-known Manchester machine. These dynamos give 18 amperes at a pressure of 1,000 volts, and run almost as sparklessly as the low-tension machines by the same makers. There is a single circuit of Brockie-Pell arc lamps, 52 in series, each lamp of 5,000 c.p. Only one set is in use at the time, the other being kept in reserve, a very necessary precaution, as armature burn-outs due to lightning discharges are of frequent occurrence.

Coming to Western Australia, the only important installation at present working is that in Perth, the capital, of which I recently had charge. This is a low-tension station on the three-wire system with accumulators. The building (*see* Fig. 2) is a corrugated iron shed with an accumulator room added on one side. There is but one boiler, of the semi-portable locomotive type, capable of developing about 100 H.P. The engine, by Messrs. Fowler and Sons, is of the horizontal, compound, non-condensing type, with steam jacket, fitted with automatic expansion gear on high-pressure cylinder, and hand-regulated expansion valve on low-pressure cylinder. This engine develops 100 I.H.P. at a steam pressure of 100lb. per sq. in., and is provided with two flywheels, from which the two generators are driven by means of leather belting. The generators are Crompton double-magnet machines, shunt-wound for charging accumulators, and capable of giving 250 amperes at 135 volts. In the battery room there are 134 Crompton-Howell 11-plate cells, 22 of which are for regulating purposes (11 on each side), capable of carrying the full load for one hour. The cells are arranged on each side of the battery room in two tiers, rails being laid down the centre and a trolly provided for manipulating the cells. The switchboard is a very simple affair, the only novel feature being the step-switches for regulating cells, which were specially designed by Mr. Howard Harrison, who acted as superintending engineer during the carrying out of the work, for Messrs. Crompton and Co. The feeders are of 31/13 cable (light insulation), carried overhead on jarra poles, and supported by means of galvanised iron bearer wires from ordinary white glazed double bell insulators (*see* Fig. 3). There are altogether about eighteen tons of copper in feeders and network. Consumers are supplied at a pressure of 110 volts. The plant is owned by the Perth Gas Company, and is on the same site as the gas works. No street lighting is at present undertaken. Extensions, which will double the present capacity of the plant, have recently been decided upon, and the work is being taken in hand by Messrs. J. H. Holmes and Co., of Newcastle-on-Tyne.

At Coolgardie and several other towns electric lighting companies have been formed, but there is certainly not much scope at present in Western Australia for the large syndicates

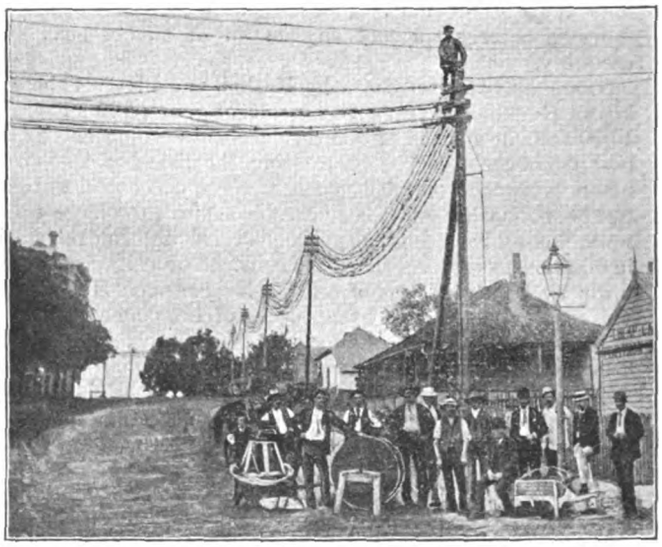

FIG. 3.—Wellington-street, Perth (West Australia). View of Overhead Electric Lighting Cables.

now forming in England for the purpose of supplying electric light and power on the mining fields. In a recent report in connection with one of these concerns it was stated that the introduction of electric motive power on the mining fields would solve the fuel and water problem, but in what manner was not explained. Probably there will be a large demand for oil engines.

I am afraid this hurried account of my acquaintance with Australian electric lighting matters will appear rather disjointed, as I have had to write it in my spare intervals, and, having to rely principally on memory, have left out many interesting details, but it may serve to give some practical idea of electric lighting work in Australia at the present time. The important stations at Launceston and Hobart (Tasmania) and many others, are of necessity omitted, my object being to mention more particularly those I am personally acquainted with.

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**Hull.**—The Electric Light Committee of the Hull Corporation have considered the position they have been placed in by the rejection by the Council of the scheme for the extension of the light in the borough; and have reaffirmed their conviction that they should obtain further generating power, and, in order to secure the carrying out of the extension, have resolved to engage the services of a consulting engineer.

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## VISIT OF LI CHUNG TANG TO THE WORKS OF THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.

On Friday, His Excellency Li Chung Tang paid a visit to the works of the Telegraph Construction and Maintenance Company, at Enderby's Wharf, Greenwich, on the joint invitation of that Company and of the Eastern Extension and Great Northern Telegraph Companies. A special train left Charing Cross shortly before 10 o'clock, with the Grand Secretary and suite and a party of over 100 guests. On arrival at Charing Cross His Excellency was met by the Marquis of Tweeddale (Chairman of the Eastern and Eastern Extension Telegraph Companies), Sir A. J. Leppoc Cappel (Director of the Eastern and Eastern Extension Companies), Mr. J. Denison Pender (Managing Director and Vice Chairman of the Eastern Telegraph Company, and Director of the Eastern Extension Company), Admiral Sir George H. Richards (Chairman of the Telegraph Construction and Maintenance Company), Commodore Suenson (Managing Director of the Great Northern Telegraph Company), Mr. William Shuter (Managing Director of the Telegraph Construction and Maintenance Company), Mr. F. E. Hesse (Manager and Secretary of the Eastern Extension Telegraph Company), Mr. F. C. C. Nielsen (Representative in England of the Great Northern Telegraph Company), Mr. E. Dickens (Secretary to the Telegraph Construction and Maintenance Company), and other Directors and officers of the companies concerned. A carriage, with four horses, postilions, and an outrider, was in waiting at Greenwich station; and His Excellency, accompanied by the Marquis of Tweeddale and Admiral Tracey, drove in this equipage, preceded by a fire-engine, to the works. On his arrival at the works the Grand Secretary was at once conducted to a telegraph table, which had been put up in one of the marquees erected for the occasion. It may here be said that the preparations for the reception of the Grand Secretary at the cable works were on the most elaborate scale. The four previous days had been devoted to clearing an extensive space at the wharf and erecting marquees upon it. A suite of rooms, comprising a retiring-room and a dining-room, had been constructed for His Excellency's use; and there were, in addition, a room for the reception of guests, and a huge marquee, 175ft. by 100ft., with an oak floor, which was used as a luncheon-room. Indeed, we have it, on the authority of Lo Feng Luh, that the Grand Secretary was "specially struck with the marquee," though not, we trust, to the exclusion of more important matters. Mr. Shuter then presented the Grand Secretary with two cable "curios," in the shape of a piece of the experimental core laid between Dover and Calais in 1850, and recovered in 1875, and a piece of the 1858 Atlantic cable, picked up in August, 1880, by the "Scotia."

On reaching the improvised telegraph office His Excellency was invited to send a message to Shanghai. Thereupon his indefatigable secretary, translator, and speech-maker, Lo Feng Luh, produced a lengthy message in numerals; but upon it being explained that for demonstration purposes a short message in plain English would be more suitable, the following despatch was sent off:—

"To Shan Shun Yan, Shea Nan Hon, Managers of China Merchants' Steam Navigation Company, Shanghai.—Leaving England for America 22nd, thence for Canada first eighth moon. Will leave Vancouver on 8th per 'Empress of China,' expected to arrive Yokohama 22nd. Please despatch either Foo Sum or Kwang Li, under the command of Captain Wallace, to wait for us there for conveyance to Tientsin. The famine funds for Ngan Hwie difficult to be collected. Where is Shen Suen Hwei? Reply immediately.—LI CHUNG TANG."

We may say that the object of the numerals was not to conceal the purport of the message, but that the Grand Secretary merely wished to avail himself of the code which the Great Northern Company had prepared by Mr. Viguier, of Shanghai, more than 25 years ago, and which is very extensively used by the Chinese in their telegraphic correspondence. An initial difficulty in the introduction of telegraphs into China was the apparently insurmountable obstacle of dealing with Chinese characters; but by the adoption of the system of taking about 6,000 of the most frequently used of these symbols arranged as in a dictionary, and giving each one a number in ordinary numerals, the problem was solved.

The message was despatched to London, thence over the lines of the Eastern Company to Marseilles, Malta, Alexandria, Suez, Aden, Bombay and Madras, thence by the Eastern Extension Company's system to Penang, Singapore, Labuan, Hongkong, Foochow and Shanghai—a total distance of 12,608 miles, no less than 13 translations being necessary. The message was 12½ minutes in transit, the reply message of 31 words occupying 7 minutes. The despatch and receipt of these messages and various others of a complimentary character were carried out under the direct superintendence of Mr. H. A. C. Saunders and Mr. T. A. Bullock, of the Eastern and Eastern Extension Telegraph Companies.

After this telegraphic demonstration the Chinese Envoy Extraordinary made a tour of the Works, under the guidance of Mr. F. R. Lucas, Engineer-in-Chief, and Mr. William Shuter Managing Director of the Telegraph Construction and Maintenance Company, and he followed with dignified interest the operations of brass-taping and armouring a cable core.

At about 12 o'clock the assembled company adjourned to the luncheon marquee; and the Chairman (the Marquis of Tweeddale) having proposed the toasts of "The Queen-Empress" and "The Emperor of China," next proposed the health of Li Chung Tang:—

To the Eastern Extension and Great Northern Telegraph Companies, whose cables connected China with the rest of the world, the name of Li Chung Tang was, he said, more than familiar. It carried with it the respect and admiration which a life-long devotion to his Sovereign and country had assuredly well earned. His Excellency had been a pioneer for the last quarter of a century. He had been the leader of progress and advancement in the vast empire which he so worthily represented. Probably few were aware of the immense difficulties he had had to contend with in bringing China into her present position in the world. He had introduced railway and mining enterprises into China. He had been the means of establishing a vast network of telegraphs throughout China, connecting the Russian, Indian, and French telegraphs, as well as the submarine cables of Europe, with all parts of the Chinese Empire. This important work was commenced in 1880, and now there were nearly 10,000 miles of telegraphs in China. When His Excellency was told that the Eastern Extension Company paid a dividend of 7 per cent., he replied that the Chinese telegraphs paid a similar dividend. That was a tribute, not only to His Excellency's enterprise, but to his great business capacity. Li Chung Tang had informed the speaker that he was the first statesman in China who advocated the cultivation of friendly relations with the telegraph companies in that part of the world. It afforded him peculiar gratification to have that opportunity of publicly thanking His Excellency for the immense assistance he had rendered towards the development of telegraphy in the Far East, without which it would have been impossible for telegraphy between the East and West to have reached its present state of efficiency.

LI CHUNG TANG'S reply was made on his behalf by Lo Feng Luh, who said: I have to thank the Marquis of Tweeddale, the President of the Eastern Extension Company, for the kind words with which he has expressed the sentiments of the institution. We live in a world of evolution, in which the two principles, the struggle for existence and the survival of the fittest, will always hold good. Telegraphs and railways are the fittest means of communication, and these companies which entertain us, I daresay, are the fittest manufacturers and controllers of one of the fittest means of communication. They are the two pioneers who worked in the new field of their enterprise in the East, and who served as the best instructors of the Chinese as to how to build telegraph lines; and the prosperity of the Chinese Imperial Telegraph Administration reflects the services and merits of the two cable companies. I have always advocated the amalgamation and combination of European skill with the unlimited natural resources of China; and the prosperity of the Chinese Telegraph Administration shows the effect of this combination. I hope that the other industries will follow the example of the two cable companies, who are the pioneers in the East, and who have effected a combination of European scientific knowledge with the Chinese natural resources, not only for the benefit of England and China, but for the benefit of humankind in this world. As the Viceroy has an engagement in London I have to bring his speech to a conclusion, and drink to the prosperity and success of the combination of European scientific skill with the Chinese unlimited natural resources.

The Grand Secretary then left, accompanied by the Marquis of Tweeddale, and returned to London, Admiral Sir George Richards taking the chair.

The toast list concluded with "Submarine Telegraphy," for which Commodore Suenson, of the Great Northern Telegraph Company and Admiral Sir George Richards responded. We give below the full text of their remarks.

Commodore SUENSON: Unaccustomed as I am to express myself publicly in English, it is with much hesitation that I venture to address this most distinguished company. It is, however, not only a sense of duty but also the sentiments of my heart that prompt me to speak on behalf of the Great Northern Telegraph Company of Copenhagen, with



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which I am so closely connected, and to which belongs the honour of having established the first submarine cable in Chinese waters, and the first overhead land lines on Chinese soil. The appreciation of this honour is associated with a feeling of gratitude for the hospitality which my Company has so long enjoyed in the Celestial Empire. In fact, it is now more than 26 years since I as a young man went out to China to arrange for the establishment of our first cables; and to speak the truth, the object of my visit was not greeted with enthusiasm either by the Chinese, who did not yet realise the idea of telegraphy, or by the European residents, who only too well realised the immediate effect of the innovation. I here specially refer to the great commercial firms and houses, who were quite aware that the extension of the telegraph lines to China would deal a severe blow to their supremacy by putting an end to great speculations and by enabling the small merchants to keep in touch with the movements of the markets all over the world. However, once laid down, the cables were freely used by the Europeans and only *too* freely by the Chinese, although not exactly in the way we should have preferred. In fact, large pieces of them were picked up by the Chinamen, and the copper and steel wires were turned into nails for tea-boxes; this really was "to add insult to injury." By-and-by, however, the intelligent Chinese merchants convinced themselves that telegraphy was neither humbug nor devilry, and that the cables could be used in a more respectful and profitable way. The object of my Company was, however, not only to lay *cables*, but also to build *landlines*, which might spread the benefit of telegraphy to the 400 millions of people living within the limits of the Celestial Empire. But here we had to deal with the less intelligent and more superstitious populations of the interior. For ten years we struggled hard, and lost no opportunity to further our object. In 1874 and 1875 we thought we had succeeded, having obtained permission from the authorities at Fohkien to build a landline between Foochow and Amoy. The country was surveyed and the building commenced by our engineers; but when 30 miles of the line had been erected, it was torn down by the population, under the pretext that it interfered with the graves and was offensive to the famous "Fungshui," that it attracted the evil spirits, and what not. After a whole year's repeated vain attempts we were obliged to give it up, succeeding, however, in saving out of the wreck a short telegraph line between Foochow and Pagoda Anchorage, as well as a telegraph school for the instruction of Chinese pupils. These and many other efforts in different parts of China, however, paved the way, and had, above all, the effect of drawing the attention of His Excellency the present Ambassador, Li, to the subject. From the year 1880 I may truly say that His Excellency became the Providence of telegraphy in China, as he has been China's Providence in many other respects. He gave a contract to my Company for establishing a landline between Shanghai and Tientsin and a telegraph school for young Chinamen at the latter place. This was a considerable work. The line had a length of 900 miles, and entailed the erection of not less than 21,000 telegraph poles, besides the crossing of several rivers by cable. Nevertheless, the whole line was built in about five months, and, I am glad to say, to the entire satisfaction of His Excellency. I need not add that all the superstitious fears about its interfering with anybody or anything vanished as soon as it became known that the work was performed under the protection of China's most eminent and all-powerful statesman. From this moment the development of telegraphy in China may be illustrated by saying that the telegraph poles in China's fertile soil vied in growth with the bamboos. In a very few years a network of telegraph lines was spread over the Middle Kingdom, forced its way even through the Chinese Wall, and now extends to the remotest frontiers of the immense empire. I am proud to say that most of these lines have been surveyed by, and built under the superintendence of, Danish engineers, and I feel sure that my British colleagues and friends, who, with their great predecessors in submarine telegraphy have covered England with more unfading glory than any other nation, will not grudge the small country which was the fatherland of Oersted, and I may add of the Princess of Wales, the honour of having introduced telegraphy in the far East, in China and Japan. We should never have been able to do so had not British pluck and enterprise, such as has been shown by the Anglo-American Telegraph Company, the present Eastern and Eastern Extension Companies and others, set the example, and had not the necessary experience and materials been supplied by British science and industry, such as are embodied in the grand and magnificent establishment which we have seen to-day. Allow me to add one more fact and one more reflection to this hurried sketch of the history of telegraphy in China. The fact is this, that although China since 1884 has been engaged in two wars with foreign powers, neither the Chinese Government nor the French in 1884 and 1885, nor the Japanese in 1894 and 1895 have interfered with the telegraph cables landed on Chinese territory or with the service performed by them. They have been allowed to pursue their neutral, useful and peaceful work to the benefit of all parties concerned, although in the last war they directly connected the two belligerent powers. This is a proof of regard for neutral property, of respect for international telegraphy, and of recognition of the immense services rendered by it, which ought to be noted, and to serve not only as an example worthy of imitation, but also as an argument in favour of the submarine companies' repeated demands for the neutrality and the inviolability of neutral cables in time of war.

Admiral Sir G. A. RICHARDS: On the part of the Telegraph Construction Company, I beg to offer to His Excellency our cordial thanks for the honour he has done us in associating the name of our Company with the toast he has just proposed, and to you, gentlemen, for the way in which you have received it. Commodore Suenson, in the excellent speech he has just delivered, has ably dealt with the political and other difficulties his Company has had to overcome in carrying the telegraph into Northern China. I had, perhaps, better confine myself briefly to the practical, all-round question of the laying and maintaining of these great ocean lines. It is a little difficult to deal with one's own achievements in public, and my colleagues have always been averse to dwelling on what the Company has done or is going to do, and we prefer to leave that to the telegraph companies whose great works we have carried out during the last thirty years, with whom we have always been on terms of the greatest confidence and harmony, and who are so well represented here on this occasion, and we have been always ready to accept their verdict. We are all known as telegraph companies, but the difference is that the one establishes, owns, and works the cable, and has its difficulties political and otherwise with foreign countries; while the other manufactures, and lays and maintains the cable at the bottom of the sea. Its difficulties and risks are of a technical nature, incident to the elements and the depth of the ocean, and have been so far solved, as far as they may be, by the skill of the seaman and the engineer. Gentlemen, if I depart to-day from the modest reticence which is most congenial to ourselves, I trust you will impute it to the exceptional nature of the present occasion. We don't feel that it would be proper or respectful to our illustrious guest to withhold from him any information which he has shown so much anxiety to obtain on all subjects. I will therefore recapitulate briefly the nature and extent of the works which we have carried out during our comparatively brief existence of a little over thirty years, although we are the most ancient cable manufacturing company in the world. The first of our great works was the laying of the Atlantic cable in the year 1865, after many difficulties. Since then we have successfully laid, I think, six cables between Great Britain and North America. More recently we may say, I hope with pardonable pride, that we have carried out all the great telegraphic enterprises conceived by the great father of ocean telegraphy, Sir John Pender, who has recently been taken away from among us, and whose name must always be conspicuously remembered in connection with these achievements. Thus, in a comparatively brief period Great Britain has been connected with Lisbon, which has been made one of the great centres of marine telegraphy, and with the Mediterranean, Malta, Egypt, thence via the Red Sea with Aden, Singapore, India, Hong Kong, Australia, and New Zealand, and on the South and West with West Africa, the Cape of Good Hope and Brazil. It is true the globe has not yet been girdled across every ocean, though this will probably be done; but all sides of it have been brought together, and every continent and considerable island and place of importance has been connected with this country generally by duplicate, often by triplicate, lines of telegraph. In carrying out these works this Company alone has manufactured and laid something over one hundred and sixteen thousand miles of cable. I believe there is no finality for the electric cable, and I am sanguine enough to predict equal prosperity in the generation yet to come.

It is to be hoped that Commodore Suenson's eloquent appeal to belligerents to respect the property of submarine cable companies will not, now that such a good example has been set us in the Far East, fall on deaf ears; but that a decision creditable to our much-vaunted civilisation will be arrived at.

In addition to those already mentioned there were present at this notable gathering—

Vice-Admiral Tracey, Mr. B. C. G. Scott, Mr. J. C. Lamb, Prof. Crookes, Admiral Sir J. Commerell, Mr. Louis Floersheim, Lieut-General Sir Andrew Clarke, Mr. Latimer Clark, Admiral Sir A. H. Hoskins, Sir R. W. G. Herbert, Admiral Sir W. Dowell, Sir Eyre Shaw, Sir Henry Mance, Mr. J. D. Campbell, Mr. J. Campbell, Mr. J. Coppen, Mr. G. H. Pember, Colonel Walters, Mr. George Draper, Mr. H. Thwaites, Mr. F. le B. Bedwell, Mr. J. Latey, Mr. A. G. Angier, Mr. H. W. Lucy, Mr. G. Von Chauvin, Mr. W. A. Pickering, Mr. A. D. Shuter, Mr. G. R. Neilson, Mr. G. R. Elphinstone, Dr. Wholey, M. Guernier, Mr. J. Boon, Mr. W. R. Lyne, Mr. F. Youle, Mr. J. C. Parkinson, Mr. L. L. Hartvigsen, Capt. Cato, Mr. O. Moll, Mr. W. H. Baines, Mr. H. St. L. Smith, Capt. Manning, Capt. Woodcock, Mr. C. B. Barnes, Capt. Lang, Capt. Kennedy, Hon. A. G. Brodrick, Capt. Trott, Mr. G. W. Campbell, Mr. C. F. Vennedt, Mr. Keswick, Mr. G. M. Davey, Mr. H. F. Hesse, Mr. Arthur Dearlove, Mr. H. C. Forde, Mr. R. Peake, Mr. W. T. Ansell, Capt. Scott-Smith, Capt. Ingles, Mr. R. J. Reidy, Mr. H. Holmes, Mr. T. Finnis, Mr. R. T. Brown, Mr. W. P. Granville, Mr. H. Clifford, Mr. J. Lloyd, Mr. R. M. Cunningham, Mr. Youngson, Mr. Ch. Gerhardi, Mr. S. Collett, Capt. Seymour, Mr. R. Collett, Capt. Gifford, Mr. D. H. Goodsall, Mr. L. Schott, Mr. W. J. Browne. Mr. S. Barber, Mr. W. C. Johnson, Mr. W. O. Smith, Mr. C. E. Günther, Mr. R. London, Mr. F. Dawes, and Mr. W. H. Axworthy.

**Physical Chemistry.**—The publication of a journal of physical chemistry will begin in October of this year. This journal is to be issued upon the first of every month—except in July, August, and September, when no numbers will appear. It will contain articles embodying original research in all branches of experimental and theoretical physical chemistry; and this matter will be supplemented by thorough and prompt reviews of the current literature of the subject, *i.e.*, of all journal articles and books which bear upon any phase of it. The new publication will accordingly present a continuous and complete account of all work done in the field in question after June, 1896. The subscription price will be, in England ten shillings per volume, *i.e.* per year, the first volume running to the close of 1897, and comprising twelve numbers. All communications, concerning either articles or subscriptions, should be addressed to the *Journal of Physical Chemistry*, Ithaca, N.Y., U.S.A. The editors of the journal will be Prof. Dr. Wilder D. Bancroft and Prof. Dr. Joseph E. Trevor.

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## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August 7, 1896.*

**Electrical Executions.**—The last Legislature of the State of Ohio enacted a law providing for the execution of condemned murderers by electricity, as is now the practice in New York State. The new law came into effect on July 1st; and in order to be in a position to carry out its provisions when occasion requires, the Ohio prison officials have been endeavouring to secure the necessary apparatus. But in this they have met many obstacles and difficulties, which may not have been unlooked for, in view of the fact that the New York prison authorities encountered similar difficulties. These difficulties arise from the fact that none of the manufacturers of alternating-current apparatus are willing to dispose of their machines for the purpose of killing human beings. They argue that such use casts discredit upon the apparatus so used, and they are in business to build up and not pull down. Of course, such a position is based largely upon sentiment; yet there is admittedly good reason for the objections urged. It cannot be denied that the use of any particular make of alternator for the purpose of executing the death penalty would be no recommendation for the particular machine, especially in the public mind; and it is not surprising that the various manufacturers of this class of apparatus object to their machines being used for the purpose of killing. The New York authorities were compelled to resort to strategy in order to secure an alternator. After trying all the manufacturers of such machines without success they finally secured one by ordering it through an obscure supply house in Texas. The machine was delivered to the Texas concern, and then reshipped to Auburn, New York, where it was to be used in launching condemned criminals into eternity. The Ohio authorities have about concluded that they will have to resort to similar means of procuring an alternator. Ohio now stands on record as being the second State to adopt electrical executions.

**Trolley Patent Decision.**—On July 29th, Judge Shipman, in the United States Circuit Court for the district of Connecticut, handed down a decision modifying a former decision, thereby permitting the restoration of trolley bases by those engaged in the repairing and renewing of trolley equipments. The earlier decision referred to was rendered by Judge Townsend last December, sustaining the Vandepoele patent covering the fundamental principle of the trolley, which patent the Court defined as applying to a long, swinging, pivoted, hinged, upwardly spring-pressing arm on top of a car, and having an under-running contact with an overhead conductor. The Court at the same time dismissed a bill relating to a second patent of Van Depoele covering a trolley base. In the present opinion Judge Shipman holds that the trolley base is but a feature of the Van Depoele patent, no particular type or form of which is necessary for the successful operation of the trolley. The order so modifies Judge Townsend's opinion that permission is given to replace broken stands, or those worn by use, but not to reconstruct or rebuild a combination sold by the patent owners. The owner of the Van Depoele trolley patents, as is well known, is the General Electric Company.

## CORRESPONDENCE.

### THE DECIMAL-METRIC SYSTEM AND NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of August 7th (p. 489) a letter from Mr. Oliver Heaviside about the metric system. That gentleman believes that *names* are capital for popular use. That is right, but I hold that it would be neither advantageous nor necessary to adopt *officially* other names than those of the metric system, because the names of the units must be international, like the system itself. If you adopt "popular" names you ought, if consistent, to vary them in the different counties of England, and you would forego many of the benefits of the metric system. The man in the street will probably give a name of his own to the units most often used; but he ought to know that a pint, a quart, &c., have such and such a value and such and such a name in the metric system. Thus, convenience will be respected, and for official and international transactions the correct terms will be employed. This is what is done in France; there there are "popular" names for a great many units. The men in the street talk of—

| | |
|---|---|
| Boisseau for ..... | a décalitre. |
| Quart for ..... | 2 litres. |
| Choppine for..... | $\frac{1}{2}$ litre. |
| Demi-setier for ..... | $\frac{1}{4}$ litre. |
| Sou for ..... | 5 centimes. |
| Lieue for ..... | 4 kilometres. |

And so on. The *cresson* is sold at "6 liards la botte" (2 *bundles* for 15 centimes). The butchers and grocers sell their goods at so much a déca (décagramme), and say—

| | |
|---|---|
| Livre for ..... | $\frac{1}{2}$ kilogramme. |
| 2 onces for ..... | $\frac{1}{10}$ " |
| 1 once for..... | $\frac{1}{32}$ " |

The same names are not used in all parts of France; but, whatever term is used, everyone knows what is the correct value and the corresponding metric name. An error never occurs, and nobody would care to alter the scientific terms of the metric system, and to adopt "popular" names that would be altered with time and fashion, whilst the metric system must not be altered, and is intended to last longer than a fashion.—Yours, &c., A MAN IN THE STREET.

Paris, August 18, 1896.

## LEGAL INTELLIGENCE.

### Farringdon Works (Limited) v. I.E.S. Accumulator Company (Limited).

This action was heard in the Lord Mayor's Court, London, on the 11th inst., and was for the recovery of £52. 13s. 9d. for goods sold and delivered. The defendants denied liability and counter-claimed for damages, alleging that the plaintiffs contracted to supply them with five tons of oxide of lead; but they only delivered two tons, which were not according to contract, and by reason of which they suffered damage. Counsel for the plaintiffs stated that the defendants required a compound which was called red oxide, and used in connection with the manufacture of accumulator plates. This red oxide was, apparently, a mixture of an ordinary red lead and also of an ingredient called litharge. The defendants had a secret in regard to the proportions in which these ingredients were to be mixed so as to produce a compound suitable for application to the plates. The plaintiffs had supplied them with red oxide which they (plaintiffs) obtained from the manufacturers, Messrs. Walker, Parker and Co. The latter firm had been previously instructed by the defendants as to the method of preparing the compounds. On April 23rd last the plaintiffs received an order from the defendants for the supply of five tons of oxide exactly as before. The two tons were duly delivered, the invoice price being £35, and this sum, together with a balance of £22. 13s. 9d. from an old account, made up the £52. 13s. 9d. now sued for. The defendants refused payment on the ground that the oxide supplied was not according to contract. After delivery they telegraphed, "The last two tons of oxide no good; all plates spoiled; send some more at once." The plaintiffs were told by the manufacturers that the oxide complained of was of exactly the same quality as that previously supplied, and had been manufactured in precisely the same way, and Mr. Arthur Billyeald (manager to Messrs. Walker, Parker, and Co.) gave evidence to this effect. For the defence it was stated that the sum of £12. 6s. 3d. had been paid by the defendants off the price of the two tons of oxide supplied, leaving a balance of £22. 13s. 9d. The defendants declined payment of that, on the ground that the stuff supplied was absolutely useless to them, and, in addition, they counter-claimed for the return of the £12. 6s. 3d., and also for damages by reason of the defective condition of the oxide. The material was used in connection with the manufacture of accumulator plates. It was mixed in certain proportions with sulphuric acid, so as to form a cement with which the accumulator plates were covered. If the red oxide and litharge were mixed in proper proportions, it would, when treated with dilute sulphuric acid, form a binding cement. The plaintiffs had supplied the defendants with a sample of the stuff which they were prepared to supply. The sample was tested and approved, and the order was given on March 10th for oxide "as per sample." That worked properly, and made a perfectly binding cement. On April 23rd an order was sent for a further five tons of oxide "as before." The two tons were not equal to the oxide previously supplied; and in consequence of the red oxide and litharge being impro



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perly mixed, it did not make a binding material when mixed with sulphuric acid. The cement did not adhere, and 1,600 plates, which cost 6d. each, were rendered useless, and the defendants had been put to an expense of a halfpenny for the treating of each plate. After hearing the evidence the jury returned a verdict for the plaintiffs on both the claim and counter-claim.

### Braulik v. Darton.

At the City of London Court on Monday, Mr. G. Braulik, electrician, of Upper Thames-street, sued Messrs. F Darton and Co., of St. John-street, Clerkenwell, for the recovery of £7. 4s. 5d. for electrical bells sold and delivered. Evidence of the receipt of the order and the supply of the bells was given by the plaintiff's traveller, who said no size of bell was mentioned in the order; and when payment was applied for defendants complained that the bells supplied were the wrong size. For the defence, it was contended that the bells supplied were not according to the sample submitted by the traveller, and measured 2¼in. instead of 2⅜in. In reply to the Judge, the traveller said he could not swear what size of bell he showed the defendants; but quotations for several sizes were given, and the order was for 2½in. bells at 15s. After evidence for the defence had been given, the Judge entered judgment for the defendants, observing that it appeared to him that there had been a mutual mistake, and that no agreement was ever arrived at.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged is quite up-to-date, and includes the new Board of Trade Regulations**

### NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either *singly* at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied. price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. s also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issu of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

TENDERS INVITED.—The Cork City Council invites proposals from persons willing to carry out the terms of Cork Provisional Order (1896). The Council has made arrangements with the local Electric Tramway Company for taking a supply of electric current for working the tramways from the assignees of the Order. Offers should be sent by noon on Friday, September 11th, to the Town Clerk (Mr. Alexander M'Carthy), Municipal Buildings, Cork. Some additional information is given in our advertisement columns.

——— The Corporation of Glasgow is prepared to receive tenders for the electric lighting of the St. Andrew's Halls. Specifications, &c., from Mr. William Arnot, electrical engineer, 75, Waterloo-street, and tenders should be sent to the Town Clerk (Sir J. D. Marwick), Town Hall, Glasgow, by 10 a.m. on Friday, the 28th inst. Further particulars appear in our advertisement columns.

——— The Electric Lighting Committee of the Bath Corporation invites tenders for (*a*) boiler-house plant—boiler and fittings, feed pump, &c.; (*b*) engine-house plant—steam alternators, oil filter, fittings, &c., steam, exhaust, feed, blow-off and sundry pipes, valves, &c.; (*c*) mains; (*d*) crane; and (*e*) arc lamps and posts. Tenders must be sent in to the Clerk (Mr. F. H. Moger), 3, Wood-street, Bath, on or before Monday, the 31st inst.

——— Her Majesty's Commissioners of Works invite tenders for the execution of pneumatic and electric bell-hangers' work for public buildings, &c., in the London district for three years from October 1st. Schedules with forms of tenders may be obtained from Her Majesty's Office of Works, 12, Whitehall-place, S.W., between 11 a.m. and 5 p.m., and tenders must be delivered at the office by noon on Wednesday, the 26th inst.

——— The Electrical Committee of the Bristol Town Council requires tenders for additions to the electric lighting station at Temple Back. Tenders to the Secretary of the Electricity Department, Temple Back, Bristol, by the 4th September.

——— The Newport (Mon.) Harbour Commissioners require tenders for the electric lighting of the new landing stage by means of incandescent lamps.

——— The Spanish Government is inviting tenders for the construction and working of a telephone system in Mayagüez, in Porto Rico. Some particulars may be seen at the Commercial Department of the Foreign Office between 11 and 6 daily. Tenders should be sent in to the Minister of Public Works, Madrid, by October 8th.

——— The Sociedad Co-operativa Gaditano de Fabricacion de Gas, of 25-29 San José, Cadiz, Spain, invites tenders for electrical plant and apparatus, capable of supplying current to about 2,000 16 c.p. lamps. The electricity station is intended for private lighting only, and must be equipped so as to be capable of furnishing a continuous supply of current. Tenders must include plans of all the plant and cables, the latter to have a carrying capacity of 4,000 16 c.p. lamps, and should be quoted both for overhead suspension and laying underground. The Society also wishes to have particulars as to cost of the following types of stations:—Steam, gas, and Dowson gas. If required, gas and water supply will be laid on by the Society, and further particulars will be given if necessary. The price of coal is 30 pesetas (£1. 4s.), and coke 24 pesetas (£1) per ton. Firms desirous of obtaining the contract are advised by H.M. Consul at Cadiz to send representatives to treat personally with the Company. Tenders have to be in by September 15th. Some additional particulars may be seen at the Commercial Department of the Foreign Office, Downing-street, S.W., between 11 and 6.

——— Tenders are being invited by the Municipal Authorities of Merida for the electric lighting of the streets. Tenders to El Secretario del Ayuntamiento de Merida (Badajoz), Spain, by the 25th inst.

——— The Municipal Authorities of Spa, Belgium, require tenders for the lighting of the public streets, either by electricity or acetylene. Tenders to the Collège des Bourgmestre et Echevins, Spa, by September 15th.

——— The French Post and Telegraph Department invites tenders for the supply of iron pipes required in connection with the pneumatic tubes used in the Post and Telegraph service. Tenders to the Direction Générale des Postes et des Télégraphes, 103, Rue de Grenelle, Paris, by September 1st.

——— The Hamburg Finance Deputation requires tenders for the erection of an electric lighting installation at the Bourse. Tenders by the 25th inst.

——— The German State Small Arms Works Authorities at Dantzig invite tenders for the supply of incandescent lamps and arc-lamp carbons. Tenders to the Königliche Direction der Gewehrfabrik, Dantzig, by September 12th.

——— The Municipal Authorities of Bloemfontein invite tenders for supplying and laying down a complete electric lighting installation. Descriptions, plans and specification of schemes

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should be sent to the Town Clerk, Mr. W. A. Koller, Bloemfontein, Orange Free State, by October 1st.

TENDERS ACCEPTED.—The Hapton Parish Council has accepted the tender of Messrs. Simpson Bros., of Hapton, Burnley, for the electric lighting of the district from 1st September, 1896, to 30th April, 1897, for £124. Messrs. Sharp and Kent also submitted a tender at £275.

——— Messrs. Crittall and Co. inform us that the contract for lighting St. Saviours' Church, Southwark, with 350 16 c.p. incandescents has been entrusted to them; and that they have been successful in securing the contract for telephones, fire alarms, and attendants' recording apparatus at the West Sussex Asylum, Chichester.

APPOINTMENTS VACANT.—From our advertisement columns it will be seen that the Hammersmith Vestry requires a resident engineer to supervise (under the consulting engineer) the erection of the electric lighting plant, and afterwards to undertake the management and control of the electric light department. Salary £200 per annum, to be increased to £250 when the installation is in working order. Applications must reach the Vestry Clerk (Mr. W. P. Cockburn), 57, Fulham Palace-road, Hammersmith, London, by 4 p.m. on September 2nd.

——— A teacher of physics and kindred subjects is required at the Liverpool School of Science, Technology and Art. Salary £150 per annum. Applications to be sent in by the 31st inst.

PLANT FOR SALE.—Particulars are given in our advertisement columns of some electric lighting plant, consisting of a Norwich D-type dynamo, meters, switch, belting, &c., which Messrs. Lewis P. Garrett and Co., 58, Broomielaw, Glasgow, have for sale.

LIQUIDATION.—It has been decided to wind-up the Queen Anne's Mansions Lighting and Heating Company (Limited), and Mr. E. H. R. Trenow, 20, Threadneedle-street, London, E.C., has been appointed liquidator.

BANKRUPTCIES.—A receiving order has been made against G. L. Schultz, lately trading as George Schultz and Co., iron and steel merchants, at 90, Cannon-street, E.C. The debtor explained that he sold his business in April last, and had since acted as manager for the purchasers. Liabilities not stated.

——— In the Bankruptcy Court yesterday, upon the application of Messrs. Routh, Stacey and Co., a receiving order was made by Mr. Registrar Giffard against the old-established firm of Messrs. Paterson and Cooper, electrical engineers, European Works, Pownall-road, Dalston, N.E., and Prince's-mansions, Victoria-street, S.W., London, and also of Glasgow. The liabilities were stated to amount to about £21,000, and the assets to £16,000.

DIVIDEND.—A first and final dividend of 9¾d. in the £ is payable at the Official Receiver's, Halifax, in the failure of Charles Frederick Fox, electrical engineer, 1, Bond-street, Halifax.

NEW FIRM.—We are informed by Messrs. Nalder Bros. and Co. that, on account of the increase in the demand for their ammeters and voltmeters, this branch of their business will in future be carried on at 34, Queen street, Cheapside, London, by Mr. F. H. Nalder, one of the partners of the firm, in conjunction with Mr. E. Thompson, who has been for some years past manager of the ammeter test room at their works in Clerkenwell. The style of the new firm will be Nalder Bros. and Thompson, to whom all communications connected with electric light apparatus should be addressed. The position of the firm of Nalder Bros. and Co. is unaltered by the new arrangements, the partners remaining as before.—Messrs. F. H. Nalder, C. W. S. Crawley and A. Soames, the old firm retaining the whole of the business, with the exception of the manufacture of ammeters, voltmeters, wattmeters, cut-outs, switches and resistance frames, the manufacture of which is transferred to the new firm.

NEW WORKS.—The British Aluminium Company proposes to erect branch works at Baker-street, Greenock. These works will be fitted up for the manufacture of the carbon necessary in connection with the Company's works for the manufacture of aluminium at Foyers.

REMOVALS.—The private address of Mr. G. W. de Tunzelmann, B.Sc., will in future be 6, Penywern-road, Earl's Court, S.W.

——— Mr. J. S. Cunnington, electrical engineer, informs us that he has taken premises at 18, Cecil-court, Charing Cross-road, London, W.C.

——— Mr. F. J. Warden-Stevens notifies that he has removed his London offices to Connaught Mansions, Victoria-street, S.W. The Guildford offices remain as heretofore.

ELECTRICAL TRADES' UNION.—We are asked to state that a meeting of the members of this Union will be held at the Club and Institute Buildings, Clerkenwell-road, London, on Monday next, at 8:30 p.m. Mr. F. E. Sims, the general organising secretary, is to address the meeting on "The Objects and Benefits of the Union."

"SALAMANDER" DECORATIONS.—We have received from the United Asbestos Company, of Dock House, Billiter-street, London, E.C., a catalogue showing a choice variety of designs for staircase dados, ceiling decoration, freizes, door panels, &c., made by the Company from asbestos. It is well known that asbestos lends itself to a variety of uses; but, from the fact of its being uninflammable, its use in the preparation of wall and ceiling coverings is especially desirable. In the course of the Company's experiments in the manufacture of these "Salamander" decorations, Italian asbestos, which has a light grey tint, has proved the most effective, as it retains the hard, firm impression made upon its surface by the special process of embossing which is used in the preparation of these decorations. The designs here illustrated are the productions of leading artists, and the material used is capable of decoration in any manner. There will undoubtedly arise a large demand for these decorations, which are a great advance upon similar goods now on the market.

PRICE LIST.—We have received from Messrs. J. Bagshaw and Sons (Limited) their illustrated price list of wrought-iron pulleys, shafting and friction couplings. Accompanying the list are some rules and tables for engineers and architects. The list is fully illustrated.

PAN-RUSSIAN EXHIBITION.—The Russian Imperial authorities are making every effort to interest British visitors to the Pan-Russian Exhibition, now being held at Nijni Novgorod. The catalogue of the Exhibition is in Russian throughout, but a Guide-book to the town, the fair, and the Exhibition is issued in Russian, English, French and German, so that Continental visitors may be assisted. We have received a copy of the Guide-book, which gives an interesting description of the chief features of the Exhibition, with illustrations of some of the principal pavilions and stands. The work, which has been translated by Mr. Seymour E. F. Haye, is clearly written in an altogether superior style to that we are used to expect from such Continental publications. An electric railway has been constructed by Messrs. Siemens and Halske from the Exhibition to the town; there is a circular electric railway, built by Messrs. Podobyédoff and Co.; and the Finnish Steamship Company has put down an electric railway in the town for the purpose of carrying passengers up the steeper gradients. The Guide book gives every information that a visitor is likely to require.

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ABERDEEN.—An important debate took place at the meeting of the Town Council on Monday, on the question of the proposed acquisition of the local tramways by the Great North of Scotland Railway Company. A letter was read from Mr. W. Moffatt, the Secretary and General Manager of the Company, stating that his Directors were of opinion that the acquisition of the tramways by the Company would facilitate the construction of light railways in the country, and that the Company could more easily than any other body accomplish the improvement and development of the existing tramway system to the extent now demanded by the growing importance of Aberdeen; and, further, that the working of the tramways and light railways in conjunction by one Company would result in greater efficiency of service over both systems. His Directors would carefully consider the question of dispensing as far as possible with horse haulage, and of substituting therefor electrical and other mechanical motive power. The Company would also give a better service and increase the speed of the cars. They therefore proposed that, in view of the capital outlay which would be required for these purposes, the Town Council should agree to an extension of the period of the concession held by the Tramways Company. Mr. Moffatt suggested that the Council should appoint a Committee, with whom his Directors would confer on the whole matter. A letter from Mr. L. Mackinnon (secretary of the Tramways Company) to Mr. Moffatt was also read. This letter stated that the Directors of the Tramways Company were prepared, subject to the consent of the Town Council being obtained, to recommend the sale of their undertaking, including horses, buildings, plant, &c., at the price of £16 per share of 5,649 shares; and payment of all outlay to be incurred for constructing and equipping the extension to Bayview and doubling the line in Albyn-place. The Railway Company would also have to relieve the Tramways Company of its mortgages and other liabilities and take over its officials and staff. The Chairman, Bailie Edwards, moved that the whole matter be sent to the Finance Committee for consideration and report. Mr. James Gray moved as an amendment that the consideration of the question be deferred for three months, in order that the new Council and the community might have an opportunity of discussing the scheme. Captain Taylor proposed a further amendment that the matter be considered by the whole Council in Committee. After a long discussion the latter amendment was carried by 19 votes to 9.

ASHTON-UNDER-LYNE.—A report by the Electric Light Committee recommending the adoption of a combined electric lighting and refuse destructor scheme, prepared by Mr. Clirehugh, was considered by the Town Council at its last sitting. The Committee

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suggest that the generating station be erected on the site of the town's yard, and that the low-tension continuous-current system of supply be adopted. Dealing with the question of refuse destruction, Mr. Clirehugh stated that the difficulty of utilising refuse to generate steam for electric lighting purposes only was due to the fact that electric lighting stations were only fully occupied for about two hours out of the 24, while refuse was continually coming in and could not conveniently be stored; or provision could not be economically made for burning so large a quantity of refuse as was at their disposal in so short a time. The Council could probably arrange for supplying the Tramway Company with power, and, provided the Company were willing to pay a reasonable sum per unit for energy, it would be an excellent customer for the Corporation. They would probably require about 150 H.P. continuously, and this would enable the refuse to be consumed as fast as it was brought in. The system would enable the machinery to work fully loaded for a great portion of the 24 hours. After discussion the Council endorsed the Committee's report, and requested the Town Clerk to write to the Tramway Company on the matter; and the Market and Lighting Committee was requested to consider and decide as to which streets it was desirable to lay electric light mains in for street lighting purposes.

ASYLUM LIGHTING.—The Omagh District Asylums Board has decided to light the asylum electrically.

CANTERBURY.—The question of the erection of joint electricity supply and dust destructor works occupied the attention of the City Council on Wednesday for a considerable time. The Lighting Committee reported in favour of the combined scheme; but it was decided that the question should be considered by a committee of the whole Council a little later.

COUNTRY HOUSE LIGHTING.—The electric light installation at Mr. J. J. Murphy's residence at Passage West, Cork, has recently been overhauled. Current is now supplied by a Mather and Platt dynamo, driven by a Crossley oil engine. There is, in addition, a battery of 54 R type cells of the Chloride Electrical Storage Syndicate. The contract was entrusted to Mr. J. P. Pawsey, of Cork.

DORKING.—The District Council proposes to apply for a Provisional Order.

DOUGLAS.—A long debate on the lighting of the streets arose at the last meeting of the Town Council. It was proposed that the scheme of public lighting submitted by the local gas company for lighting the town by means of incandescent gas lamps, for a period of five years at £2. 14s. 4d. per lamp, should be accepted. This was opposed by Mr. Councillor Barron, who moved an amendment that the consideration of the matter be delayed, with a view to interviewing the Electric Tramway Company as to the cost of supplying the electric current for lighting the whole of the town. Alderman Proctor contended that if the town was to be lighted electrically the installation should be in the hands of the Council. Eventually the matter was adjourned for three months.

EALING.—The District Council has decided to apply to the Local Government Board for sanction to borrow £20,000 for electric light extension and other purposes. The Electric Lighting Committee has been instructed to put in another boiler at the electricity works at a cost of £500. There is at present an equivalent of 7,754 8 c.p. lamps connected, and orders are in hand for about 1,250 more.

ECCLES.—The Local Government Board has declined to sanction the Town Council's application for power to borrow £20,000 for the purpose of establishing electricity supply works. There was considerable opposition at the inquiry in June last. It was stated that the Council's scheme was only carried by the casting vote of the Mayor, and at the present time there is a small majority against electric lighting. The Council obtained a Provisional Order in 1893; but the date of the Order was recently extended to June 12, 1897, by the Board of Trade.

ELECTRIC POWER TRANSMISSION IN SOUTH AFRICA.—The Rand Central Electrical Works (Limited) hope to commence the supply of electrically-transmitted energy to Rand mining properties situated on the Main Reef line east of Paardekraal in November next. The present plant has been designed to supply 2,100 B.H.P., and it is stated that most of this has already been contracted for. Extensions of the plant are already spoken of.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from August 12th to August 18th, with the ports of destination:—

*Aden*—£16,800 (telegraph cable). *Argentina*—Rosario £1,122 (telegraph material. *Australasia*—Melbourne, £216 (including £194 telegraph material); Sydney, £714; Wellington, £328. *Belgium*—Brussels, £68. *Chili*—Iquique, £25. *China*—Shanghai, £70; Tientsin, £12. *Denmark*—Copenhagen, £52. *Egypt*—Alexandria, £60 (telegraph apparatus). *Holland*—Flushing, £10; Rotterdam, £251. *Hong Kong*—£16. *India*—Bombay, £30; Calcutta, £1,699. *Malta*, £30. *Russia*—Archangel, £88 (lamps); Libau, £64. *South Africa*—Cape Town, £402 (including £151 telegraph material); East London, £550; Port Elizabeth, £393; Beira, £667 (telegraph apparatus). *Spain*—Gandia, £635. *Straits Settlements*—Singapore, £1,116. *Sweden*—Stockholm, £23. Total £24,600.

FULHAM (LONDON).—Electric lighting matters still drag their slow length along at Fulham. At the last meeting of the Vestry a report by the Electric Lighting Committee, recommending the appointment of a deputation to visit towns where electric lighting and refuse destructor works had been installed, for the purpose of obtaining information and reporting to the Vestry, gave rise to a long and animated discussion. In the end the report was rejected by 18 votes to 13. The Vestry, however, decided to oppose the application of the County of London and Brush Provincial Company for a Provisional Order. The electric lighting question has been before the Vestry for the last three years, and numerous discussions on the subject have taken place, but no progress whatever has been made.

GLASGOW.—The Sub-Committee recently appointed to consider the question of the proposed extension of electric lighting in Glasgow has presented its report. Visits have been made to the stations at Manchester, Brighton, Islington and Bankside. The Council is recommended to adhere to the low-tension continuous-current system of distribution in whatever further electric lighting extensions may be decided upon. The report states that the Committee has been influenced in its decision by the fact that under this system current could be supplied from the one station for both lighting and traction purposes.

HALSTEAD (ESSEX).—In connection with the proposed scheme for the electric lighting of this district, last week an engineer from Messrs. Crompton and Co. made a canvass of some of the principal tradesmen with a view to obtaining information as to the amount of support likely to be accorded to the scheme, the probable demand for current, &c.

HAMPSTEAD (LONDON).—The demand for electric current continues to increase in a highly satisfactory manner. Connections are being constantly made by the Electric Light Committee, and it is stated that if the present rate of increase is kept up the whole of the available plant at the station will be in full use by the end of the autumn. The work of extending the station buildings, for which a loan of £30,000 was recently obtained, has been commenced.

HASTINGS.—A Local Government Board inquiry was held at Hastings on Wednesday into the application of the Town Council to borrow £7,560 for electric lighting purposes. Owing to differences with the Hastings and St. Leonard's-on-Sea Electric Light Company as to the price of current supplied to the arc lamps illuminating the sea front, the Council recently decided to establish electricity supply works. At present the Council is paying £25 per lamp per annum for 52 lamps, but the Directors of the Company have intimated that they cannot continue to supply current at this price. The station is to be erected on the site of an old pumping station in Waterworks-road. The application was supported by the Town Clerk and the Borough Engineer (Mr. P. H. Palmer). It is proposed to put down plant capable of supplying current to 105 arc lamps. Private lighting is not to be undertaken, but the municipal buildings will be lighted electrically. Provision will also be made for the future extension of street lighting.

HOVE.—The Hove Electric Lighting Company propose to extend their mains in portions of the East Steyning district.

HUDDERSFIELD.—With a view to testing the advisability of employing electricity more generally for street lighting, the Town Council has authorised the Electric Lighting Committee to electrically light a section of one of the streets in the central district.

INVERNESS.—The Town Council has considered the request of an electric light company for the sanction of the Council to its proposed application for a Provisional Order. It has been resolved that, as the Gas Commissioners are quite capable of supplying electric or other artificial light, the application be refused.

IPSWICH.—Prof. A. B. W. Kennedy has prepared a long report on the electric lighting question for the Electric Lighting Committee. This report is to be considered by the Committee on October 14th.

LIVERPOOL.—As the result of a report by the city electrical engineer (Mr. A. Bromley Holmes) the Lighting Committee has decided to reduce meter rents from 2s. to 1s. per month, and that in place of the present uniform charge of 7½d. per unit for electric current, the following scale be adopted after October 1st:—For each unit up to 1,000 per month 7d., and for each unit beyond 1,000 per month 4d. The price of current for heating, cooking, and power purposes, when supplied through a separate meter, has been reduced from 5d. to 4d. per unit. The Committee has further decided to allow consumers occupying two or more places of business to have all the current supplied included in one account.—Mr. Bromley Holmes is preparing a scheme for the electric lighting of St. John's Market for the Markets Committee.

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MANCHESTER.—The Gas and Electric Lighting Committee of the Town Council has addressed letters to the District Councils of Stretford, Moss Side, Withington, and Levenshulme, respecting the extension of the Corporation's electric light mains in these districts. The Moss Side Council has already appointed a deputation to attend the conference.

MOSS SIDE (MANCHESTER).—At the last meeting of the District Council it was reported that a deputation had waited upon the General Purposes Committee on behalf of the South Manchester Electric Supply (Limited). Mr. S. V. Clirehugh, who acted as spokesman for the deputation, expressed an opinion that the cost of laying the first instalment of electric light cables in the district would be about £5,000. The Company would offer the Council a general supply of current at a charge of 4d. per unit, leaving the Council to supply customers and collect accounts. The usual charge by the Company was 7d. per unit. The Council could acquire the undertaking in their district at any time by giving six months' notice. The district of supply would comprise Moss Side, Stretford, Withington, Levenshulme and Heaton Norris, and the supply station would be situated near the Crematorium at Withington. It was also reported that the Committee had received a deputation from a syndicate for supplying electricity for lighting and for motive power. The deputation suggested an electric tramway scheme in connection with the project for laying suburban lines from Peel Causeway through Brooklands and Sale to Stretford. The lines could be continued along Seymour Grove, Old Trafford, branching off at West Point to Chorlton-cum-Hardy; and also to Brooks's Bar, along Raby-street and Moss-lane East, Wilmslow-road, and Dickenson-road to Longsight, with a branch at Stretford along Edge-lane to Chorlton-cum-Hardy, and so forward past the Manchester Cemetery, Burton-road, Lapwing-lane, and on through Heaton Mersey to Stockport. The Council is at present considering these important proposals.

PLYMOUTH.—The Plymouth Town Council has fixed the charge for electrical energy at 5½d. per unit. The Council has decided to introduce electric traction on the local tramways.

POLICE.—At the Birmingham Police Court, on Friday, a lad named George Willetts was charged with causing wilful damage to an electric repeater belonging to the Midland Railway Company. For the prosecution it was stated that the lad went down the embankment near the Five Ways tunnel leading to New-street station, and broke the glass in an electric repeater and tore out the coil, thereby destroying the connection with the signal box. The indicator was used to show the signalman in the box when anyone was working a lever to cross a train from one line to another. In consequence of what the lad did the communication was destroyed, and a serious accident might have occurred.—Remanded.

PORTSMOUTH.—The Town Council is supplying electric current to the Baths and Washhouses Committee during the daytime at 2½d. per unit. The Council has decided to let on hire electric motors, heating and cooking apparatus, &c.

REDDITCH.—The District Council intends to apply for a Provisional Order.

SOUTHAMPTON.—The Town Council has decided to purchase a piece of land adjoining the electricity works for the purpose of extending the station. It has also been decided to apply to the Local Government Board for sanction to borrow an additional sum of £50,000 for electric lighting purposes.

SWANSEA.—The Syndicate which recently offered to purchase the Mumbles Railway for the purpose of equipping the line electrically, has now submitted an amended offer. It is stated that the negotiations with the Directors of the Railway Company are likely to result in the purchase of the line by the Syndicate.

TELEPHONE EXTENSIONS IN LINCOLNSHIRE.—The National Telephone Company propose to extend the telephone exchange service to Stamford, and other South Lincolnshire towns.

WITHINGTON (LANCS.).—The District Council has authorised a canvass of the ratepayers to be made in order to ascertain the probable demand for electric current. Should there be evidence of anything like a reasonable prospect of making an electric lighting scheme pay, the Council intends to apply for a Provisional Order.

## BOOKS RECEIVED.

"The Engineering Index." Vol. II., 1892-95. Edited by J. B. Johnson, C.E. (New York: The *Engineering Magazine*.)

"Calendar and Prospectuses of the Day and Evening Classes at the Durham College of Science. Session 1896-7." (London: Andrew Reid and Co.)

"Les Applications de l'Électrolyse à la Métallurgie." By M. U. Le Verrier. (Paris: Gauthier-Villars et Fils.)

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 20, 1896.

16,019. R. E. B. CROMPTON and E. A. N. POCHIN. London. Improvements in regulating switches.

16,057. C. KELLNER. London. Improvements in electrolytic apparatus.

July 21, 1896.

16,091. A. STEVENS and F. PUTTAERT. Brussels. Improvements in electric batteries.

16,152. J. ESTRADE. London. Apparatus for controlling electric currents.

16,168. B. DU B. SMOCK. London. Improvements in insulators.*

July 22, 1896.

16,231. G. SEYMOUR and S. A. LETTS. London. Improvements in electric motors and dynamos.

16,256. L. M. BULLIER. London. Improvements in electric furnaces. [Date applied for under Patents, &c., Act, 1883, Sec. 103, December 28, 1895, being date of application in France.]

16,257. L. M. BULLIER. London. Improvements in electric furnaces. [Date applied for under Patents, &c., Act, 1883, Sec. 103, December 28, 1895, being date of application in France.]

16,268. W. ROWBOTHAM. London. Improvements in electric batteries.

16,270. M. O. A. GARREAU. London. Improvements in secondary electric batteries.

July 23, 1896.

16,326. F. W. GOLBY. London. Improvements in apparatus for obtaining electric discharges. (A. Vosmaer, Holland.)

16,342. C. O. BASTIAN and H. C. HODGES. London. Improvements in or relating to prepayment mechanism for electrical or other meters.

16,358. H. J. GILL. Liverpool. Improvements in or in connection with electric railways or tramways.

July 24, 1896.

16,373. W. ILLINGWORTH and T. SMITH. Manchester. Improvements in the distribution of electricity and in junction-boxes for use therein.

16,404. S. JEVONS and W. COLLINS. Birmingham. Improvements in and relating to electrical signalling apparatus or bells.

16,418. W. DE GRAAFF. London. Improvements in the method of and means for automatically regulating arc lamps and other electrical apparatus.*

16,435. F. E. W. BOWEN. London. Improvements in filaments of electric incandescent lamps.

16,445. SIEMENS BROS. AND CO. (LIMITED). London. Apparatus for controlling electrically-actuated railway point apparatus. (Siemens and Halske, Germany.)

16,457. P. BRANDT and A. HEUSCH. London. Improvements in solenoid cores for voltmeters.*

July 25, 1896.

16,475. E. JONES, A. E. JONES, and G. KYNOCH AND CO. (LIMITED). London. Improvements in electric arc lamps.

16,484. C. E. PETERS. Manchester. Improvements in bottle washing machines.*

16,502. W. WHITEHEAD. Manchester. Improvements in or connected with electric clocks.

16,514. W. J. DAVY. London. Improvements in electrical switches.

16,516. J. VAUGHAN-SHERRIN and H. H. SHERRIN. London. Improvements in accumulator batteries.

16,533. F. DE MARE. London. Improvements in filaments for electric glow lamps and in methods of manufacture of the same. [Date applied for under Patents, &c., Act, 1883, Sec. 103, January 28, 1896, being date of application in France.]

16,534. F. DE MARE. London. Improvements in filaments for use in electric glow lamps.

16,539. P. ORMISTON AND S. B. APOSTOLOFF. London. Improvements in the manufacture of cables for telephonic, telegraphic, electric lighting, and other electrical purposes.

July 27, 1896.

16,566. J. RENDELL. Devizes. Improvements in or relating to electric bells or signals.

16,592. B. HAWKE and THE LONDON ELECTRIC WIRE COMPANY (LIMITED). London. Connecting plug for telephone cords.

16,597. R. M. J. HEURTEY and P. GERMAIN. London. Improvements in and relating to primary batteries.

16,608. J. D. R. BLAIN. London. An improvement relating to magnetic compasses.

16,629. J. D. R. BLAIN and W. J. PAWSON. London. Improvements in the construction of electric cables.

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July 28, 1896.

16,657. G. A. J. Telge. London. Improvements in means or apparatus for the measurement of electric energy.

16,683. J. A. McMullen. London. Improvements in alternating electric current transformers.

16,726. F. W. Schneider. London. Improvements in electrodes for secondary batteries.*

16,729. L. G. Attenborough and E. A. Sulman. London. Improvements in the manufacture of caustic soda and other alkaline hydrates and compounds by electrolysis.

16,737. J. D. R. Blain. London. Improved apparatus for generating or collecting electric energy.

July 29, 1896.

16,790. H. Ehricht. Berlin. Telegraph-wire reel.*

16,801. A. Farkas. London. Improvements in electrical cut-outs.

16,852. G. Poore. London. Improvements in electrolysis.*

July 30, 1896.

16,894. J. Finlayson. Glasgow. Improvements in and relating to instruments for measuring electric currents.

16,916. E. Strzelecky. London. Apparatus for obtaining oxygen and hydrogen from steam by electrolysis.

July 31, 1896.

17,001. R. Pauli. Birmingham. Electrolytic manufacturing of cyanide of alkali.

17,025. T. A. Rose and Rose and Bird (Limited). London. Improvements in incandescent electric lamps.

17,044. W. Edwards. London. Improvements in and connected with apparatus for lighting and extinguishing gas jets by means of an electric current.

August 1, 1895.

17,088. H. W. Headland. London. Improvements in electric batteries.

17,093. G. M. Sellick. London. Improvements in counter-balance weights for electroliers, gasoliers, and other suspended fittings.

17,098. A Sautter and J. J. Sautter. London. An automatic electrical switch or exchange.

17,101. J. H. Field. London. Improved electrical switch.

17,122. H. H. Lake. London. Improvements in metallic junction-boxes and means for uniting metal conduit-tubes thereto and to each other. (E. T. Greenfield, United States).*

17,123. H. H. Lake. London. Improvements in insulating joints for metal or armoured conduit-tubes, more especially suitable for electrical conductors. (E. T. Greenfield, United States).*

## SPECIFICATIONS PUBLISHED.

Note.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

12,613. Lorrain (Esmond).—Electric railways.

12,615. Lorrain (Esmond). Electric railways.

12,616. Lorrain (Esmond). Electric railways.

12,697. Harsen and Frimand. Automatic electric fire alarm.

13,113. Lake (Baivy). Telephonic installations.

13,175. Stock. Telephone exchange switchboards.

15,174. Atkinson. Alternate-current motors.

15,288. Lake (Société Anonyme La Précision). Electric clocks.

16,247. Edmunds. Electric cables or conductors.

16,248. Edmunds. Electric transformers and dynamo armatures.

16,897. Hirst and Gibson. Holders and supports for electrical candles.

17,123. Herst. Linked suspensions for electroliers, &c.

17,782. Wall. Electric contact for use with clocks, &c.

18,483. Davis. Electric glow lamps.

18,870. Langdon-Davies and The Alternate-Current Electromotor Syndicate (Limited). Electromotors and transformers.

19,628. Boult (Damseaux). Electric burglar alarms, &c.

1896.

4,617. Coerper. Electric railways.

6,437. Lake (Union Electricitats Gesellschaft). Current collectors for electric trams.

7,896. Bell and Sloss. Electrical hair-cutters and singers.

8,948. Lake (Painter). Electrical signalling apparatus.

9,171. Fairweather (Munson, Roberts, Alston, Reid and Reid). Electric railways on the conduit system.

9,817. Bach, Lewis and Saunders Electric lamp shade.

10,047. Stern. Electrical transportation.

10,099. Mackin. Arc electric lamps.

10,772. Otis Elevator Company (Limited). (Otis Bros. and Co.). Starting and stopping devices for electrically-operated elevators.

11,162. Golby (Winter). Electric time alarm apparatus.

11,391. Reynolds. Electric cut-outs.

11,417. Brown and Huntress. Means for electrically connecting rails of electric railways.

12,650. Cox and The Cox Thermo-Electric Company. Thermo-electric generators.

# COMPANIES' MEETINGS AND REPORTS.

## Cuba Submarine Telegraph Company (Limited).

The fiftieth ordinary general meeting of this Company was held on Wednesday at the offices, 58, Old Broad-street, E.C.; Mr. Charles W. Parish (Chairman of the Board of Directors) presiding.

The SECRETARY (Mr. James Scott) read the notice convening the meeting.

The CHAIRMAN: I presume, gentlemen, that you will accept our report as read. When we last met, six months ago, I ended my remarks by recalling to your minds that our next meeting would be our fiftieth, and I said, "I hope we may then meet you with the same satisfaction as we do to-day." Gentlemen, I am glad to say this hope has been fulfilled, for our Company has passed through another term of six months, and we are able to report that our cables have worked well, and that we have earned a larger sum of money than in any previous half-year of our existence. The traffic receipts for the first half of 1895 amounted to £29,164, while this half-year they are £34,868, including the subsidy on the Cienfuegos-Manzanillo cable. Our expenses during the same periods were £6,118 and £9,425 respectively, leaving a balance of £23,046 to June 30, 1895, as compared with a balance of £25,443 to June 30, 1896, or an increase of £2,397, notwithstanding a charge of £1,787 falling upon the half-year now under review, in connection with sundry repairs, from which the first half of 1895 was happily free. If we compare the heads of expenditure for the two half-years you will find that all the totals are either the same or below those for 1895, with the exception of station expenses, which have risen from £3,521 to £5,175; this, however, was to be expected, and chiefly arises from our now working eight stations instead of three. The actual cost of the Cienfuegos-Manzanillo cable has come out at £41,412. 17s. 8d., which is less than the estimate which we gave you in our last report, the difference being due to a rather shorter length of cable having been required than was prepared for, the remainder of the cable being put into stock, and increasing the value of that account from £6,500 to £10,000. You will be glad to know that the amount of £41,412. 17s. 8d. represents the total cost of all the cable used, and its laying, the station huts and other expenses, including the fee paid to Mr. Keith for acting on behalf of the Company in testing and taking over the cable from the contractors. You will recollect I mentioned at our last meeting how valuable Mr. Keith's assistance, with his special local knowledge, had been, not only to the Company but to the contractors. After meeting the cost of this cable out of our reserve it stood at £78,587. 2s. 4d., and we felt it absolutely necessary to the wellbeing of our Company to add all we could spare to build up this fund again. We have therefore added to it £1,502. 8s 4d., which was a profit on investments realised, and £17,910. 9s. 4d. from revenue account, bringing up the total to £98,000. But satisfactory as these results are, I must mention to you that the last six months have been a period of anxiety to your Board, not only on account of the disturbed political state of the island of Cuba, but also to the great agitation which is going on amongst promoters of fresh cable schemes and new companies all over the world. Those of our shareholders who follow up telegraphic matters are doubtless aware of the numerous suggestions which interested parties are pressing upon some of the European Governments to connect their Colonies by their own particular cables, the French Government being particularly active in this respect. How far these proposals are practical, or how far they are needed, remains to be seen. I think myself their necessity and advantage are exaggerated; but we must nevertheless be ready to face any new situation which may arise. Our own Government are considering the question of a cable from Bermuda to Jamaica, and have been in communication with our allies, the West India and Panama Company, and ourselves on the matter; it is not a new scheme, but it is a very difficult one, and I have no definite information to lay before you at present concerning it. But I refer to these different points that you may know that your Directors have good reason for strengthening the reserve fund of the Company. New cables must mean competition, and I feel sure from past experience that in building up our strength to meet future events we shall be earning the complete approval of our shareholders. I think, gentlemen, I need not detain you any longer, and I will, therefore, conclude by moving the following resolution—

*"That the report and accounts for the half-year ended June 30th last, now submitted, be received and adopted."*

Mr. GEORGE KEITH: I beg to second that.

Mr. W. GRIFFITH referred to the Company's lawsuit with the Spanish authorities, and complained that the Company had been badly treated.

The CHAIRMAN agreed with Mr. Griffith, but was afraid there was no redress. He then moved the payment of dividends at the rate of 10 per cent. on the Preference and 8 per cent. on the Ordinary shares.

Mr. R. K. GRAY seconded, and the motion was unanimously carried.

The re-election of Mr. C. W. Parish as a Director was then agreed to on the motion of Mr. G. KEITH, seconded by Mr. J. P. HOOPER, who at the same time proposed that a sum not exceeding £1,000 should be distributed among the old servants of the Company at home and abroad in the way of bonus.

This was seconded by Mr. M. CURRY.

The CHAIRMAN: I quite sympathise with Mr. Hooper's suggestion. We owe a great deal to our staff, and I think this would be the proper way to show our recognition of it. Then, with your permission, we will find out how it can be best done and carry it out. Of course, the amount so distributed will appear in the next accounts.

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Mr. GRIFFITH: I think the bonus suggested is rather too large a sum. Nothing special has occurred why this bonus should be given, except length of service. I do not know whether we give our staff any pension.

The CHAIRMAN: We do not.

Mr. GRIFFITH: That is a strong argument in favour of the bonus.

The CHAIRMAN: Perhaps the simplest plan would be for the shareholders to leave the matter in the hands of the Directors now that you have expressed your feelings so clearly with regard to it. If you leave it with us we will do what is necessary and try not to give extravagantly, although we understand it is your wish that we should be liberal.

Mr. John Gane was then re-elected auditor of the Company.

A vote of thanks to the Chairman, proposed by Mr. CURRY, and seconded by Mr. HOOPER, brought the proceedings to a close.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**CENTRAL LONDON OMNIBUS COMPANY (LIMITED).**—This Company was registered on August 13th, with a capital of £1,000, in £1 shares, to carry on in the United Kingdom and elsewhere the business of electricians, electrical and mechanical engineers, manufacturers and owners of electrically-propelled vehicles and carriages, workers of and dealers in electrical machinery, appliances, apparatus, &c. The subscribers, with one share each, are G. Cox, H. Lafone, H. A. Moore, A. J. McMillar, W. B. Parsons, P. H. Senior, and B. Jackson.

**MANLOVE, ALLIOTT AND CO. (LIMITED).**—This Company was registered on July 29th, with a capital of £150,000, in £10 shares, to acquire the business of Manlove, Alliott and Co. (Limited), incorporated in 1868, and to carry on the business of mechanical, civil and consulting engineers, boiler and engineering tool makers, founders, millwrights, &c.

**GORSEINON ELECTRIC LIGHT COMPANY (LIMITED).**—The annual return of this Company to April 9th has just been filed. The whole capital of £1,000, in £1 shares, has been taken up, and 16s. per share has been called and paid.

**W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).**—The annual return of this Company to March 27th was filed on July 28th. The whole capital of £130,000, in 10,000 Ordinary and 3,000 Preference shares of £10 each, has been taken up, and the full amount has been called and paid.

**HOOPERS' TELEGRAPH AND INDIA-RUBBER WORKS (LIMITED).**—The annual return of this Company to June 1st has been filed. The capital is £50,000, in 1,000 Preference and 4,000 Ordinary shares of £10 each. All the former and 1,050 of the latter have been taken up, and the Preference have been issued as fully paid. The full amount has been called and paid on 550 Ordinary, and £2 per share has been paid on the remainder.

**INRIG AND CHESTER (LIMITED).**—The statutory return of this Company to July 3rd has been filed. 1,105 shares have been taken up out of a capital of £2,000, in £1 shares. 500 have been issued as fully paid, and the full amount has been called and paid on the remainder. Messrs. A. G. Inrig and Arthur Chester hold 450 shares each.

**MANCHESTER EDISON-SWAN COMPANY (LIMITED).**—The annual return of this Company to August 7th has been filed. The capital is £350,000, in 50,000 £5 "A" shares, and 10,000 £10 "B." All the "B" shares have been taken up and issued as fully paid. 20,000 "A" shares have been subscribed for, and £1. 10s. per share has been called.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30$\frac{5}{16}$d. per oz. (Aug. 20th). Consols (2$\frac{3}{4}$ per cent.) 113$\frac{1}{4}$—113$\frac{1}{2}$ for money, 113$\frac{5}{16}$—113$\frac{7}{16}$ for account; 2$\frac{1}{2}$ per cent. 108—108$\frac{1}{2}$ (Aug. 20th). Stock Exchange Settling Days: Consols, Sept. 1st; Stocks and Shares Continuation Day, Aug. 26th; Ticket Day, Aug. 27th; Pay Day. Aug. 28th; Mining Share Carry-over Day, Aug. 25th.

**BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).**—The transfer books of the First Debenture Stock of this Company will be closed till September 1st inclusive, in view of interest payable on that date.

**CITY AND SOUTH LONDON RAILWAY.**—The traffic returns of this Company for the week ended August 16, 1896, amounted to £1,110, against £924 in the corresponding period of 1895, an increase of £186. The total receipts for the half-year amount to £6,529, compared with £6,008 in the corresponding period of 1895, an increase of £521.

**FOREIGN COMPANIES IN FRANCE.**—A decree which modifies the existing laws relative to stocks or shares of foreign companies in France has recently been issued by the French Finance Minister. In future any company obtaining an official quotation for its shares must appoint a responsible agent in France, who must be accepted by the Minister of Finance or his representatives. No subscription list for an issue of shares can be opened, nor any issue of shares in a foreign company take place, until such responsible agent has been duly nominated and approved.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The coupons falling due on the 1st September on the 1883 (series B) debenture bonds of this Company should be presented for payment between 11 and 2, at Messrs. C. J. Hambro & Son's, 70, Old Broad-street, E.C. Coupons should be left three clear days for examination.

**INTERNATIONAL IMPROVED ELECTRIC COMPANY (LIMITED).**—The capital of this Company has recently been increased to £100,000 by the creation of 25,000 new shares of £1 each, and the name of the concern has been changed to the Improved Electric Glow Lamp Company (Limited). The certificate for such change was granted by the Board of Trade on 28th July.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 16th inst. amounted to £1,375, against £1,374 in the corresponding week last year, an increase of £1.

**LONDON, DEPTFORD AND GREENWICH TRAMWAY COMPANY (LIMITED).**—At the half-yearly meeting of this Company on Tuesday the Chairman (Mr. W. J. Carruthers-Wain), in moving the adoption of the report and accounts, referred to the question of the adoption of an improved system of mechanical traction, and said that any method of improving their receipts or decreasing their expenses would be carefully considered by the Directors. It was of no use to be in too great a hurry, unless, of course, they get a very considerable price for their undertaking, and other people were going to take the risk. When in America last autumn, he inspected one or two systems supposed to be good for crowded thoroughfares and heavy traffic; but he really did not see (subject, of course, to the improvements that had since been made) anything that would be suitable for the peculiar line which they owned. They had tried the Connolly oil motor on their line, they had triedcompressed gas, and they had also considered the claims of the Lurich gas motor, which had been in operation on some of their tramways for some little time. They must therefore wait a little while, and he had no doubt that those who waited the longest would get the best results.

**MERSEY RAILWAY COMPANY.**—At the half-yearly meeting of this Company on Friday last the Chairman (Mr. A. G. Kitching) announced that the Bill authorising the working of the line by electricity had received the royal assent. It was, however, a purely permissive Bill, and simply authorised the Company to employ electricity as the motive power if they so determined.

**NEW ZEALAND ELECTRICAL SYNDICATE (LIMITED).**—At the adjourned general meeting of the shareholders of this concern, held at Cannon-street Hotel on Tuesday, with Mr. Daniel de Castro in the chair, a squabble arose as to the legality of the proceedings of the previous meeting in electing Messrs. Boustead and Savory as Directors in the place of Messrs. De Castro and Grewing. Mr. Huxtable complained of the action of the Chairman, and was informed that he had his remedy. The Chairman stated that the Directors of the Company had been unable to obtain any information from the Receiver and Manager of the Company, who was in possession of the property and books of account. The Directors were, therefore, unable to present any accounts or balance sheet. Under these circumstances the Directors tendered their resignations; but, as the Company might be placed in a difficult position if they vacated their seats without providing for the election of their successors, they were willing to remain in office until new Directors had been elected by a properly-constituted meeting of the shareholders, after which the Chairman declared the meeting closed.

**NORTH STAFFORDSHIRE TRAMWAYS COMPANY (LIMITED).**—The half-yearly meeting of this Company was held at the Guildhall Tavern, Gresham-street, E.C., on Tuesday; Mr. W. J. Carruthers-Wain presiding. The Chairman dealt at some length with the contract for the electrical equipment of the tramways and for the extension of the present system. The Provisional Order authorising the construction of the extensions had been granted, and he thought the result would be to greatly increase the traffic over their line at other people's expense, and that, he considered, the most satisfactory way of making money. The Chairman then made reference to the Light Railways Act, and claimed credit for many improvements in the Bill, these improvements being the result of the work of the two Committees which were formed, and of both of which Committees he, as well as the Company's electrical engineer, were members. They took the opportunity of insisting that the light railways of the future were nothing more nor less than extensions of tramways, and that consequently the more tramway conditions were applied to light railways the easier they would find it possible to construct them, the cheaper they would be, and the more objections would be removed. A dividend at the rate of 6 per cent. per annum for the half-year ended 30th June on the Preference shares, and at the rate of 3 per cent. per annum on the Ordinary shares of the Company was then declared.

**RIVER PLATE ELECTRIC LIGHT AND TRACTION COMPANY (LIMITED).**—The scrip of the issue of £125,000 Five per Cent. First Debenture Stock of this Company is now ready, and can be had at the offices of the River Plate Trust, Loan and Agency Company, 52, Moorgate-street, E.C., in exchange for the allotment letters duly endorsed.

**SANITAS COMPANY (LIMITED).**—The Directors of this Company have declared an interim dividend at the rate of 10 per cent. per annum for the six months ended June 30th last.

**STOCK EXCHANGE NOTICES.**—Application has been made to the Stock Exchange Committee to allow 12,500 Ordinary shares of the Metropolitan Electric Supply Company (Limited) to be quoted in the official list, and to appoint a special settling day for 8,697 £10 Preference shares of the British Aluminium Company.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the week ended August 14, 1896, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,744.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half-month ended August 15th were £1,704, as compared with £1,660 in the corresponding period of 1895. The April receipts, estimated at £5,578, realised £5,581.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Divi-dend. | Name. | Previous Week's Price August 12. | Price Wednesday, August 19. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending August 15. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS.** | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 52 54 | 52 54 | 4 12 7 | Jan., Apr., July, Oct. | 52½ | 52½ |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 97½ 98½ | 97½ 98½ | 5 1 6 | " " | 98½ | 97½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 9 9½ | .. | .. .. | 9 7/16 | 9½ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 4 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ 9½ | 8½ 9½ | .. | .. .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15½ 15¾ | 15½ 15¾ | 4 8 11 | Mar., June, Oct., Dec. | 15½ | 15¾ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 6 7 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 2 9 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ 13½ | 12½ 13½ | 5 18 6 | February and August | — | — |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20 21 | 20 21 | 4 5 3 | | — | — |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ 4 | 3½ 4½ | 5 0 0 | April and October | .. | — |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% 110% | 107% 110% | 4 2 0 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9⅝ 10½ | 9⅝ 10½ | 4 3 0 | Jan., Apr., July, Oct. | 10¼ | 9⅞ |
| 400,000 | 10 | 5/6 | Eastern | 18 18½ | 18 18½ | 3 10 3 | " " | 18⅝ | 18 1/16 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 1 6 | " " | 19⅜ | 19¼ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 3 0 3 | May and November | 133 | 132 |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 104 107 | 4 13 6 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 18½ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18½ | 18½ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 2 | February & August | 131½ | 131½ |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 4 16 7 | January and July | .. | — |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 100 104 | 100 104 | 4 16 7 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 105 108 | 106 109 | 3 13 5 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% 113% | 111% 114% | 3 11 2 | May and November | .. | .. |
| 180,227 | 10 | 3 9 | Globe Telegraph and Trust | 11¼ 11⅝ | 11¼ 11⅝ | 3 13 7 | Jan., Apr., July, Oct. | 11⅝ | 11⅝ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 18 18½ | 18 18½ | 3 5 9 | " " | 18 5/16 | 18½ |
| 150,000 | 10 | 5/0 | Great Northern | 23½ 24½ | 23½ 24½ | 4 1 8 | Jan., April, and July | 24¼ | 23⅞ |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 105 108 | 105 108 | 4 14 4 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 53 56 | 53 56 | 4 9 3 | May and November | — | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | .. | 111 114 | 5 7 7 | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 111 114 | .. | .. | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel.4% Guar. Debs."Red"1942 | 108 111 | 103 111 | 3 12 5 | — | .. | — |
| 11,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | .. | .. |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 140 145 | 140 145 | 4 2 9 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 6 | 5 6 | 5 0 0 | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 104 107 | 104 107 | 4 15 3 | March & September | 106 | 106 |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. | January and July | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 99 101 | 99 101 | 7 15 0 | June and December | — | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | .. | 1 5/16 | 1 5/16 |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 12 | 5 0 0 | May and November | 11¾ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | — | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 10 6 | June and December | — | — |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8¾ 9¼ | 8¼ 9¼ | 4 17 4 | May and November | .. | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 7 7½ | 7 7½ | 5 0 0 | — | 7⅜ | 7⅜ |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 2¾ | 2½ 2¾ | .. | — | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 107 | 103 107 | 5 12 2 | February & August | — | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 107 | 103 107 | 5 12 2 | " " | — | — |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 3 7 | May and November | .. | — |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 104 107 | 104 107 | 5 14 10 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chill Telephone (fully paid) | 3½ 4 | 3½ 4 | .. | — | .. | — |
| 224,850 | 10/0 | 1¼d. | Consolidated Telephone Const.& Manufacturing | 1/16 1/8 | 1/16 1/8 | .. | May and November | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅛ ¼ | ⅛ ¼ | 5 14 3 | Yearly | 1/8 | 1/8 |
| £84,597 | 5 | 2/6 | National | 7⅞ 8 | 7⅞ 7⅞ | 3 10 3 | June and December | 8 | 7 11/16 |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | " " | .. | — |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 18 | 17 18 | 3 8 7 | " " | 17⅞ | 17½ |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅞ 7⅛ | 6⅞ 7 | 3 11 5 | — | 7 | 7 |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 3 9 | January and July | 108 | 107¾ |
| 58,000 | 5 | 4/0 | United River Plate | 3¾ 4¼ | 3¾ 4¼ | 4 14 2 | July | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 101 106 | 101 103 | 4 14 9 | January and July | 101 | 101 |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 15½ 16½ | 16 17 | 2 18 10 | February & August | 16½ | 15½ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17 18 | 17½ 18½ | 3 4 10 | January and July | 18 | 17¼ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 133 137 | 133 137 | 2 13 3 | June and December | — | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | — — | — — | .. | — | .. | — |
| £30,000 | £5 | 2/6 | Charing Cross & Strand Electricity Supply Corp. | 8¾ 9¼ | 8¾ 9¼ | .. | — | 9⅛ | 8⅝ |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — — | — — | .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. | — | 9 | 9 |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 13½ 14 | 13½ 14 | 4 5 9 | — | 14⅛ | 14⅛ |
| 8,322 | £5 | — | House-to-House Electric | .. — | — — | .. | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | — — | — — | .. | January and July | — | — |
| 111,000 | 5 | .. | London Electric Supply | ¾ 1¼ | .. | .. | — | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13½ 13¾ | 13½ 13¾ | 2 18 2 | — | 13¾ | 13⅝ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 119 123 | 119 123 | 3 13 4 | June and December | 122 | 121 |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 11 12 | 11 12 | .. | — | .. | — |
| .. | .. | .. | Rand Electric | 1⅜ 1½ prem. | — — | .. | — | — | — |
| 19,980 | £5 | 2/6 | St. James and Pall Mall | 12½ 13½ | 12½ 13½ | 2 17 5 | — | 13½ | 13 |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 6 8 | — | .. | .. |
| 59,900 | 5 | 3/0 | Westminster Electric Supply (fully paid) | 11 11½ | 11 12 | 2 18 4 | — | 11⅝ | 11⅝ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1 1½ | 1 1½ | .. | — | 1 7/16 | 1 |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1½ 1½ | 1⅜ 1⅝ | .. | — | 1⅜ | 1⅜ |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 112 115 | 112 115 | 3 19 9 | March & September | .. | — |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July | .. | ... |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) xd | 1⅞ 2¼ | 1⅞ 2¼ | 6 13 4 | February & August | 2 1/16 | 2 |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 5 1 | January and July | 104 | 104 |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | — — | — — | .. | — | — | — |
| 110,000 | 2 | .. | Electric Construction | 1⅝ 1⅞ | 1⅝ 1⅞ | .. | — | 1⅛ | 1⅛ |
| 12,845 | 2 | 2/9⅓ | Do. 7 per Cent. Cumulative Pref. | 2⅝ 3⅛ | 2⅝ 3⅛ | 4 6 2 | September | 3⅛ | 3 |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ ¾ | ⅝ ¾ | .. | — | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | — — | — — | .. | — | — | — |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 22 23 | 22 23 | 4 6 11 | February & August | 22⅝ | 22⅝ |
| £200,000 | 100 | 4% | * Do. 4 per Cent. Debentures | 106 109 | 107 110 | 3 12 9 | March & September | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ¾ 1 | .. | .. | .. .. | — | — |
| 87,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 39 42 | 39 42 | 4 5 9 | March and July | 41 | 40 |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 105 | 102 105 | 4 15 8 | January and July | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 17½ 18½ | 17½ 18½ | 4 10 1 | March & September | 18½ | 17⅞ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 18 19 | 18½ 19½ | 3 11 10 | " " | 18¾ | 18¾ |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 109 114 | 112 117 | 3 16 11 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £680,000 | Stock | 1⅜% | City and South London Railway Con. Ordy. | 46 48 | 46 48 | 2 12 0 | January and July | 47½ | 46⅝ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15 | 14½ 15½ | 3 4 6 | " " | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 138 | 136 138 | 2 18 0 | May and November | .. | — |
| 37,500 | £10 | .. | Liverpool Overhead Railway | 13¾ 13¾ | .. | 2 3 0 | — | .. | — |
| 10,000 | 10 | 5% | Do. 5% Preference | 17⅝ 17⅝ | .. | 2 17 7 | — | — | — |
| 115,000 | Stock | 4% | Do. 4% Debenture | 112½ 114½ | — | 3 9 10 | January and July | — | — |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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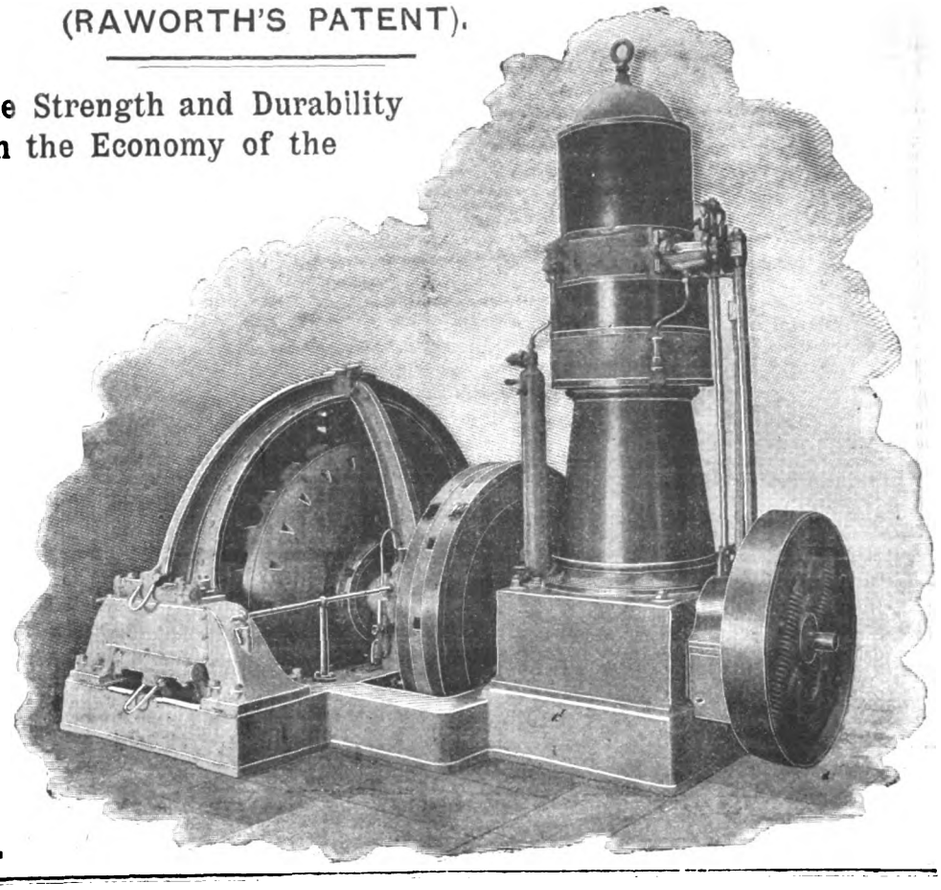

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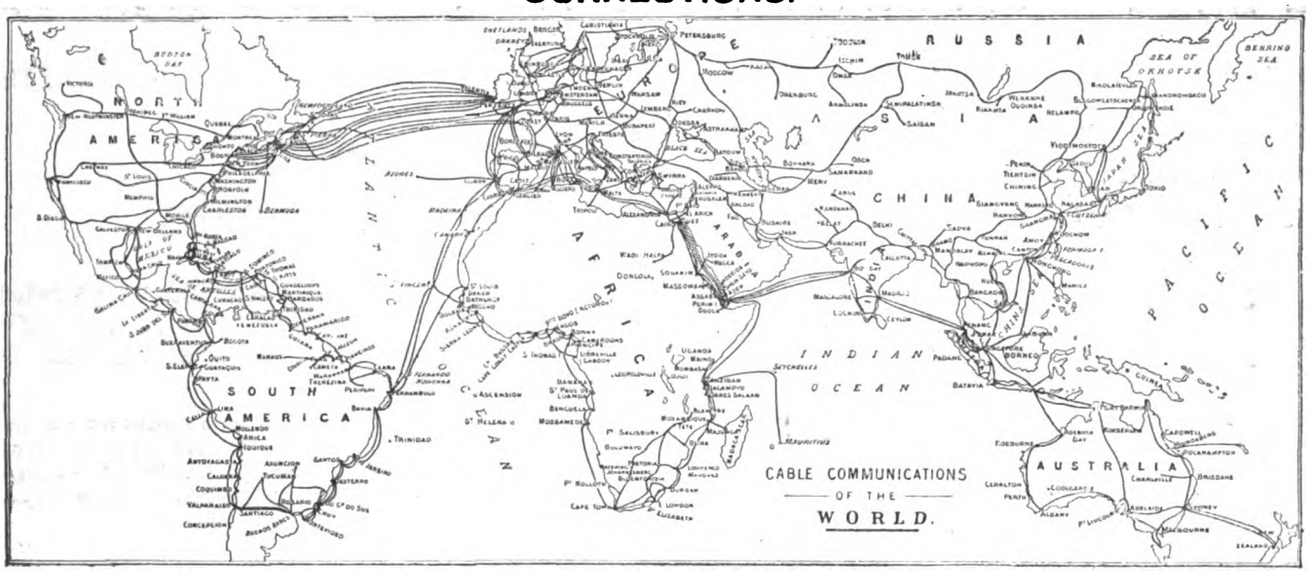


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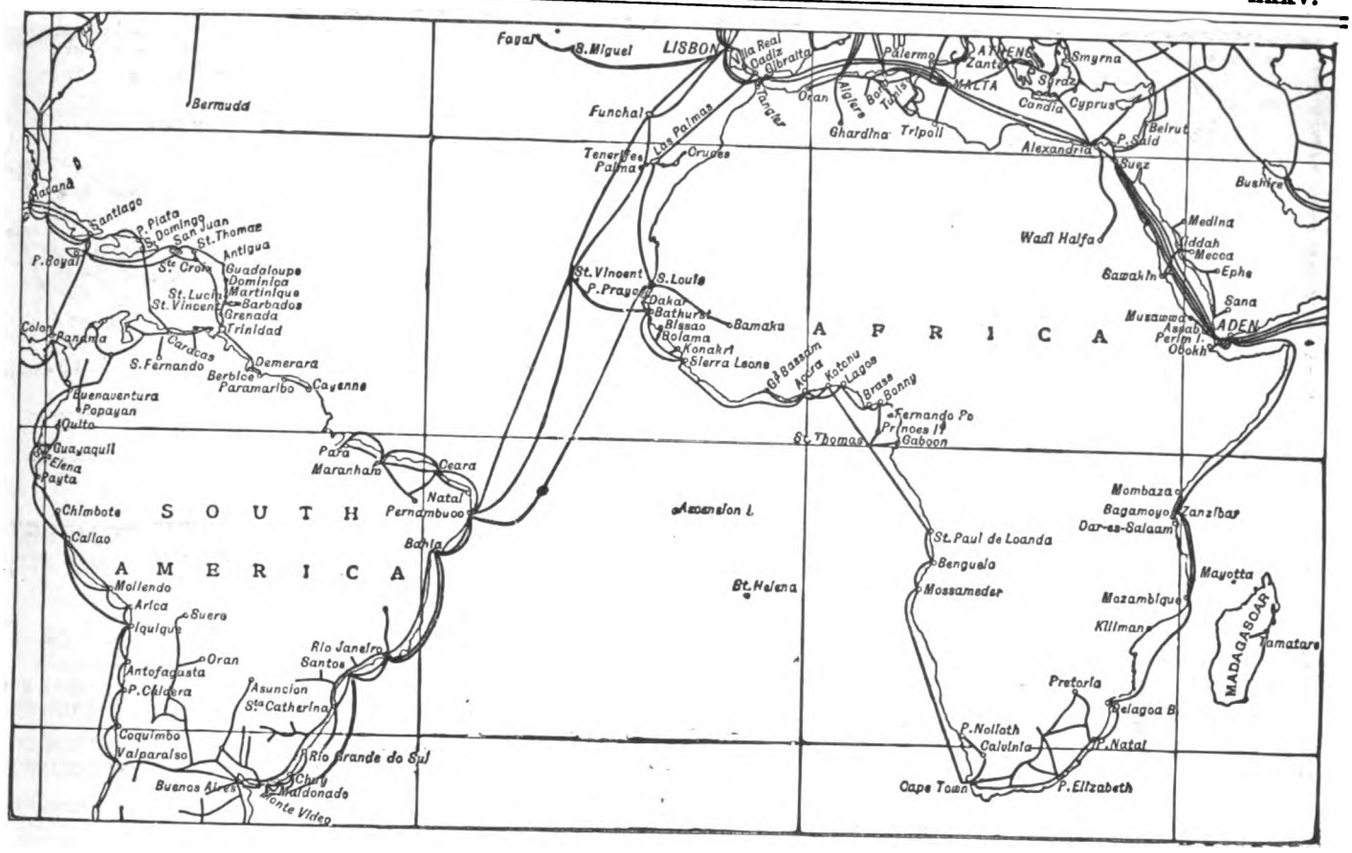


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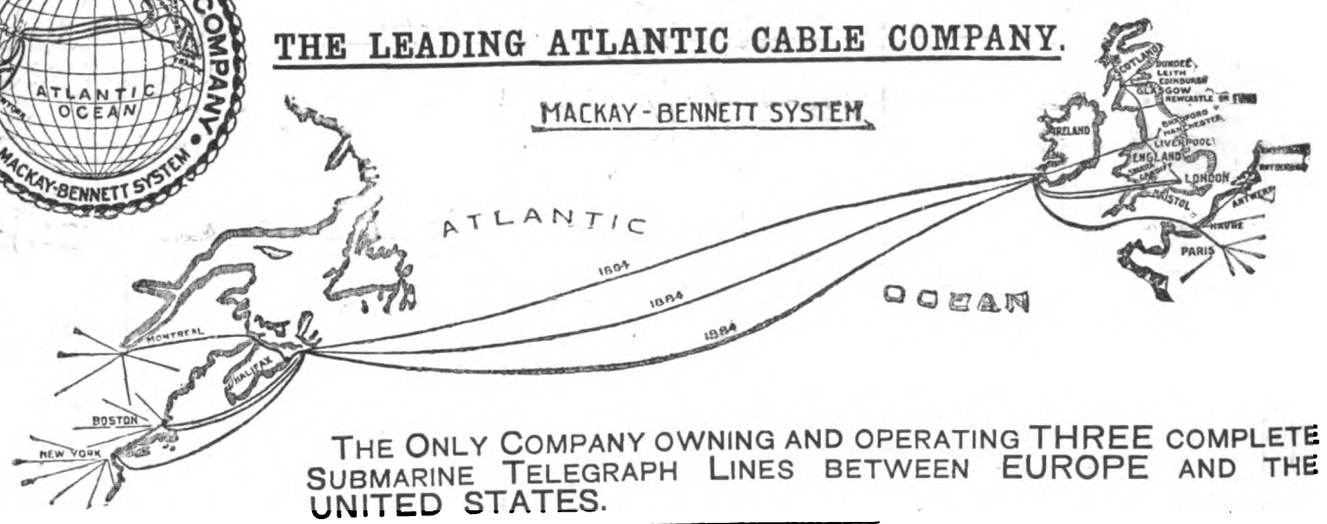


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The person appointed will be required to reside in the parish, and must give the whole of his time to the duties of his appointment.

Applicants must have had a thorough mechanical training and well versed in the erection and running of boilers, engines, and electrical machinery.

The salary will be £200 per annum during the erection of the works, &c., to be increased to £250 when the installation is completed and in working order.

Forms upon which applicants must send in their application may be had from the undersigned at the Vestry's Temporary Offices, 57, Fulham Palace-road, Hammersmith, on and after the 20th day of August, and any further information may be obtained on application to Mr. A. H. Preece, Consulting Engineer, 39, Victoria-street, Westminster.

Applications, marked on the outside "Resident Engineer," must reach me not later than Four o'Clock on the 2nd September.

Canvassing, both personal and otherwise, will disqualify candidates.

Applicants will not be required to attend on the above-mentioned day, and no travelling or other expenses will be allowed.

By order,

W. P. COCKBURN, Vestry Clerk.

Temporary Offices, 57, Fulham Palace-road,
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By order,

ROBERT E. FOX, Town Clerk.

Town Hall, Blackburn, 27th August, 1896.

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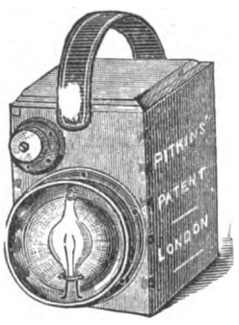


FIG. 1A.

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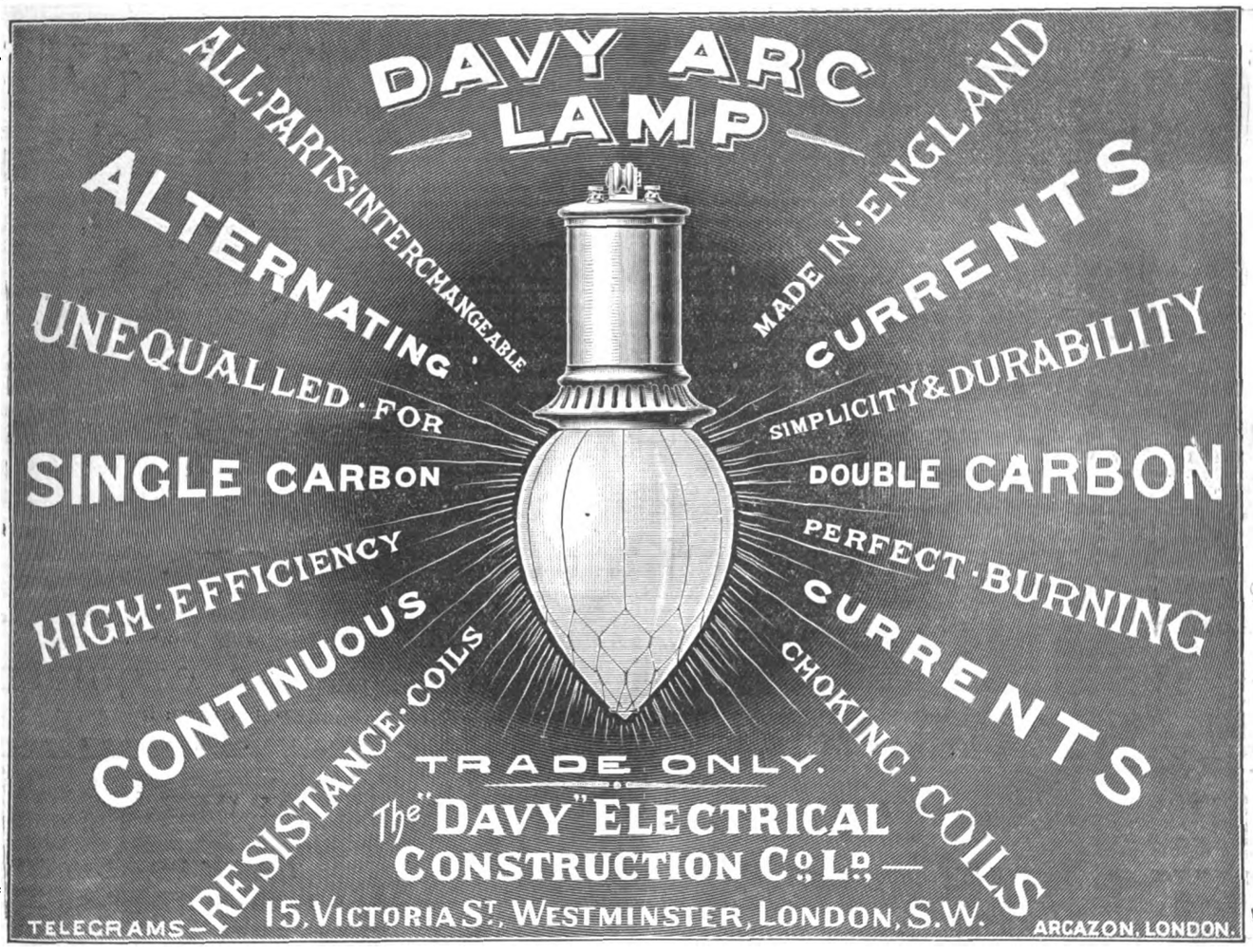


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In this original work is described the procedure on board ship when removing a fault or break in a submerged cable, and the mechanical gear used in different vessels for this purpose. Further, as regards the electrical tests in use for the detection and localisation of faults, to consider the best and most recent practice, and the various difficulties that occur to the beginner. With a total length of nearly 140,000 miles of cable submerged, and a fleet of 36 steamers employed solely in laying and repairing cables, some idea may be gained of the vastness and importance of this enterprise, and the various interests it involves. Of late years many improvements have been introduced in the tests used for locating the positions of faults in cables, and these have resulted in a considerable saving to the owners in cost of maintenance.

The book will be found of quite exceptional interest, and the illustrations assist the text in an unusual degree.

### TABLE OF CONTENTS:

**CHAPTER I.—The Cable Ship on Repairs.**

Speaking Apparatus—The Mark Buoy—Grapnels and Grappling—Special Grapnels—Cable Inboard—Buoying the Cable—Picking up—Types of Cable—Underrunning—Capacity of Tanks—Picking-up Gear—Removal of Fault—Joint in Core—Cable Splice—Slipping Splice—Cable Stoppers—Paying Out—Buoyed End Inboard—Final Splice and Completion of Repair—Regulations affecting Cable Ships at Sea—Buoying a Bight.

**CHAPTER II.—Types of Cable Ships.**

The Cable Ship "Faraday"—The Cable Ship "Store Nordiske' and "H. C. Oersted"—The Cable Ship "Monarch"—The Maintenance of Home and Continental Cables—The Cable Ship "Electra"—The Cable Ship "Mackay-Bennett"—The Cable Ship "Retriever'—Cable Depôts—Cable Gear on the "John Pender."

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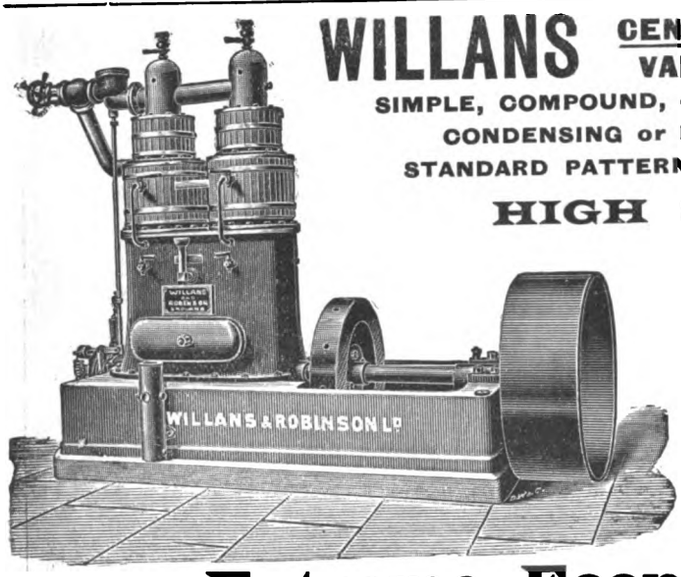


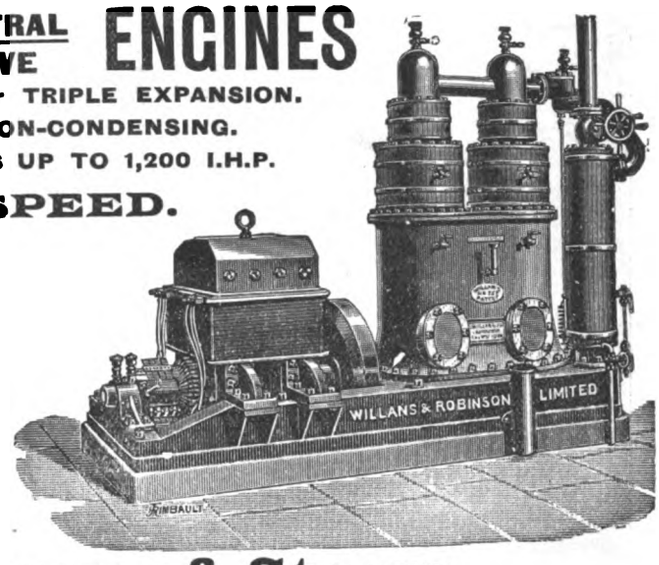


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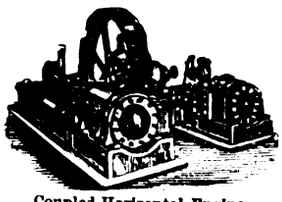

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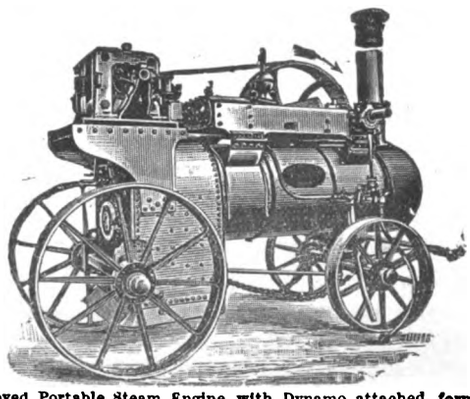

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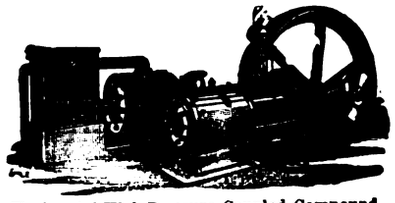

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 954. [Vol. XXXVII. No. 18.] FRIDAY, AUGUST 28, 1896. PRICE SIXPENCE.


## NOTES.

THE year 1895-6 having been one of unexampled prosperity for the Telegraphs as well as for the Post Office, some extracts which we print this week from the POSTMASTER-GENERAL'S Annual Report will be read with unusual interest. Never since the year 1886-7, when the number of telegrams rose from thirty-nine millions to fifty millions, has the traffic made so big a bound as in the past year, when the total of 1894-5 has been exceeded by seven and a quarter millions. Nearly three millions of these telegrams, strange to say, are represented by the increase in London alone; and as this local traffic had been almost at a standstill for many years, it would look as if the telephone service had either reached its high level in the metropolis, or had ceased to meet its requirements. The revenue returns, as usual, are obscured by different modes of computations in different parts of the Report, so that in one place there would appear to be a deficit, whilst in another a substantial surplus is shown; yet in both places (pp. 4 and 87) each item is described as Net Revenue.

THE combined totals of Post Office and Telegraph incomes are this year brought together; but as the lesser figures for the Telegraphs—those showing a deficit—are employed in the combination, the effect is to reduce the apparent net revenue of the Post Office as a whole, while swelling its gross earnings. The deficit is obtained by eliminating a number of sources of income in the one case, and including them in the other. United States politicians just now had better take note of this. People in this country also will observe with surprise that a sum of £89,313, though not included in the Vote, is charged to the cost of the Telegraph service, on account of "Buildings." We cannot help wondering where and how this large sum, which has been nearly equalled every year for six years past, is expended on buildings for telegraph purposes. It seems to us to be out of proportion to the total sum expended on Post Office buildings for the same periods.

IN our issue of July 3rd, p. 325, we gave an extract from a report of the British Consul at Bilbao regarding engineering contracts generally, and with especial reference to contracts for electrical plant and apparatus. The Consul pointed out that British manufacturers of electrical plant had a good opportunity of entering into competition with German makers and of securing a share of Spanish orders. In the same report the Consul invited British trade papers to take a greater interest in consular reports, and to help the trades represented by such journals to become acquainted with the requirements of foreign countries. There have recently been published particulars of tenders invited for electrical plant, &c., abroad, and we considered the opportunity a good one for placing before our readers items of information of this character, and accordingly wrote the Foreign Office, asking that particulars of contracts of an electrical character should be forwarded to *The Electrician*. On the 22nd the following letter, in answer, was received:—

"With reference to your letter expressing a wish to be regularly supplied with information respecting the invitation of tenders abroad, I am directed by the Marquess of Salisbury to state that the supply of such information to the technical press cannot be undertaken by this Office, but that *all information on these subjects may be obtained from the daily Press*.—I am, Sir, your most obedient, humble servant, F. H. VILLIERS."

The italics are ours. Should the British Consul at Bilbao read these lines, he will appreciate the special facilities which are offered by the Foreign Office to the technical Press to place such items of information before their readers. In connection with the recent appointments of commercial *attachés* at the principal commercial centres abroad, it would surely not be out of place to appoint an officer at home to supervise the preparation of contract notices for the leading trade journals. We are aware that the information *is* published, but usually too late to give those interested time to make the necessary inquiries and prepare specifications. We hear from time to time of the strenuous efforts made by the German Government Departments to keep German manufacturers in touch with the requirements of foreign countries. Has not the time now come when the Foreign Office should take a leaf out of the book of the German Government?

ALTHOUGH some progress is undoubtedly being made in the Navy in the direction of substituting electric motors for the many auxiliary steam engines by which a modern man-of-war is encumbered and endangered, England has not taken the lead which she did when the adoption of quick-loading guns was the question in hand. As is so often the case, the French, German and American naval authorities would appear to have a more open mind. Herr EICKENRADT'S Paper, which we reprint elsewhere in the present issue, is a well-reasoned exhortation to naval architects to vastly extend the use of electricity on board ship; indeed, the only operation which Herr EICKENRADT is at present disinclined to entrust to

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the electric motor is that of working the steering gear: a trying job, it is true, for any kind of motor, but much less so, we should have thought, for a rotary apparatus than for a reciprocating engine.

THE case for the electric motor, however, is overwhelmingly strong; it makes for safety, economy and comfort. For what is involved by the general adoption of electricity as the motive power on board a modern battle-ship? Nothing less than the abolition of long lines of cumbersome and wasteful steam pipes (which in action are a grave source of danger to the ship's company, and in everyday life a source of distinct discomfort), and the concentration of the steam-engine plant out of harm's way below the water line; a concentration which would result, if the best type of engine were employed, in a marked economy in steam consumption. The ventilating arrangements of our five-million dollar battleships are none too original or effective; by employing electrically-driven fans they could be revolutionised, and greatly improved. Space is precious, and coal is precious on board a man-of-war, Type 1896. Both would be economised if the latent resources of electricity were made full use of. Herr EICKENRADT seems to think that when electric motors come into universal use aboard ship, alternating currents will have to be employed, at any rate for power purposes, in order to avoid dangerous disturbances of the compasses. We venture to think that with concentric leads and "iron-clad" motors, there will be no need, on this account, to adopt alternating plant. A simple and a robust constitution, is, of course, essential in a ship motor; and from this point of view the use of alternating currents for motive purposes may, no doubt, present many advantages.

WE publish to-day an account of some experiments made by Mr. ERNEST WILSON on a non-synchronous two-phase alternate-current motor. These experiments were directed to the examination of the actions which take place in the inducing and induced circuits of an induction motor. It is, perhaps, a pity that the motor was of very small size, and had a length of air-space more than three times as great as holds in modern practice, so that the essential actions of such a motor were masked to a considerable degree. The form of magnetic circuit and arrangement of the inducing circuits is one which has only one example in practical use, viz., in the Stanley-Kelly two-phase motor. Nevertheless, the experiments contain many points of interest to designers of this class of machine. One point Mr. WILSON notes, which may often be observed in induction motors, viz., that there appears a disturbance of low period, giving rise to a variable torque. Mr. WILSON thinks this is due to the revolving field not being uniform, but it is more probably due to the irregularity of the winding or magnetic circuit. If it were due to this latter cause its period should be the time in which the difference in motion between the revolving field and the armature amounts to one revolution. Now, in the case of Mr. WILSON'S motor, the slip when loaded was about 1 in 25; and as the frequency in the experiment was 25, we should expect the period of the inequality of torque, did it arise from inequalities in the electric or magnetic circuits, to be one second, which is what it is stated to have been.

WHEN the form and material which might best fulfil the conditions necessary in a standard of electric resistance were under discussion, there was a body of opinion, of high scientific authority, which was strongly in favour of the Siemens' unit. On the other hand, there were those who held that *solid* material had many advantages over *fluid*, and that the experience of the B.A. Electrical Units Committee had not exposed any grave defect in the electric-resistance properties of the solid metals with which they had experimented. As might have been expected, the result of this state of affairs was a compromise, the question of the material for the standard ohm being to that extent left open. Germany has declared for the Siemens' form of unit ohm, and accordingly has engaged the splendid resources of the Reichsanstalt to construct a cylinder of mercury 106·3cms. long, and having a cross-section, uniform throughout its length, of 1 sq. mm. The statement of what is required is simplicity itself; but the time, labour, manipulative skill, and scientific attainments necessary to produce the article so defined are, to say the least, considerable.

WE print in another page a Paper by Dr. W. JAEGER, giving a summary of the investigations undertaken at the Reichsanstalt with a view to the preparation of legal "mercury" standards of electrical resistance for Germany. As a piece of careful scientific work, the standard mercury ohm of the Physikalisch-Technische Reichsantalt is worthy of all honour; and to Dr. JAEGER and his colleagues all praise is due for their admirable work. When all this is said, however, would it savour of the heterodox to confess to a slight suspicion? The mercury unit depends as a standard upon the determination of the specific resistance of mercury, which may be determined by the Lorenz method. The mercury employed in the Lorenz apparatus is used under conditions differing greatly from those applying to the mercury which constitutes the unit resistance. Can we assume that these two portions of mercury are alike in their physical properties to the required degree of accuracy? It is obvious that the degree to which we *know* the equality of their electrical properties is a precise measure of the degree to which we *know* the accuracy of the resultant mercury unit. But further, it must be shown that it is possible to formulate a specific treatment, which, if applied to any specimen of mercury, will produce a purified mercury having electrical properties which are definitive and predictable. When we consider the results which Prof. ROBERTS AUSTEN has obtained in his investigations concerning the character and extent of the diffusion of one metal within another, and recall the well-known property of mercury as a solvent (so powerful in some cases) of many metals, there appears to be ample justification for an open mind towards the definitiveness and permanence of the physical properties of mercury. Before we can comfortably allow the "mercury" unit to take rank as a standard there must be more reproductions of it by divers workers. It must be shown that, accepting the specific resistance of mercury as determined in Berlin, Paris, or London, it is reasonably possible to construct a mercury unit in China or Peru. Moreover, surely all this is concerned exclusively with a

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determination in absolute measure of the unit in question. When the question of providing standards for the purposes of measurement, either scientific or practical, is considered, new conditions emerge which are not readily met by the "mercury" unit, *e.g.*, the need for working at low temperatures; the limitations imposed on the testing current, &c., &c. Further, the last has not been said yet as to the permanency of the "mercury" unit, and we fear Dr. JAEGER is scarcely justified in claiming such constancy as he does; certainly, one would feel happier if one could see more evidence on the subject.

**Carborundum.**—The daily output of the Carborundum Company, which is operated by electric power from Niagara, has reached 4,000lb.

**South Shields.**—Mr. Jeckell informs us that the Corporation electricity works will be opened on September 1st. The current will be turned on at 7:30 p.m.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique ..... ..... | Dec. 19, 1895. |
| Monte Alegre—Santarem ..... | May 5, 1896. |
| Para—Maranham ..... | Aug. 6, 1896. |
| Zanzibar—Mombasa ..... | Aug. 23, 1896. |

**Obituary.**—We regret to have to announce the death of Mr. Walter Eccles, of the City of London Electric Lighting Company. Mr. Eccles had been cycling in Scotland while on his holidays, and on Sunday last, when proceeding from Portsonachan, Lochaweside, he apparently lost control of his bicycle in descending a steep hill near Cladich, and the unfortunate result was concussion of the brain, which terminated fatally on Monday morning. Mr. Eccles was a most promising member of the engineering staff of the Company, and had endeared himself to all employed at the Bankside Works, where he had worked for the last three years, and his untimely end is much regretted by all who knew him.

**The Telephone and its Application to the Deaf.**—The *Lancet* of August 15th contains an account of some telephonic experiments made by Dr. Bertram Thornton, medical officer to the Deaf and Dumb Asylum at Margate. Dr. Thornton says:—"My experience tends to show that this modification of the telephone promises to be of material use in the education of those deaf mutes who possess a fragment of hearing power, and it has the following important advantages over the single speaking tube that is sometimes used: firstly, that the wires from several receivers can be coupled up to one transmitter, and thus a teacher can instruct a group of children at the same time; and, secondly, that, as it is not necessary for the teacher to apply his mouth close to the transmitter, the pupils have a full view of his facial expression and lip movements, which is not the case when he has to direct his attention and his voice into the mouth of a speaking tube or trumpet."

**Electric Transmission of Power at Bâle.**—For some time past the Cantonal Authorities of Bâle have been considering the question of supplying current on a large scale for light and power purposes to the town of Bâle, and to this end have investigated the possibilities of the Rhine, running close by. These investigations have now been completed, and as a result the authorities have resolved to proceed at once with the building of an electric generating station. The Rhine will be tapped at Augst, about three miles from Bâle, and a channel about three-quarters of a mile long will carry the water to the turbine house. At first 7,700 cubic ft. of water per second will be available, representing about 9,000 H.P.; but should necessity arise a dam could be built into the river, and the capacity increased. The generators, consisting of direct-connected turbines and alternators on vertical shafts will be arranged in two groups; a voltage of 2,000 volts will be used. At Birsfelden a storage pond, nearly 20 acres in extent and 8·5ft. deep, will be built.

**Franco-American and Antilles Cables.**—According to the *Bulletin de la Télégraphie* and other sources, the result of the issue of obligations of 500fr. each, bearing 4 per cent. interest, of the Cie. Française des Cables Télégraphiques, has been very satisfactory. The amount asked for has been largely covered, the greater part having been previously underwritten—which is considered a significant fact when the capitalists are out of town. The number of small subscribers was very great. It will be recollected that the French Government gave a subsidy to this Company of 800,000fr. for the establishment of a cable from France to New York, and thence to San Domingo. According to the Ministerial stipulations, the Crédit Foncier will be charged to receive the amount subscribed, and to place funds at the disposition of the Company, according to its requirements, under the authority of the representatives of the State. The New York-Puerto-Plata (San Domingo) cable has been manufactured for the Company, and shipped on board the "Seine." The laying is expected to be completed by the middle of next month.

**The Glow Lamp Business in the United States.**—"We understand," says the *Electrical Engineer* of New York, "that the long-discussed agreement among the manufacturers of incandescent lamps for the purpose of arranging a schedule of prices has at last assumed definite shape, and that almost all of the lamp manufacturing companies in the country are represented in the combination. While little of the detail of this agreement has been made public, it is understood that the first move of the companies will be to return to the 20-cent price for 16 c.p. lamps, which was generally in vogue about a year and a-half ago. . . . About two years ago, when the fundamental Edison lamp patent expired, a war of extermination was declared between the General Electric Company and all the other lamp manufacturers in the country, and from the prices of 30 to 35 cents, then current for 16 c.p. lamps, a reduction was soon made to about 18 cents, and in some cases large orders have been quoted at from 12 to 15 cents. Although these prices come very close to the actual cost of manufacture, only a very few of the weakest concerns have been forced out of the business, though probably not a single concern is earning a profit. The strenuous competition has had the effect, of course, of keeping the quality of lamps up to a fair standard, but there is much room for improvement."

**Electric Motors in Building Operations.**—"An ingenious application of electricity has recently been made at the Hotel Cecil, which," says the *Builder*, "as it may often save time and labour, is worth recording. In the marble staircase of this building the balusters had been placed so far apart that it was quite possible for a child to slip through between them; and so, in order to make it perfectly safe, it was resolved to put a brass baluster between every two marble ones. In order to do this as quickly as possible with the minimum of noise and dirt, Mr. Jacob, of Messrs. Waring and Sons, suggested an electric motor with flexible shaft and twisted drill. A small ironclad motor was used of about 1 H.P., which could be run from the house mains at 110 volts, and could be started and stopped by an ingenious switch worked by the foot of the operator. The holes in the lower side of the handrail are 1¼in. broad by 1in. deep; on the steps smaller holes were made. The rate at which they were drilled was 25 of the large ones and 30 or 40 of the smaller ones in a day. The mere drilling took very little time, but arranging the guide for the drill had to be carefully done, as the balusters were often at different distances apart. The holes made were neat and clean, with very little fracture at the edges. It is an admirable method for rapidly drilling holes in marble when electric power is available, and is capable of many other applications."

**Electric Mining Locomotive.**—A heavy and powerful mining locomotive has just been built by the Baldwin Works of America. It is a six-wheel electric locomotive capable of drawing 40 loaded cars up a 2 per cent. gradient at a rate of 6 miles per hour, developing a draw bar pull of 10,000lb. The track gauge is 44in., and the locomotive will pass through an opening 6ft. 11in. high above the rails, 10ft. wide at bottom and 8ft. wide at top. The total weight of the locomotive is 44 tons, and the following are the principal dimensions:—Diameter of driving wheels, 33in.; total wheel base, 6ft.; total length of locomotive, 18ft.; width, 6ft. 2in.; and height, 5ft. 6in. The electrical equipment consists of two 100 H.P. Westinghouse

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motors, one controller, one rheostat, two trolleys, two electric headlights, Wurts lightning arrester, switches, &c. The two motors, which are mounted near the centre of the locomotive, are of the consequent pole type. They are series-wound and may be operated either in series or parallel. The series arrangement is used for slow speeds and the parallel for higher speeds. The motors are connected to driving axles by double reduction gears. The controller is of the commutator type, and can be operated from either end by means of a suitable shaft and gear. The change of direction of travel is accomplished by changing direction of rotation of the controller handle, no reversing switch being used. The rheostat is mounted on the rear, and consists of coiled iron strips mounted in a suitable casing. One electric headlight is placed at each end, and two lamps are placed on each side of the locomotive. A switch is provided for changing the connections of the motors from series to parallel, and another switch cuts off all current excepting to the lighting circuit, which is provided with a separate switch. The wires connecting the motors, controller and rheostat are enclosed in an iron pipe, thus providing complete protection. The average speed of the locomotive with the motors in parallel is six to eight miles per hour. Current is supplied at a pressure of 500 volts.

**Road Traction.**—The following circular letter has been received by us from the Secretary of the Self-Propelled Traffic Association :—

"Sir: After a long period of labour, the 'Locomotive on Highways Bill, 1896,' has become an Act, and probably at no period in the history of the English Legislature has so liberal a measure been passed; indeed, the President of the Local Government Board cannot be charged with a want of faith in humanity, believing, as he must do, that no abuses will follow the help he has so freely extended to the new movement. For the great freedom given in this measure I feel that I am in a large degree responsible Mr. Chaplin and the officials connected with the Local Government Board and the Home Office having accepted the various points which I advocated in person and in writing, as well as the amendments which were finally adopted in Committee on Mr. Chaplin's recommendtion, and those which were not opposed by him at that Committee. In rendering all the assistance in my power to those who had charge of the Bill during its passage through the Houses of Parliament, and to those whose duty it now is to make Regulations in connection with this Act, my hands were immensely strengthened by the support received from so many distinguished and eminent men conversant with the subject—all, like myself, entirely disinterested and unbiassed by personal or pecuniary motives. These gentlemen include statesmen, engineers, scientists, and a host of others. My object in requesting the publication of this letter is, on the one hand, to express the gratitude of all those I represent in this movement to the Government, to the permanent Officials of the Departments concerned, and to all others by whose labours and influence success has been obtained; and on the other, to appeal to everyone interested in the movement, whether as manufacturers or users of motors, to do nothing on their part to abuse the freedom which has now been extended to them. It behoves everyone concerned to act with prudence and consideration; to avoid injury to the roads; to use every possible care not to frighten horses; to store no dangerous liquids thoughtlessly, which might endanger life or property; and to act generally with such discretion that it shall not be said in a year or two hence, another Act must be passed to control those who have shown their inability to control themselves, or misused their privileges; there cannot be the slightest doubt in the mind of any reasonable man, that this Act will be productive of great changes, and that if all those who have an interest in modern progress will strive to improve self-propelled traffic, and those who avail themselves of its benefits will act fairly towards others having no direct interest in the movement, it will be giving the English nation an advantage which can hardly be overrated, and without entailing, as I hope and believe, a vestige of discomfort or annoyance on any individual.—Yours faithfully, David Salomons (President Self-Propelled Traffic Association)."

**International Memorial of Submarine Telegraphy.**—The following is a complete list of those who have already signified their willingness to join the Committee which is being formed :—The Most Hon. the Marquis of Tweeddale, Field Marshal Viscount Wolseley, Viscount Peel, the Right Hon. the Earl of Selborne, Admiral of the Fleet Lord John Hay, Lord Kelvin, the Lord Chief Justice of England, the Right Hon. Lord George F. Hamilton, M.P., Lord Sackville Cecil, Lord Richard H. Browne, Duc de Loulé, Marquis de Lima, Baron d'Erlanger, Admiral the Right Hon. Sir Henry J. C. D. Hay, Bart., Sir Robert Herbert, Admiral Sir Anthony H. Hoskins, Admiral Sir George Richards, Admiral Sir Leopold Heath, Sir Courtenay Boyle, Sir Eyre M. Shaw, the Right Hon. Joseph Chamberlain, M.P., Rear Admiral W. J. L. Wharton, Sir Juland Danvers, Sir Richard E. Webster, Q.C., M.P., Sir Montagu F. Ommanney, Sir Donald A. Smith, Sir A. J. Leppoc Cappel, Sir Saul Samuel, Sir Samuel Canning, Sir John Robinson, Sir Henry C. Mance, the Lord Provost of Edinburgh, Mr. J. C. Lamb, Mr. C. W. Stronge, Mr. W. H. Preece, Mr. J. Spencer Brydges Todd, Mr. Walter Peace, the Hon. H. Marsham, the Hon. A. G. Brodrick, Mr. Kenneth Anderson, Mr. William Andrews, Mr. F. A. Bevan, Mr. G. W. Campbell, Mr. Latimer Clark, Mr. W. S. Cunard, Mr. James Pender, M.P., Mr. J. Denison Pender, Mr. C. W. Earle, Mr. Edmund Etlinger, Mr. Louis Floersheim, Mr. Hubert Herkomer, R.A., Mr. G. G. Nicol, Mr. Alexander Siemens, Mr. William Shuter, Mr. S. W. Silver, Mr. J. H. Tritton, Mr. E. M. Underdown, Q.C., Mr. G. Von Chauvin, Mr. Robert K. Gray, Mr. J. G. Griffiths, Dr. Alexander Muirhead, Mr. Herbert de Reuter, Mr. Herbert Taylor, Mr. James Tulloch, Mr. Frederick Walters, Mr. George G. Ward, Major Alexander Wood, Mr. F. Youle, the President of the Institution of Civil Engineers, Mr. H. Alabaster, Mr. W. T. Ansell, Mr. W. H. Axworthy, F. Le B. Bedwell, Mr. W. H. Baines, Mr. T. W. Bischoff, Mr. G. C. Bompas, Mr. W. G. Bond, Mr. R. T. Browne, Mr. T. A. Bullock, Mr. J. H. Carson, Mr. Henry Clifford, Mr. R. Collett, Mr. Clement S. Colvin, Mr. John Coppen, Mr. R. M. Cunningham, Monsieur F. H. Delarge (Director-General of Belgian Posts and Telegraphs), Mr. E. Dickens, Mr. George Draper, Mr. T. Finnis, Mr. H. C. Forde, Mr. Charles Gerhardi, Mr. A. R. Hardie, Mr. F. E. Hesse, Mr. William Hibberdine, Mr. Alexander G. Low, Mr. F. R. Lucas, Mr. Oscar Moll, Mr. John Newton, Mr. H. A. C. Saunders, Mr. Willoughby S. Smith, Mr. F. Ward, Mr. T. H. Wells. It is, as yet, too early to forecast the shape which the Memorial will take, but there will probably be a statuary design—the balance of the fund being devoted to some suitable object.

**Contemporary Electrical Science.**—Electricians will be glad to have some authentic information regarding the true magnetic properties of electrolytic iron. According to W. Leick's results in *Wiedemann's Annalen*, iron deposited from a 3 per cent. solution of ferrous sulphate and sal-ammoniac is very much like hard steel in its magnetic behaviour, and not like soft iron, as often supposed. Soft iron may be saturated in a field of 10 C.G.S. units. Electrolytic iron requires over 90 units. The iron was deposited in Herr Leick's experiments on rods of brass by a current of 0·1 to 0·2 amperes. The iron plates thus obtained were only a few millimetres thick, and were hard and lustrous. They showed an extraordinary amount of permanent magnetism, usually 65 per cent. of the temporary. It is probable that, if the plates were indefinitely thin, the percentage would closely approach 100. The author also precipitated nickel from the sulphates of nickel and ammonia. Its intensity of magnetisation was about one-tenth that of iron, and its permanent magnetism about one-sixth of the temporary. Cobalt was about the same, with a very small magnetic susceptibility. An interesting attempt was made to obtain from the mixed salts an alloy of iron with nickel or cobalt, such as is found in meteorites. The result was in the case of nickel, a dull mass containing about 5 per cent. nickel, which could be brought to an intensity of magnetisation of 1,830 C.G.S. units, the highest value on record with any substance. Herr Leick believes this to be due to some arrangement by which the nickel molecules facilitate the orientation of the iron molecules.——W. Nernst works out a theory of contact electricity, based upon an application of the laws of diffusion to the motions of the ions, and gives a valuable equation for the calculation of differences of potential from the "ionic mobilities."——A. Schlamp describes an electric method for determining specific heats of liquids; it is very useful for substances like naphthaline or phenol, which are solid at ordinary temperatures. He uses manganin wires to conduct the current through the liquid and the standard of comparison. The latter is usually nitrobenzol.——Leo Arons has made some further experiments on the action of thin metallic septa in checking the current flowing through an electrolyte, and shows that all the phenomena may be explained without assuming the existence of microscopic holes in the plates.——Otto Müller describes some experiments on the diffusion of Röntgen rays. He obtained a "shadowgraph" of a wire grating in the shadow, or rather, penumbra, of a brass cylinder. The rays seemed to pass round the cylinder on to the plate. This is a case of something like diffusion, not diffraction, as no interference bands could be obtained by any method.

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## ELECTROMAGNETIC THEORY.—LXXXIX.*

BY OLIVER HEAVISIDE.

(*Continued from page* 370.)

§ 355. A case which is similar to that of § 353 occurs when R is zero, making

$$V=\left(\frac{Lp}{K+Sp}\right)^{\frac{1}{2}}C \qquad (37)$$

The form is the same as (21). So the developed solution is the same for V due to C impressed as for C due to V impressed, provided we interchange the electric and magnetic quantities S and L, R and K. For instance, if the source is the current $h$, steady after $t=0$, and zero before, then (27) is transformed to

$$V=\frac{h}{Sv}\epsilon^{-bt}I_0(bt),\quad b=K/2S, \qquad (38)$$

which shows the voltage required to produce the steady current.

The $Sv$ that occurs here is the instantaneous admittance. It is the reciprocal of $Lv$, the instantaneous impedance. In the distortionless circuit the impedance remains $Lv$ always (that is, in common units, 30 ohms × the number representing the inductance per centim., say from 10 to 30 usually, according to the size of the wires and distance apart), unless interfered with by reflection. But $Lv$ is the instantaneous impedance always, that is, whatever values R and K may have. In the corresponding plane electromagnetic waves, $E=\mu vH$, when undistorted, and the impedance is $\mu v$. It is only a different way of reckoning, using the elements of V and C instead of the totals. That is, $\mu v$ is the impedance for a unit tube of flux of energy, and $Lv$ is the total effective impedance for the total flux. But if R and K ($g$ and $k$ in the proper wave problem) are not balanced, the impedance immediately begins to alter by reflection due to the unbalanced action of $g$ and $k$ upon the magnetic and electric fluxes.

§ 356. If R and L are both zero, then V/C is 0, and C/V is ∞, obviously. But if K and S are both zero instead, then C/V is 0. In this case no finite voltage can produce a current, because the resistance of the conductor is infinite, and the leakage is stopped, both elastic and conductive.

If S is alone zero, then

$$C=\frac{K^{\frac{1}{2}}}{(R+Lp)^{\frac{1}{2}}}V=\left(\frac{K}{R}\right)^{\frac{1}{2}}\left(1+\frac{2a}{p}\right)^{-\frac{1}{2}}\left(\frac{2a}{p}\right)^{\frac{1}{2}}V. \qquad (39)$$

This is for a leaky circuit in which the permittance is of insensible effect compared with the other influences. The initial admittance is zero, the final is $(K/R)^{\frac{1}{2}}$, the effective steady conductance, as we see by putting $p=\infty$ and 0 in turn.

As regards the state at time $t$, when V is steady, observe that the method of expanding in rising powers of $p$ appears to fail. We get a constant term, plus an infinite series of zeros. Now there are zeros *and* zeros. An absolute zero is like the point in geometry, which you cannot see even when you use a magnifying glass, as the schoolboy said. But some zeros can be magnified, and an infinite number of them might make finiteness. I do not think that is the explanation here, though. But we can pass the matter over at present, because the other way of expanding by the binomial theorem, viz., in descending powers of $p$, presents no difficulty. Thus,

$$\frac{C}{V}=\left(\frac{2K}{R}\right)^{\frac{1}{2}}\left\{\left(\frac{a}{p}\right)^{\frac{1}{2}}-\left(\frac{a}{p}\right)^{\frac{3}{2}}+\frac{1.3}{\lfloor 2}\left(\frac{a}{p}\right)^{\frac{5}{2}}-\frac{1.3.5}{\lfloor 3}\left(\frac{a}{p}\right)^{\frac{7}{2}}+\dots\right\} \qquad (40)$$

$$=\left(\frac{2K}{R}\right)^{\frac{1}{2}}\left\{\frac{(at)^{\frac{1}{2}}}{\lfloor\frac{1}{2}}-\frac{(at)^{\frac{3}{2}}}{\lfloor\frac{3}{2}}+\frac{1.3}{\lfloor 2}\frac{(at)^{\frac{5}{2}}}{\lfloor\frac{5}{2}}-\frac{1.3.5}{\lfloor 3}\frac{(at)^{\frac{7}{2}}}{\lfloor\frac{7}{2}}+\dots\right\} \qquad (41)$$

$$=\frac{2}{\pi^{\frac{1}{2}}}\left(\frac{Kt}{L}\right)^{\frac{1}{2}}\left\{1-\frac{Rt}{3L}+\frac{1}{5\lfloor 2}\left(\frac{Rt}{L}\right)^2-\frac{1}{7\lfloor 3}\left(\frac{Rt}{L}\right)^3+\dots\right\} \qquad (42)$$

This is complete, the integrations being done at sight by $p^{-n}1=t^n/\lfloor n$, as explained in § 351. Or, in terms of the error function, before used,

$$\frac{C}{V}=\left(\frac{K}{R}\right)^{\frac{1}{2}}\mathrm{erf}\left(\frac{Rt}{L}\right)^{\frac{1}{2}}. \qquad (43)$$

It is curious in how widely different a manner this function arises now. *See* § 247.

§ 357. There is a similar case when L is alone zero. Then

$$V=\left(\frac{R}{K+Sp}\right)^{\frac{1}{2}}C,\ \text{or}\ \frac{V}{C}=\left(\frac{R}{K}\right)^{\frac{1}{2}}\mathrm{erf}\left(\frac{Kt}{S}\right)^{\frac{1}{2}}, \qquad (44)$$

when C is steady, as we see by comparing with (39) and (43), and interchanging symbols. But it will be more instructive to vary the method. We have, when C is constant,

$$\frac{V}{C}=\left(\frac{R}{S}\right)^{\frac{1}{2}}\frac{1}{(p+2b)^{\frac{1}{2}}}=\left(\frac{R}{S}\right)^{\frac{1}{2}}\epsilon^{-2bt}\frac{1}{p^{\frac{1}{2}}}\epsilon^{2bt}=\left(\frac{R}{S}\right)^{\frac{1}{2}}\frac{1}{p^{\frac{1}{2}}(1-2b/p)} \qquad (45)$$

by changing the operand from 1 to $\epsilon^{2bt}$, and then to 1 again, in the manner of § 354. Or

$$\frac{V}{C}=\left(\frac{R}{K}\right)^{\frac{1}{2}}\epsilon^{-2bt}\left\{\left(\frac{2b}{p}\right)^{\frac{1}{2}}+\left(\frac{2b}{p}\right)^{\frac{3}{2}}+\left(\frac{2b}{p}\right)^{\frac{5}{2}}+\dots\right\},$$

$$=\left(\frac{R}{K}\right)^{\frac{1}{2}}\epsilon^{-2bt}\left\{\frac{(2bt)^{\frac{1}{2}}}{\lfloor\frac{1}{2}}+\frac{(2bt)^{\frac{3}{2}}}{\lfloor\frac{3}{2}}+\frac{(2bt)^{\frac{5}{2}}}{\lfloor\frac{5}{2}}+\dots\right\},$$

$$=\frac{2}{\pi^{\frac{1}{2}}}\epsilon^{-Kt/S}\left(\frac{Rt}{S}\right)^{\frac{1}{2}}\left\{1+\frac{1}{3}\left(\frac{2Kt}{S}\right)+\frac{1}{3.5}\left(\frac{2Kt}{S}\right)^2+\dots\right\}, \qquad (46)$$

showing the result in terms of the product of an exponential and another series. Multiplying them together, we shall obtain the result (44) again.

§ 358. Connected with the last examples is the inversion of the same. Say,

$$V=\left(\frac{R+Lp}{K}\right)^{\frac{1}{2}}C=\left(\frac{Lp}{K}\right)^{\frac{1}{2}}\left(1+\frac{R}{Lp}\right)^{\frac{1}{2}}C. \qquad (47)$$

By the process of § 356, we obtain

$$\frac{V}{C}=\left(\frac{R}{K}\right)^{\frac{1}{2}}\left\{\left(\frac{R}{Lp}\right)^{-\frac{1}{2}}+\frac{1}{2}\left(\frac{R}{Lp}\right)^{\frac{1}{2}}-\frac{1.1}{2.4}\left(\frac{R}{Lp}\right)^{\frac{3}{2}}+\frac{1.1.3}{2.4.6}\left(\frac{R}{Lp}\right)^{\frac{5}{2}}-\dots\right\}$$

$$=\left(\frac{L}{K\pi t}\right)^{\frac{1}{2}}\left\{1+\frac{Rt}{L}-\frac{1}{3\lfloor 2}\left(\frac{Rt}{L}\right)^2+\frac{1}{5\lfloor 3}\left(\frac{Rt}{L}\right)^3-\frac{1}{7\lfloor 4}\left(\frac{Rt}{L}\right)^4+\dots\right\} \qquad (48)$$

This is straightforward enough, but there is a simpler way still. For

$$\frac{V}{C}=\frac{R+Lp}{K}\left(\frac{K}{R+Lp}\right)^{\frac{1}{2}}=\frac{R+Lp}{K}\left(\frac{K}{R}\right)^{\frac{1}{2}}\mathrm{erf}\left(\frac{Rt}{L}\right)^{\frac{1}{2}}, \qquad (49)$$

by using (43), which is the solution of (39). Only one differentiation is now concerned. When executed, the result is (48). But it is not a general truth that we may introduce $(R+Lp)/(R+Lp)$ and consider it to represent 1. We did the integration represented by the denominator first. If we do the differentiation first, it will make a difference. Thus $pp^{-1}1=pt=1$, but $p^{-1}p1=p0=0$, unless we say $p^{-1}p1=p^{-1}\frac{t^{-1}}{\lfloor -1}=\frac{t^0}{\lfloor 0}=1$. This property has to be remembered sometimes.

§ 359. Now let all four electrical constants be finite. Then

$$C=\left(\frac{K+Sp}{R+Lp}\right)^{\frac{1}{2}}V=\frac{1}{Lv}\left(\frac{2b+p}{2a+p}\right)^{\frac{1}{2}}V=\frac{1}{Lv}\left(\frac{p+\rho-\sigma}{p+\rho+\sigma}\right)^{\frac{1}{2}}V, \qquad (50)$$

where there are only two effective constants, $a$ and $b$, or $\rho$ and $\sigma$, connected thus,

$$a=R/2L,\quad b=K/2S,\quad \rho=a+b,\quad \sigma=a-b, \qquad (51)$$

when $\sigma=0$ we have the distortionless case, and when $\sigma=\rho$ we have the case of no leakage, § 353.

Now we can expand each of the two radicals in (50) in powers of $p^{-1}$; their product is then a series in rising powers of $p^{-1}$. The algebrisation is then immediate, by integrations according to $p^{-n}1=t^n/\lfloor n$. But this is a mechanical and complicated process, without illumination, and the resulting series contains $\rho$ and $\sigma$ in a way that does not show plainly how to simplify it. So vary the method.

Introduce $\epsilon^{\rho t}$ into the operand, by simultaneously introducing the factor $\epsilon^{-\rho t}$, and turning $p$ to $p+\rho$. Follow (35). Then (50) becomes

$$C=\frac{\epsilon^{-\rho t}}{Lv}\left(\frac{p-\sigma}{p+\sigma}\right)^{\frac{1}{2}}\epsilon^{\rho t}V=\frac{\epsilon^{-\rho t}}{Lv}\left(\frac{p-\sigma}{p+\sigma}\right)^{\frac{1}{2}}e, \qquad (52)$$

if $e=V\epsilon^{\rho t}$. If $e$ is constant, or the voltage is the special one $e\epsilon^{-\rho t}$, we can solve at once. Thus

$$\left(\frac{p-\sigma}{p+\sigma}\right)^{\frac{1}{2}}=\left(1-\frac{\sigma}{p}\right)\left(1-\frac{\sigma^2}{p^2}\right)^{-\frac{1}{2}}=\left(1-\frac{\sigma}{p}\right)I_0(\sigma t), \qquad (53)$$

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by (36). Here one integration upon $I_0(\sigma t)$ is wanted. The result is

$$C=\frac{e\epsilon^{-\rho t}}{Lv}\left\{I_0(\sigma t)-\left(\sigma t+\frac{(\sigma t)^2}{2\lfloor 3}+\frac{1.3(\sigma t)^5}{2.4\lfloor 5}+\ \dots\right)\right\}. \quad (54)$$

The initial current is $e/Lv$. The final current is zero, of course, because the voltage falls to zero.

§ 360. A more significant case is got by letting the voltage decay in a different way. Say $V=\epsilon^{-Kt/S}e$, where $e$ is constant. Then the first of (52) becomes

$$C=\frac{e\epsilon^{-\rho t}}{Lv}\left(\frac{p-\sigma}{p+\sigma}\right)^{\frac{1}{2}}\epsilon^{\sigma t}=\frac{e}{Lv}\epsilon^{-\rho t}I_0(\sigma t), \quad (55)$$

by (36). Here we have a compact solution, differing from (27) in having $\rho$ and $\sigma$ instead of both $\sigma$. When $K=0$, we fall back upon the case (27).

This solution is important thus. Imagine a cable which is infinitely long both ways, to be charged initially to transverse voltage $2e$ on the left side and zero on the right side of the origin. V will instantly fall to $e$ at the origin, and its later value will be $V=e\epsilon^{-Kt/S}$, as in the above. This is, therefore, the voltage impressed upon the initially empty cable to the right. The resulting current is (55). It will be generalised later to represent the complete wave of current.

Notice, in passing, that in the course of the transformations employed we are engaged incidentally upon other problems than those under discussion. For example, (52) shows that if

$$C=\frac{\epsilon^{-\rho t}}{Lv}e, \qquad \text{then } V=\epsilon^{-\rho t}\left(\frac{p+\sigma}{p-\sigma}\right)^{\frac{1}{2}}e, \quad (56)$$

which shows the voltage needed to make the current vary as $\epsilon^{-\rho t}$.

§ 361. Now let the impressed voltage V itself be constant. Then we have

$$\frac{C}{V}=\frac{K+Sp}{(R+Lp)^{\frac{1}{2}}(K+Sp)^{\frac{1}{2}}}=\frac{r(K+Sp)}{\{(p+\rho)^2-\sigma^2\}^{\frac{1}{2}}}. \quad (57)$$

This can, by what has been done, be reduced to a single integration. First, we have

$$\frac{p}{\{(p+\rho)^2-\sigma^2\}^{\frac{1}{2}}}=\epsilon^{-\rho t}\frac{p-\rho}{(p^2-\sigma^2)^{\frac{1}{2}}}\frac{p}{p-\rho}=\epsilon^{-\rho t}\frac{p}{(p^2-\sigma^2)^{\frac{1}{2}}}, \quad (58)$$

by the process (35); or, by (36)

$$\frac{p}{\{(p+\rho)^2-\sigma^2\}^{\frac{1}{2}}}=\epsilon^{-\rho t}I_0(\sigma t). \quad (59)$$

Using this in (57) we obtain

$$\frac{C}{V}=\frac{1}{Lv}\left(1+\frac{K}{Sp}\right)\epsilon^{-\rho t}I_0(\sigma t). \quad (60)$$

Thus the C due to V constant, when all four electrical properties are active, is expressed in terms of a known function, and its time-integral, the residual $p^{-1}$ meaning integration from 0 to $t$.

Similarly, $$\frac{V}{C}=\frac{1}{Sv}\left(1+\frac{R}{Lp}\right)\epsilon^{-\rho t}I_0(\sigma t) \quad (61)$$

is the V when C is constant (always understanding that $t=0$ begins the operand). We get the last by interchanging symbols R and K, L and S. The symbol $\rho$ does not change, but $\sigma$ is negatived, though this makes no difference in $I_0(\sigma t)$.

§ 362. If $V=pP$, where P is a constant, the case is that of an impulsive voltage, total P, generating the momentum P, the space integral of LC.

Then, by (60)

$$C=\frac{P}{Lv}(p+\rho-\sigma)\epsilon^{-\rho t}I_0\sigma t=\frac{P\epsilon^{-\rho t}}{Lv}(p-\sigma)I_0(\sigma t). \quad (62)$$

Or, executing the differentiations,

$$C=\frac{P}{Lv}\epsilon^{-\rho t}\{\sigma I_1(\sigma t)-I_0(\sigma t)\} \quad (63)$$

This shows the current due to the impulsive voltage. It is negative when $\sigma$ is positive, and positive when $\sigma$ is negative. That is, if R is in excess, the current following the impulse is back from the cable; if in deficit, it is forward, into the cable.

Similarly,

$$V=\frac{Q}{Sv}\epsilon^{-\rho t}(p+\sigma)I_0(\sigma t)=\frac{Q}{Sv}\epsilon^{-\rho t}\sigma\{I_1(\sigma t)+I_0(\sigma t)\}, \quad (64)$$

obtained from (62), (63), by interchanges, represents V due to the sudden injection of the charge Q, followed by insulation. That is, $C=pQ$ is the datum, and V follows. It is positive when $\sigma$ is positive and negative when $\sigma$ is negative.

From these we conclude that if the cable is infinitely long both ways, and the charge Q or the momentum P be suddenly introduced at the origin, then

$$V=\frac{Q}{2Sv}\epsilon^{-\rho t}(p+\sigma)I_0(\sigma t), \quad C=\frac{P}{2Lv}\epsilon^{-\rho t}(p-\sigma)I_0(\sigma t) \quad (65)$$

represent the resulting V at the origin in one case, and C in the other. If the line is not infinitely long, these are still true for a time, until in fact the first reflected wave arrives at the origin. The halving is done because P and Q immediately split into halves which separate. It should be noted that (65) represent V or C in the middle of the tail connecting the two heads or waves at distance $\pm vt$ from the origin. See § 208 The complete wave formulæ will follow.

§ 363. Observe that we have algebrised $(p^2+Ap+B)^{-\frac{1}{2}}p.1$. For it is the same as (59) above, if $A=2\rho$ and $B=\rho^2-\sigma^2$. That is,

$$\frac{p}{(p^2+Ap+B)^{\frac{1}{2}}}=\epsilon^{-\frac{1}{2}At}I_0\{(\tfrac{1}{4}A^2-B)^{\frac{1}{2}}t\}. \quad (66)$$

The extension to a cubic under the radical sign is therefore suggested, say

$$u=\frac{p}{(p^3+ap^2+bp+c)^{\frac{1}{2}}}. \quad (67)$$

We can reduce it to a quadratic by making the operand be $\epsilon^{-xt}$, where $x$ is one of the roots of the cubic. Turn $p$ to $p-x$, and put $\epsilon^{xt}$ at the beginning and $\epsilon^{-xt}$ at the end, or $(1+x/p)^{-1}$ at the end, or earlier. Thus

$$u=\epsilon^{xt}\frac{p^{\frac{1}{2}}}{p+x}\frac{p}{\{p^2+(3x+a)p+3x^2+2ax+b\}^{\frac{1}{2}}}, \quad (68)$$

that is,

$$\epsilon^{xt}\frac{p^{\frac{1}{2}}}{p+x}\epsilon^{-Ft}I_0(Gt), \quad (69)$$

when F and G are known, by (63). This may be carried further, but it would be out of place here, having no immediate relation to the matter in hand.

The following is more to the point, concerning the reversibility of the operations used. That

$$I_0(\sigma t)=\frac{p}{(p^2-\sigma^2)}1 \quad (70)$$

is clear by inspection of the form of the $I_0$ function, and then putting it in terms of powers of $p^{-1}$. We get a series which the binomial theorem allows us to write in the form (67), provided we understand that in expanding it, we are to employ integrations, not differentiations.

But it is also true that

$$\frac{(p^2-\sigma^2)^{\frac{1}{2}}}{p}I_0(\sigma t)=1. \quad (71)$$

Expand by the binomial theorem again in rising powers of $p^{-1}$, and execute the work on $I_0(\sigma t)$. The coefficient of every power of $t$ vanishes save the zeroth, leaving the result 1.

In connection with this, and with some of the preceding work, it is to be noted that if we have an operator $\theta$ which is the product of any number of others, say,

$$u=\theta 1=\phi_1\phi_2\phi_3 1, \quad (72)$$

and if the type of $\phi_1$ is

$$\phi_1=a_1+b_1p^{-1}+c_1p^{-2}+\ \dots\ , \quad (73)$$

that is a series in rising powers of $p^{-1}$, and if all the $\phi$'s are of this kind, then the same is true for the resultant $\theta$, and in whatever order the $\phi$'s are written. So there are all sorts of ways of algebrising (69), which are bound to lead to the same function, if properly followed, though intermediately we may be led to all sorts of functions. We may regard $u$ as $(\phi_1\phi_2)\phi_3 1$, or $(\phi_2\phi_3)\phi_1 1$, &c. The utility of such changes is to bring operational solutions to more convenient forms

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for algebrisation, by changes in the operand and operator. The matter is not so limited as it was just now stated. It is not always necessary to keep to positive powers of $p^{-1}$, that is to integrations. Sometimes a series of differentiations may equivalently replace a series of integrations. But sufficient of theory now. Practice is more important, and the final integration involved in (61) remains to be done.

*(To be continued.)*

## A NON-SYNCHRONOUS TWO-PHASE ALTERNATE-CURRENT MOTOR.

BY ERNEST WILSON.

The principal object of these experiments was to investigate the currents in the armature conductors and their effects upon the magnetic field of the motor, although other matters are dealt with. The form of motor experimented upon is shown in Fig. 1, the stationary part which receives the two-phase currents having four poles projecting radially inwards upon the armature. This stationary part is built up of 24 B.W.G. soft iron plates of the shape shown, a sufficient number being taken to make up a length of 6in. This part is not of the

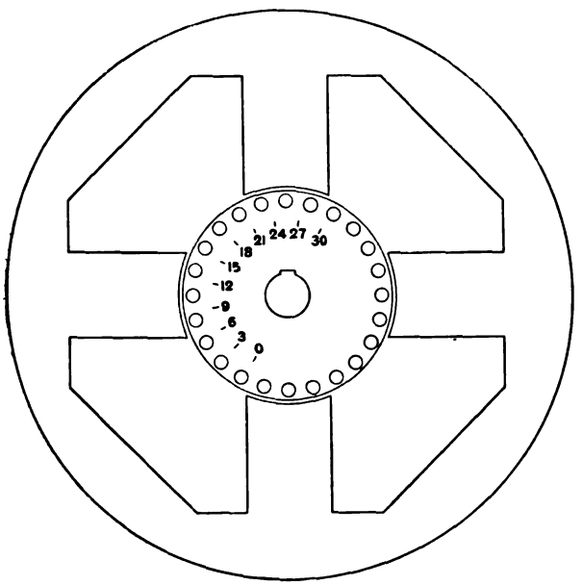


FIG. 1.

type now met with in these motors, and therefore the results do not pretend to represent recent practice. Each radial projection limb is wound with 102 turns of 2mm. copper wire. The two-phase currents are supplied by two Siemens W 12 alternators, the armatures having a phase difference of a quarter period. The connections between alternators and stationary part of motor are shown in Fig. 2. There are two distinct circuits on the motor, which are numbered 1 and 2 respectively. In Fig. 2 $r_3$ $r_4$ are non-inductive resistances in each circuit, which serve for the determination of current, the potential difference between the ends of either resistance being determined at any moment by means of a revolving contact-maker, C, fixed to the shaft of the alternators, and a quadrant electrometer, Q. The potential difference between the extremities of each circuit was reduced by means of considerable non-inductive resistances $r_1$ $r_2$, and measured at any epoch on the quadrant electrometer.

The armature is built up of sheet-iron stampings 5in. diameter and $\frac{1}{2}$mm. thick, a sufficient number being taken to make up a length of 6in. The conductors are insulated, and threaded through a series of 24 holes $\frac{5}{16}$in. diameter, punched out of the discs at equal intervals, $\frac{1}{16}$in. from the edge. As in the case of the stationary part, the plates are not specially insulated from one another. The copper conductors are solid, with the exception of four, which are copper tubes; these being at opposite ends of two diameters, at right angles to one another. The 24 conductors are soldered into solid copper rings at each end of the armature.

An exploring coil of 94 complete convolutions is threaded through two of these tubes at opposite ends of a diameter, the ends of the coil being soldered to insulated rings on the shaft, contact being made with the rings by means of brushes insulated on a wooden support. On an extension of the motor shaft, remote from the pulley, is fixed a small contact-maker, which makes contact once in each revolution. The position at which contact is made can be determined on a divided circle, and the contact-maker placed in any part of any circuit.

Let $E_1$, $E_2$ be the potential difference in volts at the extremities of the circuits Nos. 1 and 2 respectively at any epoch. Let $R_1$, $R_2$ be the resistances in ohms of those cir-

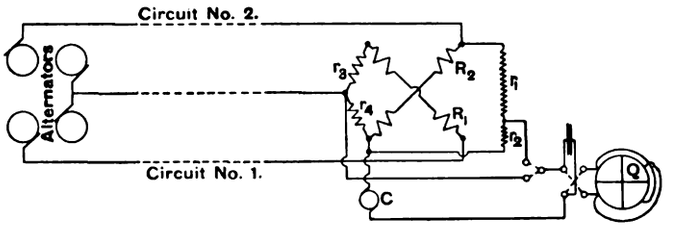


FIG. 2.

cuits, and $x_1$, $x_2$ the current in amperes at corresponding epochs. Let $m_1$, $m_2$ be the total turns on the two circuits, and $I_1$, $I_2$ the total induction. Then—

$$E_1 = R_1 x_1 + m_1 \frac{dI_1}{dt}, \qquad E_2 = R_2 x_2 + m_2 \frac{dI_2}{dt},$$

in each case. The curves in Fig. 3 give the amperes $x_1$, $x_2$ and volts $\frac{dI_1}{dt}$, $\frac{dI_2}{dt}$ when the motor is running light, and when loaded by means of a rope brake on the 5in. pulley.

In Fig. 3, $f_1$, the frequency of alternator, is 33·5 and 35·5, and $f_2$, the frequency of the motor, is 33·3 and 34, motor running light and loaded respectively as measured on a Harding counter. It is interesting to examine the agreement between the theoretical characteristic curve of this motor and what we have observed. Circuit No. 1, in series with a non-inductive resistance, was excited from a set of 56 storage

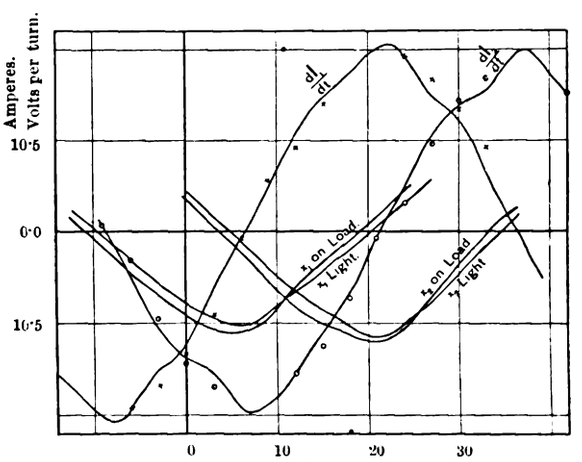


FIG. 3. $\frac{dI_1}{dt}$ on Load X
$\frac{dI_2}{dt}$ on Load O.

cells with a current of 7·6 amperes. Exploring coils were wound on the cores of each circuit, and a coil threaded through the punched holes in armature so as to embrace an angle of 90deg. This coil could then be placed opposite any of the four poles, and the kick on a ballistic galvanometer in its circuit noted when reversal of current in No. 1 circuit took place. Kicks were also observed when the ballistic galvanometer was placed in circuit with each of the exploring coils on the magnet limbs.

The results show that the ratio of induction in limb to induction in armature is 1·25 for No. 1 circuit. The effect

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**Table I.**

| — | No. 1 circuit. | | | | No. 2 circuit. | | | | No. 1 and No. 2 circuits. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Observed maximum. $\frac{4\pi m_1 x_1}{10}$ | Observed maximum. $I_1$ | Characteristic curve gives | | Observed maximum. $\frac{4\pi m_2 x_2}{10}$ | Observed maximum. $I_2$ | Characteristic curve gives | | $\frac{I_1+I_2}{2}$ | $\frac{I\nu_1+I\nu_2}{2}$ |
| | | | $I\nu_1$ | $B_1$ | | | $I\nu_2$ | $B_2$ | | |
| Motor running light..... | 2,610 | $0{\cdot}412\times10^6$ | $0{\cdot}448\times10^6$ | 5,790 | 3,000 | $0{\cdot}466\times10^6$ | $0{\cdot}437\times10^6$ | 5,640 | $0{\cdot}439\times10^6$ | $0{\cdot}442\times10^6$ |
| Motor loaded ..... | 2,790 | $0{\cdot}319\times10^6$ | $0{\cdot}430\times10^6$ | 5,550 | 3,100 | $0{\cdot}484\times10^6$ | $0{\cdot}416\times10^6$ | 5,340 | $0{\cdot}401\times10^6$ | $0{\cdot}423\times10^6$ |

of the cores of the No. 2 circuit cannot be strictly neglected, owing in great measure to inaccuracy in the length of the respective air spaces. Kicks were observed on the coil on these cores, and also on the armature coil when placed opposite them. When No. 2 circuit was excited the results show that in this case $\nu$, the ratio of induction in limb to induction in armature, = 1·21. In working out the characteristic curve for this motor the pole pieces at right angles to the particular circuit considered are neglected, and the following symbols taken to represent the different quantities involved :—

$l_1$ the length of two cores in magnet winding = 18·1cm.
$A_1$ the area of one core = 77·4sq. cm.
$l_2$ half the mean length of ring = 49·0cm.
$A_2$ twice mean area of ring = 97·0sq. cm.
$l_3$ the length of air space = 0·317cm.
$A_3$ the effective area of one air space = 87·1sq. cm.
$\nu$ leakage coefficient = 1·23 ,,
$\frac{m}{2}$ the number of turns per limb = 102 ,,

Neglecting the armature, the equation to the characteristic curve is $\frac{4\pi m x}{10} = l_1\frac{\nu I}{\mu_1 A_1} + l_2\frac{\nu I}{\mu_2 A_2} + 2\, l_3\frac{I}{A_3}$ when I is total induction in armature in C.G.S. units.

If the characteristic curve be found in the ordinary manner it will be seen that almost all the force is spent in the air space. The curves in Fig. 3, after integration of $\frac{dI_1}{dt}\frac{dI_2}{dt}$, and the characteristic curve, give the results shown in Table I.

When running light as above it was found that the average rate at which work is done on the motor is 460 watts. When delivering 287 watts at the brake the average rate from supply circuits is 794 watts. This gives a net efficiency of 36 per cent. when loaded. The power taken to drive the armature without brake is considerable, owing partly to the brushes on contact-maker and collecting rings in addition to bearing friction. The volume of stationary part of motor is about 6,000 cubic cm.; and with frequency 35 and max. B = 6,000, the loss due to hysteresis alone, neglecting disturbance in ring due to $I_1 + I_2$, might be about 63 watts; about 50 watts are expended upon magnetising coils, leaving about 350 watts for armature alone and induced currents in stationary part of motor. Then again the gain of field upon armature $f_1 - f_2$, when measured as a direct quantity by a method to be described, showed that it was little less than half when running light as compared with what it was when loaded. We are well aware that when loaded $\frac{4\pi m x}{10}$ is not the only magnetising force acting, the currents in the armature must be taken into account, that is to say, the more we load the motor the greater should the inductions as given by the characteristic curve, taking $\frac{4\pi m x}{10}$ to be the only force acting, appear. We find this to some extent verified in Table I., but the reaction in this machine is not sufficiently great with maximum torque to give any very definite results on this point, and the characteristic curve is approximate.

Referring again to the curves in Fig. 3, we note that the effect of increase of load is to reduce the phase difference between potential and current, the current being increased in amplitude. In this motor we note the large phase difference between potential and current, even when loaded as in the experiments. This is a point of practical importance, since the ratio $\frac{\text{apparent watts}}{\text{true watts}}$ in the transmission of power by alternate currents should be kept as large as possible. We see at once how small motors of this kind can be improved. The air space demands a large magnetising current; but the dissipation of energy due to hysteresis, induced currents, and friction when running light, is relatively small, and the only way to combine low dissipation with large currents is to have great phase difference. We find this automatically adjusted in this motor; and the obvious improvement consists in reducing the air-space length, or increasing the effective area of the air space. Of course, in large motors the dimensions are such as to improve the power factor, but this is not necessarily the case in small machines. If $f_1$ be the frequency of supply in complete periods per second, $f_2$ the frequency of motor armature in complete periods per second; then $f_1 - f_2 = f$, the frequency of armature opposite in direction to impressed field. As this comes in as a direct quantity in what follows, it was desirable to measure it directly. If the motor armature loses $\frac{1}{n}$th part of a period per period on the field, then when each of the two contact makers, that on the alternators and that on the motor make one contact per period, simultaneous contact will be made (*if f be constant*) by the two contact-makers every $n-1$ periods of the generator. This is strictly true when $n$ is a whole number, odd or even. It would only be necessary to place a D'Arsonval galvanometer and battery in the circuit of the two contact-makers in series, in order to count the number of contacts in a given time. It was found that $f$ is not quite constant, and to make certain of contact being made, the brush on the motor was widened so as to make contact for a longer fraction of a period. Suppose time of contact on motor be $\frac{1}{50}$th part of a revolution, the time on the alternator being small, one may say that with 2 per cent. slip two successive contacts might be made per 49 periods, but one contact is almost bound to be made. The brush on motor contact-maker was made to embrace an arc of a circle corresponding to $\frac{1}{42}$nd part of a period, and this was found to work well for all values of $f_1$ and $f$ used.

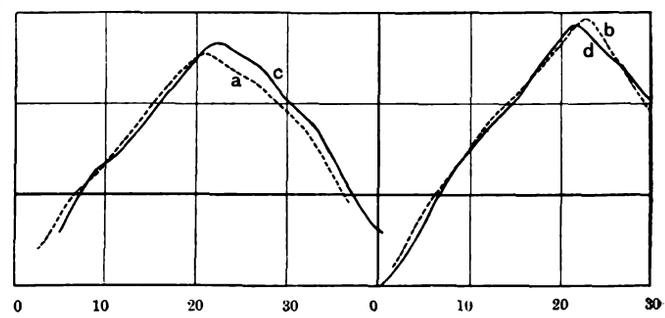

Fig. 4.

The curves in Fig. 4 are interesting as showing the disturbance on the pole face itself of one of the magnet limbs. Two exploring coils were stretched over the surface, dividing it into about equal parts longitudinally. Curves $a\,b$ were observed on the two coils when the motor was running light; curves $c\,d$ when the motor was loaded, the conditions being as in Fig. 3. The curves $a\,c$ are given by the half of magnet pole face in direction of rotation; we see that loading the motor increases E.M.F. over the leading half of pole face, and decreases E.M.F.

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over the lagging half. This effect arises from the current in the armature conductors.

We now come to Fig. 5, which gives curves obtained from the exploring coil on the armature itself; whilst Fig. 6 gives the $\frac{dI_1}{dt}$ $\frac{dI_2}{dt}$ curves and their integral curves $I_1$ $I_2$, taken again because the conditions of running happened to be a little different to those in Fig. 3.

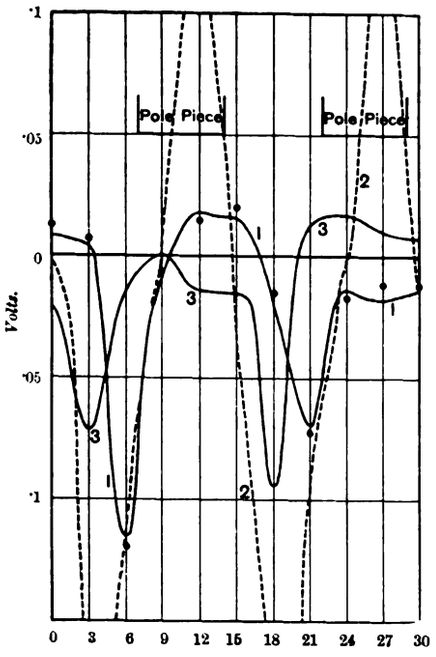


FIG. 5.

Let the two contact-makers and exploring coil on armature be placed in series with one another and with the quadrant electrometer, across which is placed a condenser of suitable capacity; $\frac{1}{3}$ microfarad was used.

Let the motor be loaded and lose $\frac{1}{n}$th part of a period per period on the field. Choose any epochs you please to start with on the alternator and motor contact-makers; then, if we wish to systematically follow what goes on, it is clear

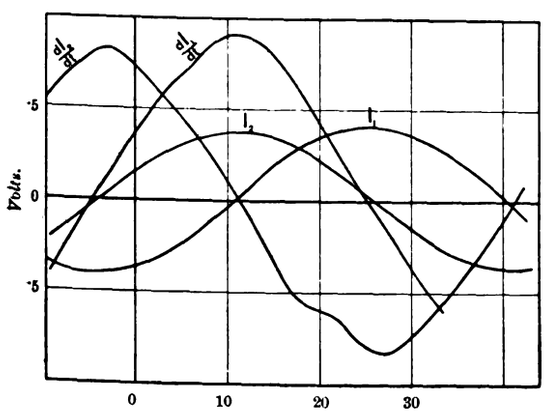


FIG. 6.

that when the motor contact-maker has passed through one half period, that on the alternators will have passed through a half period *minus* $\frac{1}{2n}$th part of its period, and so on. In Fig. 5 the motor was loaded with an effective weight on the brake of 5lb. The frequency $f_1$ was 25, and $f$ was observed directly to be 1·1; that is, the motor armature loses 4·4 per cent. of a period per period on the field. The alternator and motor contact-maker scales have each 60 divisions to the period. In Fig. 5 there are three curves numbered 1, 2, 3, and the simultaneous setting of the two contact-makers when observing these curves is as set forth in Table II., the setting being divided proportionately into smaller intervals where the peaks occur on the curves.

**Table II.**

| Curve 1. | | Curve 2. | | Curve 3. | |
|---|---|---|---|---|---|
| Alternator contact-maker in 60ths of a period. | Motor contact-maker in 60ths of a period. | Alternator contact-maker in 60ths of a period. | Motor contact-maker in 60ths of a period. | Alternator contact-maker in 60ths of a period. | Motor contact-maker in 60ths of a period. |
| 0 | 0 | 10 | 0 | 20 | 0 |
| 2·9 | 3 | 12·9 | 3 | 22·9 | 3 |
| 5·7 | 6 | 15·7 | 6 | 25·7 | 6 |
| 8·6 | 9 | 18·6 | 9 | 28·6 | 9 |
| 11·5 | 12 | 21·5 | 12 | 31·5 | 12 |
| 14·3 | 15 | 24·3 | 15 | 34·3 | 15 |
| 17·2 | 18 | 27·2 | 18 | 37·2 | 18 |
| 20·1 | 21 | 30·1 | 21 | 40·1 | 21 |
| 23·0 | 24 | 33·0 | 24 | 43·0 | 24 |
| 25·8 | 27 | 35·8 | 27 | 45·8 | 27 |
| 28·7 | 30 | 38·7 | 30 | 48·7 | 30 |

The curves in Fig. 5 constitute a true test as to the field actually experienced by the armature when loaded. If we had in this motor a perfectly uniform field of constant intensity rotating at constant speed, and if the rate at which the field overtakes the armature be also constant, we should get simple sine curves instead of those in Fig. 5. In this machine the field is jerky, the leakage is great, and the quantity $f$ is not quite constant.

We ought to be able from the curves in Fig. 5 to infer the force acting upon the armature producing torque; and since we can form a good idea of the actual work done in a given time by the armature upon brake, bearing, and other friction, we should be able to directly compare these two quantities.

Let $l$ be the length of the conductors in armature = 15½cm., **B** be the induction per square centimetre, $r$ be the radius of conductors in armature = 5·75cm., R be the resistance of one conductor in ohms = 0·00018: the resistance of each of the tubular conductors = 0·00036 ohms. This takes no account of soldered joints, the resistances being estimated.

Let E be the observed volts per turn at any epoch, as given by the exploring coil on armature.

Let $x$ be the current in the armature conductor in amperes at the same epoch. We neglect the effect of the copper rings at each end of armature.

We have

$$x = \frac{E}{2R};$$

and we assume $$\frac{E}{2} = l\,2\pi\,r f\,\mathbf{B}\,10^{-8}.$$

The force on the armature at radius $r$, due to the current in one conductor, is

$$\frac{\mathbf{B}\,l\,x}{10}\text{dynes} = \frac{E^2\,10^7}{8\pi R r f 981\ 454}\text{ lb.}$$

The ordinates of the curves in Fig. 5 have been squared, and their average taken for a half-period; they are as follows:

Curve 1, average $E^2 = 0{\cdot}0016$.
,, 2, ,, $E^2 = 0{\cdot}0160$ uncertain.
,, 3, ,, $E^2 = 0{\cdot}0010$.

The average force for a half-period (periodic time $= \frac{1}{f}$) for the 24 conductors is as follows:—

Curve 1, average force = 30·4lb.
,, 2, ,, = 304·0lb. uncertain.
,, 3, ,, = 19·0lb.

We have 5·5lb. due to brake if we correct for radii of pulley and armature conductor, and the motor is evidently doing considerable work when running without brake, since $f$ in this case $= \frac{1}{2}$. We may say that the average force in pounds acting on the armature at radius $r$ should not be more than 10lb., and this is lower than any of the figures given above. These curves have been determined again, and the points marked ⊗ in Fig. 5 show the result in the case of No. 1. No. 2, as before, exhibited great instability, and the results obtained from it are

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not trustworthy. It must, however, be remembered that the three curves in Fig. 5 only give a rough idea of the average results given by the 22 sets of such curves required before similar events practically begin to happen. There is also no doubt but that the torque varied considerably, its periodic time being about one second; at these intervals the motor vibrated as though it were experiencing very great stress, and then settled down with perfect regularity.

The conclusions we draw from these experiments are that in these motors it is of vital importance to have a uniform field of constant intensity impressed upon the armature, specially on load, and of course due notice must be taken of the currents in the armature conductors. If this is not the case, terms are introduced having different periodic times to the main effect, giving rise to variable torque and inefficiency. It seems hardly worth while to discuss fully the comparison of the curves in Fig. 5 with those in Fig. 6, since the leakage is so considerable, but it is worth noting that max $I_1$ and $I_2$ in Fig. 6 are $0{\cdot}536$ and $0{\cdot}497 \times 10^6$ C.G.S. units respectively. The maximum I, as given by the curve 1 in Fig. 5, for instance, is $0{\cdot}488 \times 10^6$. The mean of $0{\cdot}536$ and $0{\cdot}497$ multiplied by $\sqrt{2}$ gives $0{\cdot}723 \times 10^6$, and this would be the maximum induction impressed on the armature by the poles if there were no leakage and no effect from armature currents. In Fig. 1 the numerals 0 to 30 indicate the position of the exploring coil with regard to the poles in Figs. 5 and 6. Take curve 1, Fig. 5. When the coil on armature has position 17 its E.M.F. is zero, and at this epoch the curves $I_1$ $I_2$, Fig. 6, would indicate roughly a maximum induction. Take curve 8, Fig. 5. The armature coil has at position 17 considerable E.M.F. The curves $I_1$ $I_2$, Fig. 6, would at position 36 indicate roughly a very small total induction.

Sets of curves similar to those in Fig. 5, the motor running light, were obtained; but in each case the instability was so great as to render them of little value for quantitative results. The author hopes before long to place this same armature in a more uniform rotating field, and thereby get conditions in which the subject is much easier to handle.

In conclusion, I wish to thank Mr. Siemens for the loan of the stationary part of this motor, which is the same as used in 1888.* My best thanks are also due to Messrs. Cobb, Evans, Shawcross, and Woodfield. The two former constructed the armature and contact-maker, and the two latter have helped me in the experiments.

## AN APPARATUS FOR TESTING THE MAGNETIC PERMEABILITY AND HYSTERESIS OF IRON.

The magnetic properties of iron are now of such great importance in the design and manufactures of dynamos and transformers, that instruments for quickly testing these properties with a fair degree of accuracy are of considerable interest to electrical engineers.

The machine was designed with a view of showing students the practical importance of permeability and hysteresis in dynamo construction. Ballistic or magnetometric tests on iron, however accurate they may be, do not appeal very forcibly to students whose interests are chiefly mechanical, for

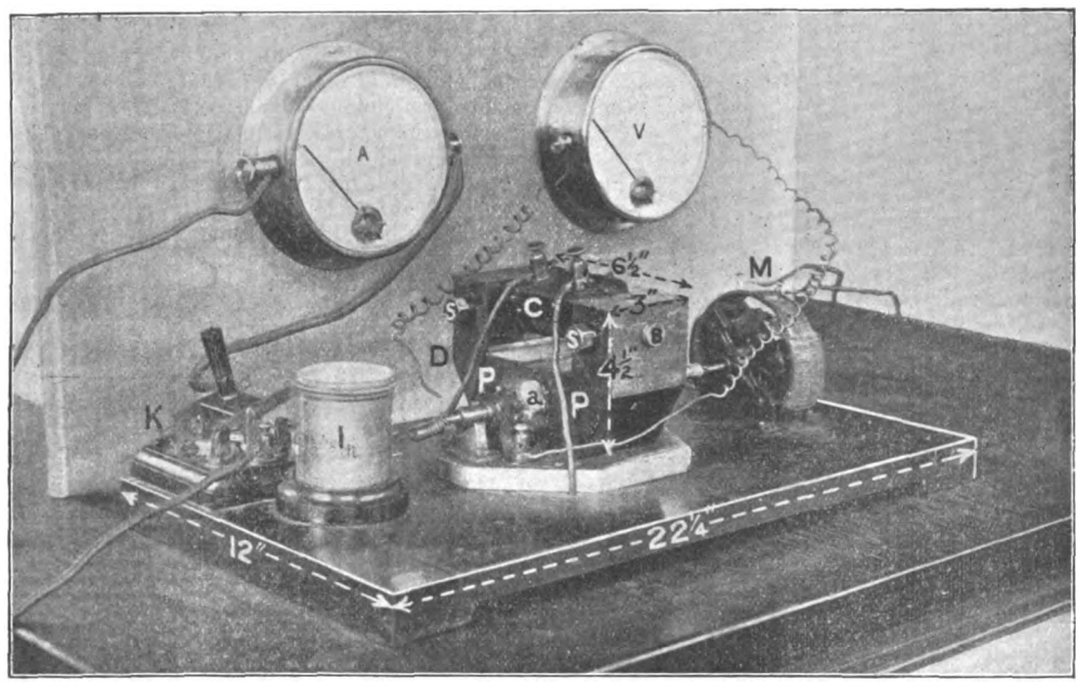


FIG. 1.—General View of the Ayrton-Mather Apparatus for testing the Magnetic Permeability and Hysteresis of Iron.
*a*, Armature; B, Test piece; C, magnetising coil; D, Dynamo; P P, Pole pieces; S S, Set screws; I, Speed indicator; K, Reversing key; M, Motor; A, Ammeter V, Voltmeter.

At the Royal Society *soirée* held on June 10th an apparatus for testing both permeability and hysteresis was exhibited by Prof. Ayrton and Mr. Mather, of which we give a dimensional sketch below.

The apparatus consists essentially of a small separately excited dynamo, D (Fig. 1), with a very short air space of large area, so that the magnetomotive force spent in the air gap is a small proportion of the whole, whilst the test piece forms the yoke between two massive pole pieces, and is comparatively long. The dynamo may be driven by a small motor, M, or in any other convenient way.

the connection between such tests and the design of dynamos appears to them somewhat remote. It was, therefore, thought desirable to construct an apparatus for making tests under conditions similar to those in which iron is used in actual dynamo machines. The general convenience of the arrangement showed that the apparatus would be useful for testing commercial specimens.

As indicated in the figure, the dynamo is arranged for testing round rods; but the machine is constructed so that rectangular pieces or bundles of plates can be readily inserted and clamped

* *See* British Patent No. 18,525, 1888

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firmly in position without disarranging any other portion of the apparatus.

In order that the various quantities required may be read off as directly as possible, the windings of the coil C are such that the magnetomotive force per centimetre of the bar is either one or ten times the current in amperes. The ammeter, therefore, reads off directly the uncorrected value of the magnetising force. Since the winding of the armature is known, it is quite easy to calculate the speed at which the motor should be run, so that the E.M.F. generated in the dynamo D is a simple sub-multiple of the magnetic flux through the circuit, or of the magnetic induction in the test piece. In this particular machine, when run at a speed of 1,280 revolutions per minute, the induction in the test piece is equal to 10,000 times the E.M.F. in volts generated in the armature.

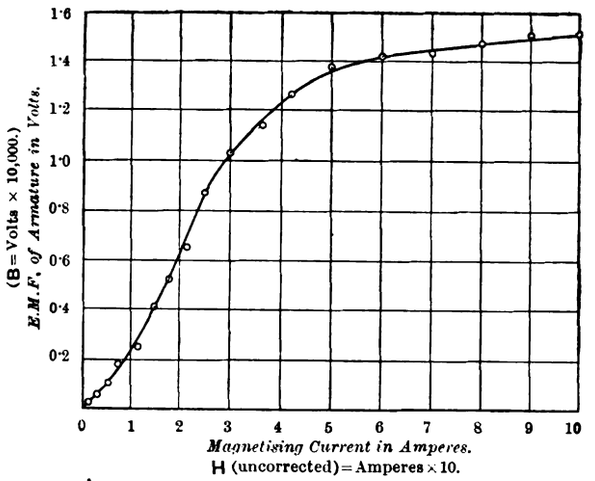


FIG. 2.—Permeability Curve of a Specimen of Unannealed Swedish Iron.

The cross-section of the armature being many times the area of the test piece the induction in it is always small; and this, together with the very short air gaps, keeps the magnetic leakage low. The average leakage coefficient in the actual apparatus is 1·12, so that a compensation can readily be effected by increasing the speed of the armature in this proportion, and this has been done in arriving at the speed given above.

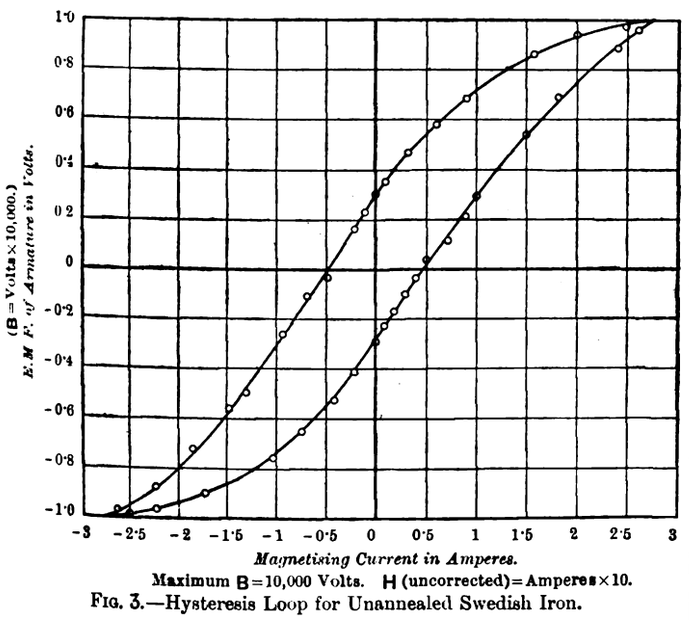


FIG. 3.—Hysteresis Loop for Unannealed Swedish Iron.

It will be evident from the foregoing particulars that the approximate absolute determination of a magnetisation curve, or of a hysteresis loop, is reduced to taking a series of simultaneous steady readings of the ammeter and voltmeter and plotting the results, and with the dead-beat moving coil instruments shown, a complete hysteresis curve can be taken in about five minutes. For more accurate determinations it is convenient to compare the results obtained with any given specimen with those of a standard bar, the properties of which have previously been determined by the ballistic method.

Below we give curves obtained by the apparatus, Fig. 2 being a magnetisation curve of an unannealed specimen of Swedish iron, and Fig. 3 a hysteresis loop for the same specimen.

The apparatus is particularly well adapted for the rapid determination of coercive force, the quantity on which hysteresis loss mainly depends. To find the coercive force no speed indicator nor voltmeter is required, for the machine may be run at any speed, and any simple detector is sufficient to show when the P.D. between the brushes is zero, the only observation necessary being the current which reduces the residual magnetism, and therefore the E.M.F. of the armature, to nought. In this test the fluxes through the air gaps and armature are zero; consequently, no corrections are required for magnetic leakage or magnetomotive force spent in the air gap.

It is interesting to note that the apparatus here described forms an instance of the partly-recognised fact of similar ideas presenting themselves to different persons in distant localities at about the same period. The dynamo shown above was designed at the beginning of January, 1894, and ordered for the Central Technical College from Messrs. Crompton and Co. in the same month. A similar machine is mentioned in *Elektrotechnische Zeitschrift*, No. 15, 1894, by Dr. Koepsel (see *The Electrician*, July 6, 1894, p. 275).

Not the least interesting feature of this interesting piece of apparatus is its exceeding compactness. When Prof. Ayrton referred to this device in the discussion on Prof. Ewing's hysteresis meter, at the Institution of Electrical Engineers, in April, 1895, many of the audience, when he spoke of an apparatus which included a dynamo and a motor, no doubt found it somewhat difficult to get rid of central-station notions and to visualise in their minds a motor-generator-set occupying a floor space of 22in. by 12in. and only 4½in. in height. We can hardly imagine a better way of bringing home to the student mind the important part played by permeability in the practical design of dynamos than by making him put a sample of iron through its paces in the apparatus just described.

## THE STANDARD MERCURY OHM OF THE PHYSIKALISCH-TECHNISCHE REICHSANSTALT.*

BY WILHELM JAEGER.

The investigations here summarised, undertaken with a view towards the preparation of legal mercury standards of electrical resistance for Germany, and fully published elsewhere, were made up to November, 1892, in company with the former member of the Reichsanstalt, Dr. Kreichgauer, and were then continued by the author alone.

In the proposals of the Committee of the Reichsanstalt † the legal ohm is defined as "the electric resistance of a mercury column at the temperature of melting ice whose length with uniform thickness is 106·3cm., and whose mass is 14·452grm., corresponding to a sectional area of the column of 1 sq. mm."

The preparation of the standard resistance thus defined is the duty of the Physikalisch-Technische Reichsanstalt, which has to keep a number of glass tubes, whose values in ohms are controlled in a uniform manner from time to time by the calibration and measurement of length of the tubes and the weighing of the charge of mercury.

For the official testing of commercial resistances standards of suitable metallic alloys are used whose resistance in ohms has been obtained from the mercury standards, and is verified at least once a year.

Since every new filling of a standard tube is subject to an individual error exceeding the experimental errors of comparison, the true resistance of each tube must be taken to be the mean of several fillings, so that in this sense the standard of resistance must always be reproduced. Further, on account of the fragility of the glass, several tubes have to be made at a time, and the mean of their values taken. This makes the unit less accurate than the

* *Zeitschrift für Instrumentenkunde*, Vol. XVI., pp. 134-146, May 1896.
† *Zeitschrift für Instrumentenkunde*, Vol. XIII., 1893, supplement.

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methods of measurement, for the electric measurements may be easily made to a millionth of their value, whereas the accuracy of reproduction of the unit hardly attains 1-100,000th. But this accuracy is ample for all measurements; in those of E.M.F. and of current strength the preceding decimal is already uncertain.

The constancy of the unit was tested by comparing numerous copies, in mercury or in wire, with each other and with the standards. The totality of these resistances (including the mercury standard) represents a unit independent of accidental changes. The mercury copies are described in detail below; for wire copies the manganine resistances introduced by the technical department of the Reichsanstalt into scientific and technical use are especially suitable. It has been shown that these are subject to slight variations only (in two years they only amounted to a few hundred-thousandths). Besides, their very small temperature co-efficient (only 10 to 20 millionths per degree at ordinary temperatures) permits very accurate measurements.

Since the temperature of 0°C. forms the basis of definition of the electric resistance, it appeared desirable to undertake the electric comparison and the measurements of length and weight at 0 deg. This avoids many sources of error, and the temperature can easily be obtained and kept constant.

To begin with, only the tubes Nos. XI. and XIV. of Jena glass, 16$^{III.}$ were intended for use as standards. Their examination is described in the following. But for purposes of control three other standards, Nos. 106, 114 and 131, were subsequently selected from a larger supply of the same glass. Upon these tubes, measured and compared in co-operation with Dr. Wachsmuth, a report will be made later on.

### A.—Geometrical Computation of the Resistance of the Mercury Standards XI. and XIV.

This operation consists of (1) the calibration, (2) the measurement of length of the tube, and (3) the weighing of the mass of mercury which fills it at 0deg.

1. *Calibration.*—The divisions necessary for calibration were traced on the tube itself in order that the calculated corrections of diameter might apply to fixed points of the tube. The division having been executed in the Reichsanstalt with our own dividing engine, whose screw errors had been taken into account, the errors of division, as shown by a careful line-to-line examination, did not exceed a few hundredths of a millimetre. The calibration was made according to the methods usual with thermometers, for which the method of calculation is exhaustively developed. In the first place, the calibre corrections were determined, and from these the relative sectional areas were at once deduced. These areas must be determined for as many places as possible, so that no further assumption is necessary concerning the form of the area curve when the resistance comes to be computed. The final result must remain the same whether the smallest intervals are calculated as cones or as cylinders. If this is not the case both results are possibly wrong, and the sectional areas must then be determined at still more points. The tubes Nos. XI. and XIV. were divided along a length of 1,000mm., and the calibration was also extended over this interval, so that the course of the area curve was known beyond the ends cut off. The smallest thread of mercury employed in the calibration had a length of about 20mm. But since with such short threads the errors of observation are cumulative, the corrections of the principal points from 100mm. to 100mm. were determined with several threads. Even with threads of 20mm. the influence of the capillary dome is very perceptible, its volume being about 1 per cent. of that of the thread. Besides, it was found that a calibration of every 20mm. gave sufficiently accurate results. All threads were also weighed as a countercheck.

During calibration, the tubes were mounted on the dividing engine, the threads were displaced by air compressed in rubber tubes, and the lengths were read with one or more microscopes, readings being taken for the scale divisions nearest the ends, and for the base and vertex of the dome. The safest reading is that for the base, since in well-cleaned tubes it is sharply marked on the walls. Every calibre correction was calculated in two approximations. The calculations showed that a calibration with threads of 20mm. only would have admitted errors of a few hundred-thousandths of the resistance. But if the principal points of the tube from 100mm. to 100mm. are determined by a thread of 100mm. and another of 500mm., and the curve found with 20mm. is transformed to these points, the factor of calibration becomes sufficiently accurate.

The following desiderata determined the point at which the tubes were cut:—(1) The resistance was to be as nearly as possible 1 ohm; (2) at the points of section the tube was to be as cylindrical as possible; (3) the points of section were to coincide as much as possible with the principal points of calibration.

The cutting of the tubes and the polishing of the end surfaces was done by Mr. Magen in Berlin; the end surfaces were polished to reflection and as truly plane as possible. This was accomplished by making a bunch of many tubes, and rubbing them to and fro on glass plate. To prevent bits breaking off the capillary interior, small glass rods were cemented in. The distances of the end surfaces from the nearest division were found micrometrically, and these distances have to be taken into account in computing the calibration factor.

Let L be the total length at 0°C. of the tube measured between the end surfaces; let it consist of $n$ intervals of length $l$, and of the distances $\alpha l$ and $\beta l$ at each end of the tube, where $\alpha$ and $\beta$ are true fractions. Then $L = l(\alpha + n + \beta)$ and the weight G of the mercury charge of the tube at 0deg. is

$$G = d\,l\,(\alpha\, q_\alpha + q_1 + \ldots q_n + \beta\, q_\beta),$$

where $d$ is the specific gravity of mercury at 0deg. and $q$ the sectional area of the small division intervals.

The relative areas $s$ resulting from the calibre curve are referred to the mean sectional area of the whole length of tube investigated as unity, while $q$ is referred to the mean area of the length L. They must, therefore, be multiplied by some constant Q in order to obtain the values $q$. Hence,

$$\frac{1}{Q} = \frac{d\,l}{G}\left\{\alpha\, s_\alpha + \sum_1^n s + \beta\, s_\beta\right\}.$$

The resistance W of the tube at 0deg., apart from the spreading resistance, is, in Siemens units,

$$W = l\left\{\frac{\alpha}{q_\alpha} + \sum_1^n \frac{1}{q} + \frac{\beta}{q_\beta}\right\} = \frac{l}{Q}\left\{\frac{\alpha}{s_\alpha} + \sum_1^n \frac{1}{s} + \frac{\beta}{s_\beta}\right\},$$

expressing 1/Q and $l$ by the above values L and $q$, as determined by measurement and weighing at 0deg., we have finally—

$$W = \frac{d\,L^2}{G} \cdot \frac{1}{(\alpha + n + \beta)^2}\left\{\frac{\alpha}{s_\alpha} + \sum_1^n \frac{1}{s} + \frac{\beta}{s_\beta}\right\}\left\{\alpha\, s_\alpha + \sum_1^n s + \beta\, s_\beta\right\};$$

and the "calibre factor" is—

$$C = \frac{1}{(\alpha + n + \beta)^2}\left\{\frac{\alpha}{s_\alpha} + \sum_1^n \frac{1}{s} + \frac{\beta}{s_\beta}\right\}\left\{\alpha\, s_\alpha + \sum_1^n s + \beta\, s_\beta\right\}.$$

The quantities $s$ and $1/s$ are determined by calibration, and the quantities $\alpha$ and $\beta$ by micrometric measurements.

By this formula we obtained for the lengths between the end surfaces of

Tube No. XI. : C = 1·001878.
" " XIV. : C = 1·000341.

2. *Measurement of the Length at 0deg.*—This measurement was carried out in the second department of the Reichsanstalt by Messrs. Leman and Göpel. By observations at different temperatures the coefficient of linear expansion of the Jena glass 16$^{III.}$ was also determined, by which the measurements in the neighbourhood of 0deg. could be reduced to 0deg. precisely.

The measurements gave:—

Length of tube No. XI. at 0deg. = 808·3667mm. ± 0·6 $\mu$,
" " XIV. at 0deg. = 757·7713mm. ± 0·7 $\mu$,

and for the coefficient of expansion (between 0deg. and 30deg.) a mean value of 7·98 $\mu$ per degree for 1m. This value agrees satisfactorily with the values obtained by other observers.

The length of the tubes is obtained so close to 0deg. that it can be accurately reduced to that temperature by a correction of a few microns; hence the coefficient of expansion need only be known approximately. The probable error of the result amounts to about 0·7 $\mu$, while an accuracy to within 7 or 8 $\mu$ only is necessary in order to know the length to a hundred-thousandth.

3. *Weighing of the Contents of the Tube at 0deg.*—The arrangements of the Reichsanstalt enabled us to undertake the weighing also at 0deg., so that reductions necessitated by the expansion of the glass and the mercury were avoided. For this purpose a room in the machine house was used, which could be cooled down to 0deg. by means of a Linde ammonia machine.

For filling the tubes in vacuo, and for closing off the mass of mercury contained in them, the following method was used: The lower end of the vertical tube $a$ (Fig. 1) may be closed by a plane glass plate, $b$, attached by a spherical joint to the screw $c$. The screw has an hexagonal head, which fits into a female screw, $d$, attached to the bottom of the glass tube A. This enables one to close or open the end $a$ of the tube by turning the glass tube even under mercury. The air-tight closing is effected by well-dried mercury filled in up to about H, which also serves for filling the resistance tube. To the upper end of the resistance tube a glass tube leading to the mercury pump is attached air-tight. Greased cocks and rubber are avoided in all these connections.

After exhaustion the tube was left connected with the pump for a while, and then the screw c was opened by turning the tube, so that the mercury entered the tube to the height of the barometer. It was then fused off, and the mercury brought above the upper end by inclining the tube, after which it was closed again by means of the screw. All adhering mercury was then carefully wiped off, and the tube was placed vertically into a glass tube $g$ (Fig. 2) filled with distilled water, which was closed by a lid at the top and placed into the inner compartment of a double-walled copper cylinder $k$

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(Fig. 3), and sompletely surrounded by ice made from distilled water.

After the whole arrangement had stood about a day at 0deg. in the room, the superfluous mercury was pressed off by a cardanically mounted glass plate *s* (Fig. 2). The appearance of Newton's rings showed in each case that the distance between the two surfaces was only of the order of the wave-lengths ; the cardanic ring gave a view of the capillary aperture. With the usual precautions the mercury was then collected in a weighing glass, and was brought to the temperature of the room in a drying apparatus filled with calcium chloride. Only when the glass had stood for some time in the balance, and it was certain that the temperatures had been equalised, were the weighings made, since otherwise the air currents would have interfered. The set of weights used was carefully tested and reduced to the standard kilogramme.

Before every new filling with mercury the weighing glasses were cleaned with dilute nitric acid and distilled water, and weighed after careful drying. It was thus certain that no mercury drops from previous fillings were left in the glasses, which was confirmed by the close correspondence of the weights of the glasses. It is remarkable that the weight of the glasses gradually diminished, only very slightly indeed, but distinctly ; this is no doubt due to a kind of solution of the glass during washing. For three glasses this diminution of the weight, after 8 washings, was. about 0·2mg. (1·200 per cent. of their weight)

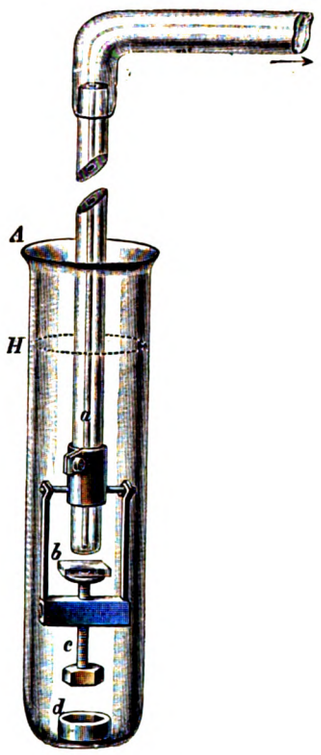


FIG. 1.

As a final result of the weighing at 0deg. the following numbers were obtained, with an accuracy of about half a hundred-thousandth:

| Tube number. | Mass of mercury. | Corresponding mean sectional area. |
|---|---|---|
| XI. | 8·38690g. | 0·763124mm.$^2$ |
| XIV. | 7·38518g. | 0·716844mm.$^2$ |

The specific gravity of mercury was taken as 13·5956 at 0deg. This gives, for the standard mass of mercury, 14·4521.

The sectional areas deduced from the calibration, and from the weights of the threads, correspond with the above numbers as much as might have been expected.

4. *Calculation of the Electric Resistance of the Tubes XI. and XIV. at 0deg.*—Disregarding the spreading resistance at the ends, we have at 0deg. for the resistance W between the end surfaces in Siemens units—

$$W = 10^{-6} \times C\frac{L^2 d_0}{G},$$

where C denotes the calibre factor, L the length of the tube in millimetres at 0deg., G the mass of mercury in grammes, filling the tube at 0deg., and $d_0$ the density of Hg at 0deg. = 13·5956.

Further, the resistance $W_1$ in *legal* ohms is $W_1 = \frac{W}{1{\cdot}06}$, and the resistance $W_2$ in *international* ohms $W_2 = C\frac{L^2}{G} \times \frac{14{\cdot}4521}{(1{,}063)^2}$

$$= 0{\cdot}0000128982\, C\frac{L^2}{G}.$$

The following is a table of the values of C, L, G, $W_1$ and $W_2$ at 0deg. for the tubes XI. and XIV. :—

| —— | No. XI. | No. XIV. |
|---|---|---|
| C..... | 1·001878 | 1·000341 |
| L..... ..... | 808·3667mm. | 757·7713mm. |
| G ..... ..... | 8·38690g. | 7·38518g. |
| $W_1$ ..... | 1·001204 | 0·997599 |
| $W_2$ ..... | 0·998376 | 0·994781 |

The factor for the spreading resistance *a* was taken as 0·80. The end radii $r_1$ and $r_2$ are deduced from the sectional area curve

FIG. 2.

FIG. 3.

and the mean sectional area Q. From these we obtain the spreading resistance A at the ends of the tubes, which is to be added to the resistance of the tubes themselves, by the formula,

$$A = 10^{-3}\frac{a}{\pi}\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

in Siemens units, *r* being expressed in millimetres. The values for the two tubes are shown in the following table :—

| —— | XI. | XIV. |
|---|---|---|
| $r_1$ ..... | 0·51103mm. | 0·48101mm. |
| $r_2$ ..... | 0·47175mm. | 0·48799mm. |
| A ..... | 0·000979 leg. ohms. | 0·000991 leg. ohms. |
| $A_2$ ..... ..... | 0·000976 int. ohms. | 0·000989 int. ohms. |

The electric measurements described below are based upon the legal ohm, assuming the spreading factor to be 0·80, and the density of mercury at 0deg. to be 13·5956. Hence we obtain for the resistance in legal ohms at 0deg. in the spreading resistance from the above figures,

Tube No. XI..... 1·002183 legal ohms.
,, ,, XIV. ..... 0·998590 ,, ,,



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### B.—Electrical Resistance Measurements.

For the electrical measurement of mercury resistances the temperature of 0deg. offers special advantages, since the resistivity of mercury changes considerably with the temperature. If the measurements are carried out at the temperature of the room, the reduction of the resistance to 0deg. amounts to nearly 2 per cent. of its value. If therefore the resistance is to be guaranteed to within 1-100,000th, this correction must be known to at least 1-20th per cent. It is true that the closely corresponding measurements of the temperature coefficient of mercury in the Reichsanstalt and in the Bureau International have reduced the uncertainty of this coefficient, which previously might well have caused errors amounting to several 10,000ths, to a few 100,000ths, but it is always advisable to avoid a correction of that magnitude. Furthermore, it is necessary to know the temperature to within 1/100deg.; with the low thermal conductivity of glass this can only be attained by the use of very constant baths, since otherwise the temperature of the mercury in the tube may be very different from that of the thermometer. These difficulties are almost entirely eliminated by working at 0deg. by means of an ice bath.

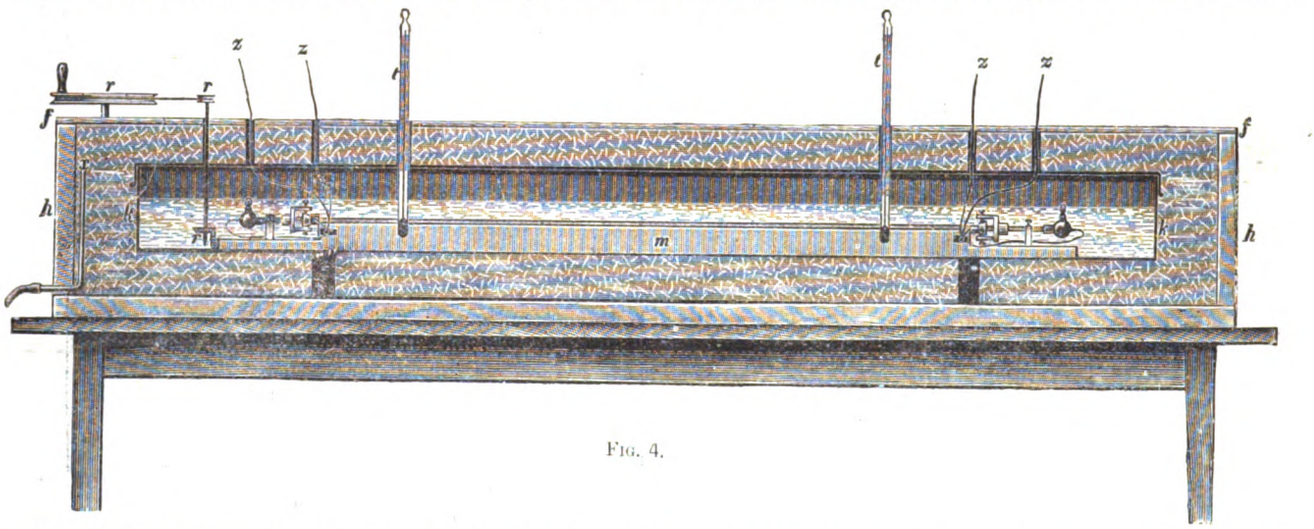


Fig. 4.

In Fig. 4 is shown the bath employed for the comparison of the standard tubes at 0deg. The tube, mounted on a brass rail, *m*, is contained in a copper box, *k*, filled with petroleum, closed by a lid with projecting edges. This box stands in the middle of a wooden box, *h*, lined with copper and filled up with small pieces of ice. The melting water flows off at *x* at such a level that it does not enter the copper box. Outside the ice is protected by a layer of felt, *f*.

For admitting the conductors *z*, the thermometers *t*, and the stirring apparatus *r*, brass tubes are soldered into the lid of the box, which go as far as the felt and are lined with glass tubes for insulation. The conducting wires are wound with silk and varnished with shellac solution. The upper opening of the brass tubes is closed by cotton wool steeped in petroleum, and before each measurement the insulation of the wires, with respect to the copper box, is tested.

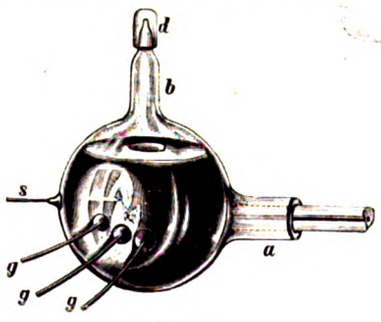


Fig. 5.

The thermometers were inclusion thermometers by Fuess, made of Jena glass $16^{III}$, and read to tenths of degrees. They were read micrometrically, and their zero points were repeatedly determined. The temperature of the petroleum bath was usually only a few thousandths of a degree above zero, which corresponds to a correction for resistance of a few millionths. By refilling with ice the temperature of the bath could be kept constant at will to within 1/1,000deg.

The end vessels always had the spherical shape shown in Fig. 5, with a diameter of about 3cm. The neck *a* served to introduce and fix the end of the tube. Through the neck *b* the tube may be joined to the air-pump or filled with mercury.

The current is conducted by a platinum wire, *s*, about 1mm. thick, fused into the glass just opposite the capillary aperture of the tube, while the thin platinum wires *g* lead to the galvanometer and the secondary circuit. Then the resistance of the tube takes effect from the point in the interior of the mercury, where the lines of flow cut the galvanometer wires. By the cap *d* the end vessel is completely closed, so that the whole tube may be immersed in petroleum.

For the filling with mercury the tubes were carefully cleaned, without using alkalies, since these always dissolve away some of the tube walls. To get rid of all fat, benzine was slowly sucked through the tube in drops, and then absolute alcohol and distilled water. The last cleaning liquid was always permanganic acid, applied after using strong acids (aqua regia, &c.). After this, distilled water was conducted through the tubes for some time, and then dry air for several hours. In this manner the aqueous film was made to cover the inner walls quite evenly, and its gradual disappearance during drying could be observed by the occurrence of Newton's colours. Before each charge the tubes were cleaned in this manner. The filling always took place in vacuo. The mercury was cleaned by distillation and subsequent electrolysis,* and was always filtered before use. The resistances of the various charges agreed to within a few hundred-thousandths of an ohm; and no change in the resistance could be detected when the tubes remain for some time filled with mercury.

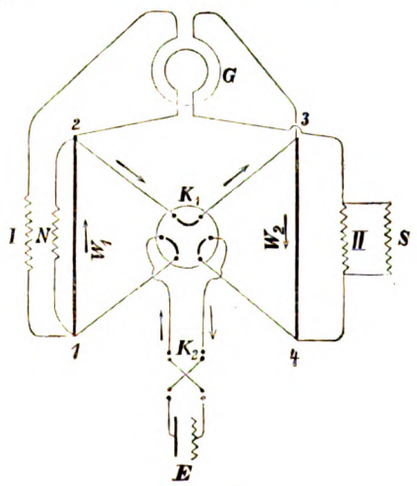


Fig. 6.

The current employed was about 0·01 ampere. The currents have to be feeble in order not to raise the temperature of the mercury in the tube. On employing stronger currents the temperature rises and gradually reaches a limit depending upon the external and internal diameters of the tube, the thermal conductivity of the glass, and the current strength. The heating is proportional to the square of the current strength. In one experiment with the standard tubes a current of 0·15 ampere gave a rise of 0·03, as measured by the change of resistance. This shows that a current of 0·01 ampere may be safely employed, even with a prolonged flow.

* *See* W. Jaeger, *Zschr. f. Instr.*, Vol. XII., p. 354, 1892, and *Wied. Ann.*, Vol. XLVIII., p. 209, 1893, on the purification of mercury.

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Thin conductors being employed in the measurements, the only method available for the comparison of resistances was Kohlrausch's secondary cross-circuit method,* since in this alone the stout conductors are dispensed with, and thermo forces and connection resistances are simultaneously eliminated.

In this method (Fig. 6) the current coming from the source E traverses the two resistances $W_1$, $W_2$ successively. The two coils of the differential galvanometer G are connected with the ends of

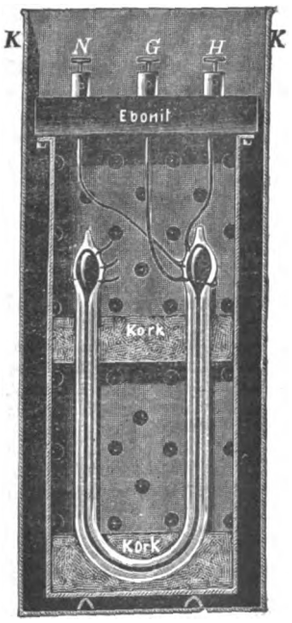


FIG. 7.

the resistances, as shown in the figure. The galvanometer remains stationary if the resistance of these two coils and the resistances $W_1$ and $W_2$ are equal, supposing that the magnetic effect upon the needle of the coils when traversed by equal currents is the same. In one position of the commutator $K_1$ these resistances, $W_1$ and $W_2$, are traversed in the direction 1, 2, 3, 4, in the other in the direction 2, 1, 4, 3. The reversal of the commutator $K_2$ reverses the current, and the galvanometer deflections are in the opposite direction. In this manner the influence of thermo forces in the resistances to

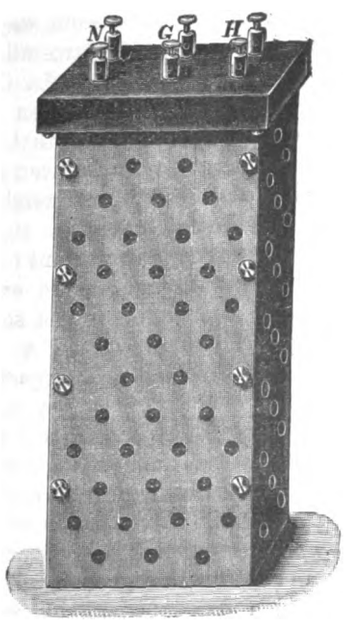


FIG. 7A.

be compared, and that of a possible asymmetry of the galvanometer, is eliminated. The branch circuit N serves for the equalisation of the resistances $W_1$ and $W_2$. 1 and 2 are ballast resistances in the galvanometer branches, and the branch circuit S restores the equality of resistances in these two branches. The method was found to be quite unexceptionable even with a galvanometer of small resistance, provided the directive force of both branches upon the needle was the same, and the resistances of the two branches were equalised.

* F. Kohlrausch, *Wied. Ann.*, Vol. XX., p. 76, 1883.

The Thomson differential galvanometer (Elliot) employed had a sensitiveness of a little over $10^{-8}$ ampere per millimetre of scale division. The ballast resistance was 16 ohms for each branch. A deflection of 1mm. meant a change of resistance of $W_1$ or $W_2$ of 1/1000 per cent. Since 1/10th scale division could be safely read, it was possible to determine the resistance to a millionth, even with currents of only 0·01 ampere.

As a check on these measurements, another method was occasionally employed, in which the galvanometer branches had no current. This gave the same result within a millionth.

For electric comparison of the mercury standards four of the manganine resistances previously referred to were used, which were compared with each other, and reduced to the mercury standards. The temperature coefficients of these resistances were determined between 5deg. and 25deg., and with their aid all the measurements were reduced to 18deg.

The accuracy of these determinations was found to be within a few millionths. The standard tubes were compared with the manganine resistances in March, 1892, in December, 1894, and February, 1895, in several series. The calculated differences of resistance of the standard tubes agreed with the observed differences within a few hundred-thousandths. Both series, separated by about three years, gave values for the manganine resistances agreeing to within about 2/100,000; this makes the constancy of these resistances and of the standard tubes extremely probable.

Another proof of this is afforded by measurements with 14 mercury copies. The construction of these copies may be seen by Fig. 7. Like the standard tubes, they consist of Jena glass $16^{III}$, and are curved partly in U-shape, partly in W-shape. After completion of the glass-blowing the copies were heated in the muffle furnace of the Royal Porcelain Works at Charlottenburg to about 350°C., and then slowly cooled in the closed furnace for two nights and a day. The filling of the copies with mercury in a vacuum was done in the same manner as that of the standard tubes. Then the tubes, filled completely with mercury except a small space, were fused at the upper end. The manner of introducing the current is shown in

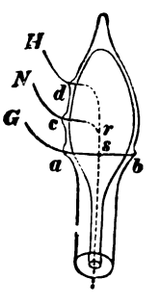


FIG. 8.

Fig. 8. Three platinum wires are fused into each of the end vessels, and joined to the binding screws H, G, N of the brass top (Fig. 7A). The main current is conducted by the wire H, while N serves for conducting the branch circuit. The lowest platinum wire G serves as a connection for the galvanometer; its position is fixed by fusing it at opposite points *a* and *b*. The resistance of a copy, therefore, counts from a fixed point, *s*, with the end vessel, where the galvanometer wire crosses the lines of flow. This is very essential to the constancy of the resistances. Special care had to be taken to ensure the good insulation of the wires leading from the platinum wires to the binding screws. The copper wires were spun with silk, dipped in a shellac varnish, and covered with varnished tissue paper. The mounting of the copies in the brass boxes by means of corks is at once explained by Fig. 7. To bring the resistances to the temperature 0deg. they were placed in a brass box, K, open at the top and filled with petroleum. The box was closed with an ebonite lid and dipped into a mixture of small ice and water up to the rim. The binding screws were also covered with petroleum, so that they also were at about 0deg. A comparison of all the mercury copies amongst themselves, and with the manganine resistances, was undertaken in the autumn of 1892 and the spring of 1894, only a few of these copies having been used meanwhile for measurements. The copies were placed in ice in groups of 5, and compared in several combinations.

As shown by these measurements, the mercury copies were also constant to within one or two hundred-thousandths, except two copies, in which the charges attained a ten-thousandth. In any case these measurements completely establish the constancy of the standard tubes and the manganine resistances to within one or two hundred-thousandths. It may therefore be taken for granted that the unit of electrical resistance, as represented by the standard tubes, by the mercury copies and by the wire resistances, has remained constant for two years to within one or two hundred-thousandths.



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## NEW MEN AND OLD PLANT.

There may be, and there probably often are, very excellent reasons why a given town should not at a given moment "go in for electric lighting." If a town be stationary or retrogressing, an increase in the local debt is most certainly to be deprecated, and that even if the outlay may be expected to prove remunerative. Again, prosaic municipal enterprises, such as a sound drainage scheme or an abundant supply of pure water, may not unreasonably be allowed to precede municipal electric lighting, in much the same way as executions on Tower Hill preceded comfortable incarceration in Holloway Gaol, or in "the topmost dungeon" of the Clock Tower, as someone recently expressed it. Again, when it is a question of a rate-supported business, the fact that a majority of one-half plus one of the ratepayers is averse to the undertaking should be allowed to carry some weight. It does not follow, of course, that the ratepayers are right; but only a considerable degree of urgency can warrant us in doing good to others against their will and at the expense of their pockets. At the same time it requires a somewhat strong dose of philosophy to listen without a certain feeling of irritation to a phrase which too frequently does duty for argument when a town council is in the throes of an electric lighting debate. "Electric lighting," someone is sure to remark, "is in its Infancy, and we don't want no infants here." The idea once started rapidly gathers momentum—and a semblance of reason. More than once the mention of the approaching birth of a wonderful primary battery, generally the invention of a local man, which will render Willans engines and Crompton dynamos suitable material for the scrap heap, has sufficed to shelve the matter of municipal electric lighting. More often, however, the opponents of the "new illuminant" throw their argument into pseudo-syllogistic form: constant change is costly, electricity is constantly changing, therefore electricity is costly. To this it may be replied, firstly, that the same argument has applied, does apply, and will apply in greater or less degree to everything under the sun; and, secondly, that although constant improvements may be introduced in an industry, it

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does not follow that they need all be straightway adopted. A new thing may very well be an improvement in the abstract, but not in a particular instance; and a thoroughly practical engineer does not consider this or that as an "improvement," so far as he is concerned, unless a saving in first cost or in operating expenses, or in both, will be achieved by its adoption. The same process of reasoning applied to naval matters would leave England without a fleet. The "rate of change" in electric lighting appliances and in electric lighting systems has been exceedingly high, and is still above the normal; but alterations in naval armaments, alterations which are often of a fundamental character, succeed each other even more rapidly. Yet we do not stop building ships awhile. No; we build the best we can design at the time, and as they become antiquated we relegate them further and further to the rear, making some use of them all the time.

Constant change, however, is always something of an irritative, even to those who are agreed as to its necessity; but it may be unnecessary, and then it is at once irritating and costly. In the first flush of a new industry constant change is indeed a condition of its being; but long after the early conditions have passed away the *tradition* continues, and the consequence is that we see to-day many electrical engineers who are never so happy as when propounding new proposals or scrap-heaping old plant. This foible, without a doubt, gives a handle to the opponents of electric lighting, and is, we venture to say, distinctly un-English. If there has been one quality more than another characteristic of the Englishman, whether engineer or not, it has been a capacity for making the best of a bad job, getting to work with things as they are instead of waiting for them to become what they ought to be, working wonders with discouraging material, and extracting the maximum of good from things evil. In the municipal electrical engineering world, on the other hand, where, thanks to inadequate salaries, there is an uninterrupted procession of engineers from borough to borough, there have been many symptoms of a contrary tendency. Instances are frequently occurring of new engineers immediately after their appointment setting to work to draw up an indictment against their predecessor's entire handiwork. They disapprove of this, object to that, and fail to see the advantage of the other. We assume, of course, that all this condemnatory energy is evinced with a single eye to the improvement of the station; but for all that we very much question whether this proceeding is always absolutely necessary and invariably discreet. It is an indisputable fact that wherever two or three electrical engineers are gathered together there will be found two or three diametrically opposite views as to methods of generation, distribution, and management. There will be slow-speed men and high-speed men, three-wire men and alternate-current men, multitubular boiler men and Lancashire boiler men, bare-wire men and rubber-insulation men, not to speak of 100-volt lamp men and 200-volt lamp men. Much may be said for most of these views; something may be said for all; and any system that has worked and is working deserves a better fate than incontinent relegation to limbo. "It were good that these men in their innovations would follow the example of Time itself, which indeed innovateth greatly but quietly, and by degrees scarce to be perceived."

An instance of this "root and branch" spirit has just been brought to our notice. A new engineer recommends the entire replacement of many miles of cable by cable of another make; the adoption for extensions of a different type of arc lamp to that previously in use; and the substitution of small transformers by large transformers banked at various points. Doubtless the recommendations are wise in their way. Nevertheless, we believe that the faulty cable is limited to one circuit, which has been subjected to very trying and exceptional conditions from the time it was first laid down; that the new type of arc lamp proposed has been tried and found useless for the particular neighbourhood, whilst the arc lamps which it is proposed to discard have been successfully in operation for over three years without giving cause for a single complaint; and the intention of the old engineer was to have removed the small transformers, which were originally installed to meet special requirements, and to have replaced them by 20-kilowatt transformers at various points when the special requirements had ceased to exist. We have particularised this instance mainly because it has been turned to good account by our good friends the gas journals, and will, no doubt, be turned to even better account by those who argue that electrical matters, being in a perpetual state of flux, had better be severely let alone.

## REVIEWS.

**Elettricità e Magnetismo.** Di Rinaldo Ferrini. (Milan: Ulrico Hoepli.)

This volume is a rewritten edition of the author's "Electricity and Magnetism" published in 1878. Needless to say, it has had to be entirely remodelled in many parts to bring it up to date. It is part of the *Fisica Tecnologica* series, and proposes to deal with the "fundamental electro-technical notions" of the day and their chief applications. As far as the book goes, Prof. Ferrini may be said to have successfully endeavoured to provide the student of electrical engineering with a volume which will give him a sound theoretical acquaintance with electromagnetic conceptions and methods of calculation, and a general view of their applications. The book does not profess to give instructions for laboratory work, or to deal with advanced modern theories, so we cannot complain of the meagreness of the references to practical measurements of resistance or self-induction. Electromagnetic radiation is left out in the cold to an extent sufficient to make a Maxwellian shiver, and in the first chapters everything is based, as of old, upon Coulomb's law. But when we come to the magnetic portion of the work we emerge into bright daylight. The treatment of magnetic circuits (p. 237) is a model of lucidity (although the word "fluid" *does* come in once), and the various aspects of impedance are done full justice to under the name of *resistenza apparente* or *impedimento*. Prof. Ferrini shares the Italian dislike for the mutilation of the name of "nostro illustre Volta" into *volt*; but it is doubtful whether *our* illustrious Faraday would be pleased to find himself "restored" as Farade, as proposed by our author, evidently to save his countrymen some trouble in acquiring the English pronunciation. Talking about names of units calls to mind the curious fact that another Italian master, whose name was once identified with the whole domain of current electricity, has been so completely forgotten in the distribution of modern electrical honours. Nobody thinks of enshrining the name of Galvani in a physical conception involving L, M, T and other things (usually as much "suppressed" as Galvani himself). Prof. Ferrini himself does not introduce $\mu$ and $k$ into his dimensional formulæ, and saves the inevitable conflict by leaving out the electrostatic system altogether. This becomes somewhat serious, according to modern views, when he omits the specific inductive capacity of air from the definition of the unit of quantity (page 11). The term convection for a point discharge is unpleasantly suggestive of the fluid theories, and the unreserved substitution of "pressure" for voltage is inadvisable. Difference of potential has received a peculiarly bad treatment. Whatever its real dimensions may be (and these are unknown until we know more about $\mu$ and $k$), it cannot possibly be work ($ML^2T^{-2}$), E.M. "Force" ($MLT^{-2}$) and pressure ($ML^{-1}T^{-2}$)

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all at the same time. Voltage is a good word, and does not imply any dimensions.

But we have no desire to find faults artificially. The book is a serious, we might even say an ambitious, undertaking. It is beautifully printed, passably well illustrated, and evidently revised with care. It marks a higher level than we have yet seen attained by Italian works of a similar kind.

**Magnetism and Electricity, with Reference to Practical Requirements.** By Dr. Gustav Benischke. (Berlin : Julius Springer.)

It is one of the greatest obstacles to the propagation of scientific knowledge, among those engaged in the technical application of electrical science, that such knowledge has usually to be gained by cumbrous and indirect means, rather than by direct reference to their practical experience. The majority of text-books on Magnetism and Electricity devote a large amount of space to the subjects of Magnetism and Frictional Electricity, and to the description of historical and obsolete apparatus, interesting and valuable doubtless to the student of pure science, but uninviting and unnecessary for the technical student. Dr. Hopkinson, in his able presidential address to the Institution of Electrical Engineers, advocated the reversal of the usual process of study, and maintained that a complete theory could be developed from the study of currents, in which view he was supported by other experienced professors.

In the volume now before us Dr. Benischke has provided a book essentially of value to the technical student, though, as a knowledge of elementary physics and the calculus is required, it is to be feared that it is above the heads of all but the more advanced of such students in this country. The old order is, indeed, retained; but magnetism and electrostatics only occupy one-tenth of the volume, the remaining nine-tenths being devoted to the study of continuous and alternating currents and of measuring instruments. The sole defect noticeable in the work is a slight tendency in places to empiricism and incomplete proof, which great compression almost inevitably leads to; but Dr. Benischke is to be congratulated on having in most cases succeeded in giving very clear and rigid proofs in small space. The collection of tables given in the book would alone render it valuable for reference; but the whole work may be well recommended to the advanced technical student, on account of its complete and practical exposition of electromagnetic theory in the smallest possible space.

## THE USE OF ELECTRICITY ON BOARD SHIPS.*

BY HERR F. EICKENRADT.

In endeavouring to comply with the flattering request of speaking before this assembly, I have chosen for this purpose a subject which at the present time should engage the attention of shipbuilders in general, viz., "Use of Electricity on Board Ships." First of all, I beg leave to request the distinguished company here assembled not to criticise my statements with the eye of the technical electrician, as I do not pretend to pose as a specialist in this subject. I rather shall endeavour to treat the question merely from the point of view of the shipbuilder. Excepting in isolated cases of minor importance, electricity has only been recently brought into extensive use for working auxiliary machinery on board ships. Not only has the technical electrician endeavoured in the last few years to interest the shipbuilding industry in the application of electricity, which took such enormous strides in its development, and to draw the equipment of ships into the province of their commercial supplies, but also the shipbuilder—whose work may be described as a rallying point of every new technical invention developed to its utmost extent and completeness, and who is thereby obliged to follow every further step onward with ever-watchful eye—could not afford to neglect the obligation to make a practical test of the value of the electric motor on board ships.

The first question, from the point of view of the shipbuilder, was to ascertain whether electricity, as such, had special advantages to offer over steam power, hitherto generally employed. This question may be answered with a decided "yes" in many cases. The large number of auxiliary engines which are in use on board modern steamers, and still more so on men-of-war, not only as accessories to the complicated main engines, but also for all other possible purposes, necessitated the laying of steam pipes into almost every nook and corner of the ship, both for the purpose of bringing steam power to the spot, and for carrying away the waste steam after use, a fact which does not exactly contribute to the comfort of the crew. This network of pipes produces, notwithstanding the most careful covering with non-conductors, not only troublesome and unnecessary heating of spaces where it is not required, but leads to still greater inconveniences in consequence of the damages to which such steam pipes are unavoidably subjected. The leaking of a single flange may make staying, even in large rooms, perfectly impossible. All these evils are avoided if the transmission of power to the different points for use is effected by a wire, which, when properly adjusted as to dimensions and well insulated, has absolutely no effect upon its surroundings. The second question is, whether the electric motor is superior to the steam motor. As to this, it must be admitted that a steam engine in every part of the ship is disagreeable; it emits heat, and is exposed to many accidents, which may produce detrimental, and, in some cases, even disastrous effects to its vicinity. Such accidents do not arise to the same degree with the electric motor, besides which it has the advantage of being very simple to manipulate, as long as it is at all efficient for use, and, what is especially of importance for the circumstances on board ship, it is much more clean to handle than a steam engine.

I make this reservation with the electric motor "as long as it is efficient for use." This point appears of importance in regard to its usefulness on board. The electric motor has, however, hitherto remained quite unknown to the engine-room *personnel*. They are not sufficiently familiar with its arrangement, especially with the often very complicated supplementary contrivances, and they do not know what to do when a breakdown occurs. On the other hand, it must be admitted that the technical electrician has already recognised this fact to a certain extent, and has provided for it, partly by simplifying every apparatus which will have to be entrusted to unskilled hands as much as possible, the reliability of the working of which has to be safeguarded under any circumstances, and partly by excluding those parts which do not require special attention from any possibility of being touched by incompetent hands. Supposing that a motor has been constructed, in this respect, with the most complete perfection, the only attention it would require would be that, at certain intervals it is necessary to inspect the bed-plates, and to ascertain the condition of the insulation in the wires. With such simple attention it becomes possible to supervise several motors, which are worked from a common centre, by a very limited number of hands, which undeniably is a great advantage.

I shall now proceed to consider successively the following subjects, viz., installations for lighting, ventilation, and heating, ships' winches, ammunition, supplies, appliances for moving guns, and steering apparatus.

*Lighting.*—When electric lighting was first introduced, there were indeed many opponents, but to-day its abolition is beyond any discussion. Its reliability of working is fully safeguarded with the dynamos in use at the present time, and any danger of fire is as good as excluded, when the installation is properly and scientifically made; therefore the advantages of electric lighting are now so generally acknowledged that even on small cargo steamers, where only a limited number of lamps are required, a small dynamo engine is installed for lighting purposes. Electric lighting installations are indeed reckoned amongst the sanitary fittings of ships, and while mentioning this we are involuntarily driven to the question whether in this respect further improvements might not be obtained by means of electricity. In answer to this question we are led to consider ventilation and heating apparatus.

*Ventilation.*—Good ventilation on board, both for living rooms and cargo spaces, may now be considered as a generally admitted necessity. But every shipbuilder is aware of the difficulties which the solution of this question presents in regard to natural ventilation, and artificial ventilation has therefore taken its place everywhere on board already. An arrangement of tubes emanating from a central point and leading into every part of the ship would appear to be the most advantageous. However, the carrying out of such a system would be connected with enormous difficulties, considering the circumstances on board ship, and having regard to the conditions which would have to be fulfilled in order to make it efficient; and especially taking into consideration the necessity of preserving the water-tightness of the bulkheads, which would absolutely forbid the passage of air tubes through them. The shipbuilder is therefore obliged to divide the entire system of ventilation into several parts, each independent of the other, and must make allowance for the division of the ship into watertight compartments. For the working of these separate ventilators, which frequently have to be fitted up in out-of-the-way corners, which are difficult of access, a steam engine has to be again supplied, to which the

* Read at the summer meeting of Institution of Naval Architects, June 13th.

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evils previously enumerated are especially applicable, and which necessitates again a special attendance. For the working of such ventilators, therefore, the electric motor is excellently adapted, and its driving may be effected from any easily accessible place with the same facility as if it were situated in the immediate vicinity of the ventilator. The kind of motor here in question is of very simple construction, does not require any complicated auxiliary arrangements, and will keep on running without any attendance at all. If there are not many ventilators of large dimensions to drive, the installation of a separate current circuit may be avoided, and the ventilators may be connected with the circuit for the lighting, for which purpose the latter will only experience an immaterial addition to its weight. Should there, however, be several ventilators with fans of 800mm. to 1,200mm. diameter, and demanding 2,000 to 4,000 watts, it is preferable to establish a separate circuit for them.

With regard to the advantages of electric motors for this purpose, it is anticipated that they will be generally adopted for the driving of ventilators, and this may occasion, again, an improvement of the systems of ventilation, as they may be extended to spaces which have hitherto been excluded. Also, the ventilators for the stoke-holds of boilers under forced draught, having a consumption of energy of from 15,000 to 20,000 watts each, and the engine-room ventilators, with a consumption of 6,000 to 10,000 watts each, are advantageously driven by electric motors. In places like the above, where electric motors are exposed to the particularly severe effects of coal-dust and heat, it is desirable to put the motor inside the suction tube of the ventilator, which can easily be done in centrifugal ventilators, with separate air-suction tubes ; by such an arrangement the electric motor will be well protected and kept cool.

*Electric Heating.*—Very little experience is available up to date in respect to electric heating, and, as far as I know, experiments in this direction have only been commenced at a very recent period. Installations for this purpose would offer a great advantage by enabling us to dispense with the very extensive pipe system required for the steam-heating process, with its innumerable flanges, taps, valves, and condensing pipes, all of which details occasion frequent inconvenience, in consequence of leakages and failures in the action of the condensing apparatus. Many perforations through bulkheads are also dangerous inconveniences. All these evils would be avoided in electrical heating, the conducting wires for which could be suitably joined to those for the lighting apparatus, with the object of minimising weight and restricting the number of conduits generally as much as possible. The disadvantage of such an installation consists, however, in the fact that a comparatively large main engine for the generating of current would have to be erected, and that this force would only be fully employed while the limited period for heating lasts. If you take it for granted that a steam-heating apparatus with heat-giving copper tubes and a total heating surface of 75 sq. metres would produce 60,000 calories hourly, an electric heating apparatus of the like power would require a main engine of about 75,000 watts, consequently a steam engine of about 100 H.P. The erection of such an engine exclusively for this purpose would, however, only very rarely be suitable for ships. But in case an electric motor is contemplated, say, for boat-hoisting apparatus, &c., which would not be often in use, and then only for a short period, the necessary engine for this purpose might in the interval be used with great advantage for heating. Electric heating all over a ship cannot, therefore, at present come into consideration, but it might be advantageous for many spaces where electric lighting has already been resorted to, and where a connection with a steam-heating system presents other difficulties. I should like to mention here that the preceding remarks have been based upon a supposed radiation of 800 calories per hour and per square metre of copper tube in the steam-heating surface. Absolute reliance, however, cannot yet be placed on these figures, and likewise the transmission coefficients have not yet been exactly ascertained which have to be taken into account for circumstances on board ship. The introduction of electric heating on board, which requires an exact previous calculation of the heating surface and of the dynamo engine, still necessitates, therefore, the investigation of the above-mentioned transmission coefficients on existing steam-heating installations.

*Ships' Winches.*—The manufacture of electric ships' winches forms already a special department with the electrical engineering firms. They are now so thoroughly understood in all their branches that their general adoption for ships may be confidently anticipated in the near future. The excellent results which many German firms have also shown in this branch have further induced them to go a step forward from the comparatively simple winches for loads up to 2,000 kilos. and 3,000 kilos. to the heavy boat-lowering winches, with a lifting capacity of 10 tons to 16 tons. Such installations, which require a development of force equal to 90 H.P. to 100 H.P., can, however, only be advantageously employed when the electric motor has been adopted for all the auxiliary machinery in a ship. In an installation of this kind it is not requisite that the power of the main engine should equal the sum total of the capacity of all the auxiliary engines ; the calculation must rather be based upon the total of all the engines which may be in use at the same time. During the period of employment of a boat winch of 50 H.P., which is driven by a central engine, it will always be possible to disconnect a corresponding number of other machines, such as ventilators, pumps, &c.

*Ammunition Hoists or Lifts.*—The adoption of electricity for many motors upon men-of-war appears already of paramount necessity. The working of the great number of ammunition hoists which have become requisite by reason of our ponderous modern armaments, with numerous guns, would necessitate a very large quantity of small but fast-running steam engines, the service of which would unavoidably lead to a considerable increase of engineer hands. The installation of electric motors, driven from a central station and requiring no particular attention and care, seems, therefore, advantageous for this purpose ; the more so, as in special cases they are adapted to be fitted in very small dimensions, whereas a steam engine would always occupy a much larger space. If the ammunition supply is not effected by Paternoster appliances, but by lifts, the motors are, however, no longer so simple in their construction as those mentioned before. In hoisting by lifts, the chairs have to be attached in such a way to the motor that the latter at the ends of travel is automatically stopped and set in motion. Besides, an electric brake must be provided, and by means of special minor appliances the quiet starting of the chair must also be guaranteed. However, there are already numerous installations of this kind in existence, and their efficiency has been proved by practical experience, from the results of which the general adoption of electrical energy for the ammunition hoists may be considered as secured in the near future.

*Gun and Turret Turning.*—The manufacture of electrical turning appliances has lately occasioned a lively rivalry ; yet, up to date, it cannot be asserted without a doubt, that they will supplant the approved appliances of hydraulic power. Considering the paramount importance of these appliances for men-of-war, the mere fact that the question has been *technically* solved in the most complete manner is not decisive ; every chance of the gear getting out of order must be practically excluded, and the crew for this service must be so completely familiar with its working that they are able, not only to guarantee its expert handling and the maintenance of its efficiency, but also, in case of need, are able to repair and make good any damage.

*Steering Apparatus.*—The steering apparatus offers the greatest difficulties for an electrical application ; but, on the other hand, this makes it one of the most interesting subjects. Before going more closely into the matter of electrical application, I will shortly explain the steam steering gear hitherto in use, in so far as it is necessary for the comprehension of the electrical appliances. The steering gear with its appurtenances may be divided into three separate parts, viz., into the motor proper for working the rudder, into the arrangement of the motor for setting it in motion from the deck, and into the arrangements of the motor for stopping it after the rudder has been moved. In the steam steering apparatus with mechanical appliance for setting it in motion this is often done by means of a hand wheel, which is fixed on the bridge, and which is turned in correspondence with a scale for bringing the rudder into the desired position. The turning of this hand wheel turns at the same time a transmission system laid through the whole ship, and moves also, by means of a worm fitted to the end of the transmitting crank, a nut which is in connection with the steam inlet valve, and which thus opens it. By these means the motor proper is put in motion, and causes, by means of the turning of the motor crank, a self-acting return motion of the nut, and places the valve again into its position of rest. As soon, therefore, as the hand-wheel on deck ceases to be turned, the motor will immediately stop itself through its own movement. Every shipbuilder, however, knows the great difficulties caused by the laying of such a long transmission system which has to be worked by hand. Even although the mounting has been successfully completed, it will often happen, after the vessel has been running a short time, that the transmission can no longer be moved, a fact which is due to the contraction and expansion of the bulkheads and decks to which the blocks have been fixed. With the electrical installation, the question is whether the motor, or the moving appliance, or the stopping appliance alone, or the whole apparatus shall be driven electrically. As far as I am aware, the use of electricity for such an entire gear has hitherto not been attempted. In most cases electricity has only been employed for the starting appliance. A combination of the starting appliance with a self-acting registration upon the control board on deck by the electric current from the tiller has, however, proved to be so difficult that to judge from what has hitherto been achieved in this direction, we can hardly expect a solution of this problem, at present, which will be satisfactory and always reliable in its action. As it stands to-day, this question allows only the installation of an electrical starting apparatus, which generally is restricted to a common governing apparatus, and which only supplies the current to a comparatively simple electrical appa-

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ratus, which in its turn again controls the steam inlet valve. The closing of the valve must then be effected by cutting off the current by means of a separate indicator with a hand showing the position of the rudder, which in its turn again is set in motion by the tiller direct. This apparatus may again be either mechanical or electrical, and several reliable electrical apparatus for this purpose are already in existence.

A very interesting starting appliance, used on the French cruiser "Bouvines," is described in the *Revue Maritime et Coloniale*. Here the distributing valve of the steam-steering apparatus is not automatically moved by the apparatus itself, but by a small electrical motor, quite independent of the steering gear, and the latter follows the movement of the valve. The starting of the motor is done from the deck by means of a governing apparatus. Here, however, the current is not led direct into the motor, but first to a relay, which then in its turn governs the motor current. The working of the governor apparatus on deck is effected according to a rudder indicator, which contains several numbered lamps. These different lamps correspond with certain rudder angles, and are lit up by the movement of the tiller. Such lamp signals, which also are employed for engine telegraphs, have, however, the great disadvantage that the different signals which are indicated by the simultaneous burning of different lamps are difficult to distinguish in strong sunlight. It is also very misleading when the different lamps burn with different degrees of brightness, and a failure in consequence of a lamp burning out is also possible.

If the construction of an electric motor for the steering gear does not at the first glance seem to present any particular difficulties, they are, nevertheless, very material. A reversible motor requires a governing apparatus, which must be of very substantial construction, if it is not to be speedily used up, or if undue heating of the same is to be avoided, regard being had to the size of the motor and to the fact that it may have to be worked, perhaps, 1,000 times in a day. A continuously-running motor, which only moves in one direction, requires again the insertion of electric couplings for the turning of the tiller to the right and left. The suitability of such couplings for frequent in-and-out turning has, however, still to be demonstrated. The employment of two constantly-moving motors, which work by means of a differential wheel appliance, demand the manufacture of very excellent wheels if this apparatus is not to work noisily. This latter type of apparatus is at present under construction in Germany, and the result will be watched with great interest. However, all these contrivances have the disadvantage that they necessitate a very well-trained *personnel* for their effective working and maintenance. If, therefore, as may with confidence be expected, electric power is introduced on board ship to a greater degree, the special training of the crew in its use will be a necessary consequence.

*Concluding Remarks.*—At the close of my remarks I will only touch upon a general question, which is of importance for electrical installations on board. With the increasing employment of electricity on board ship the question arises, whether for such installations continuous or alternating currents should be chosen? In all installations hitherto made, the continuous current has been exclusively used; it has proved completely efficient, and there has been no occasion to discard it, as long as there was only a question of illuminating the interior and of search lights. The latter can only be worked with continuous currents, otherwise their lighting power would suffer a decrease of about 40 per cent. As, on men-of-war, the consumption of energy for the search lights reaches 20,000 to 70,000 watts, it is evident that, for the kind of current required for lighting the interior, and for several small motors, continuous current only can be utilised. The injurious influences upon the compass may be avoided, with such a current, by careful disposition of the leads, and the scientific construction and fitting up of the dynamo engines. But when it comes to a general introduction of electro-motors for working the auxiliary machinery, and a 300,000 watt central station is erected for this purpose, the employment of continuous current offers considerable difficulties. In particular, the motors placed on deck for the gun-turning apparatus and ships' winches have to be placed in such dangerous proximity to the compasses, that the disturbing of the latter in the case of parallel current can hardly be prevented. For the working of this machinery, therefore, the use of the alternating current becomes unavoidable, as such a current, and likewise any motor driven by it, has no influence upon the compass. This, however, again, necessitates the erection of two central stations, viz., one for the search lights, and lighting, with current; and a second station, with alternating current, for driving the auxiliary machinery. Unfortunately, this arrangement presents the great disadvantage that the motors for one station cannot be employed in support of, and in substitution for, those of the other; and thereby a great complication would be created for the whole installation, which would demand greater capabilities from the crew. It will be impossible, however, to avoid this if the increased advantages, which the use of the electrical appliances affords on board of ships, are to be secured.

## THE POSTAL TELEGRAPH SERVICE.

The Forty-second Annual Report of the Postmaster-General has been published as a Parliamentary Paper; it is a record of the business of the Department for the year ended March 31, 1896.

In the section devoted to TELEGRAPHS and TELEPHONES, the Postmaster-General observes that a very satisfactory increase took place in the number of both inland and foreign telegrams, an increase undoubtedly due to the revival of trade throughout the country. During the year 78,839,610 telegrams of all descriptions were forwarded, showing an increase over the previous year of 7,250,546, or 10·12 per cent. 64,563,587 of these were ordinary inland telegrams (*i.e.*, excluding foreign, press, and free telegrams), showing an increase of 5,656,179, or 9·6 per cent. The total revenue from inland telegrams was £2,046,456, as compared with £1,880,206 for the previous year, making the average revenue 7·61d. per telegram, as compared with 7·66d. The number of foreign telegrams dealt with by the Department reached 6,701,838, showing an increase of 764,123, or 12·86 per cent. as compared with the year 1894-95. This total does not represent the whole of the foreign telegraphic business of the United Kingdom. It only shows the number of foreign telegrams transmitted by the Post Office, and does not include those dealt with by the various cable companies without recourse to the Postal Telegraphs. 5,915,646 telegrams were transmitted at the Press rates for newspapers, clubs, &c., being an increase, as compared with the previous year, of 513,863, or 9·5 per cent. The average weekly number of words contained in these telegrams was about 13,650,000. Telegrams sent on behalf of the various Government Departments show an increase of 22,722, or 8·33 per cent., the total for the year being 295,371, as compared with 272,649 for the previous year. The number of telegrams sent free of charge on behalf of the railway companies amounted to 1,338,818. This number represents an increase of 27·74 per cent. on the number, 1,048,064, sent in the previous year; but it is considerably below the numbers sent in former years, before the arrangements for limitation of the number transmissible free of charge. In continuation of these arrangements, a settlement has been arrived at with the Great Western and the Brecon and Merthyr Railway Companies for a limitation of their free message privilege, and there now only remain four companies with whom agreements have not been concluded.

The numbers of the various kinds of telegrams, as compared with the number in the previous year, are given in the following table:—

| Class of Telegram. | Number. | | | Receipts. | | |
|---|---|---|---|---|---|---|
| | 1895-96. | 1894-95. | Inc. | 1895-96. | 1894-95. | Inc. |
| | | | | £ | £ | £ |
| Ord. Inland ... | 64,563,587 | 58,907,408 | 5,656,179 | 2,046,456 | 1,880,206 | 166,250 |
| Press (Inland) | 5,915,646 | 5,401,783 | 513,863 | 124,881 | 119,061 | 5,820 |
| Foreign ..... | 6,701,838 | 5,937,715 | 764,123 | 331,717 | 286,215 | 45,502 |
| Railway free... | 1,338,818 | 1,048,064 | 290,754 | ... | ... | ... |
| ,, half rate | 24,350 | 21,445 | 2,905 | 469 | 414 | 55 |
| Governmt. free | 295,371 | 272,649 | 22,722 | ... | ... | ... |
| Totals..... | 78,839,610 | 71,589,064 | 7,250,546 | 2,503,523 | 2,285,896 | 217,627 |

The London local telegrams show an increase of 644,921, or 10·14 per cent., the numbers for the year being 6,999,402 as compared with 6,354,481 in 1894-95.

The large increase in the number of telegrams passing over the Government cables to the Continent, and in the number of conversations on the telephone circuits between London and Paris, has rendered it necessary to consider the advisability of improving the means of communication. With the cordial co-operation of the German Post Office, experiments were made with a view to improve the carrying capacity of the cables to Germany by the method of duplex working, which has been employed with success on some of the Anglo-French cables; but, owing to the greater length of the Anglo-German cables, the results obtained were not sufficiently successful to justify the adoption of the system for practical working. Arrangements have now been made for the laying of three additional cables to the Continent—two to France and one to Germany. These cables, each of which will contain four conductors, will afford a much-needed relief to the traffic; and it is expected that this new cable to Germany will prove suitable for duplex working.

The new agreement with the National Telephone Company, embodying the arrangement arrived at after prolonged and difficult negotiations extending over nearly four years, was executed on March 25th last. In accordance with the terms of the Treasury Minute, on which the negotiations were based, the agreement restricts the operations of the Company to local areas, and places the trunk wires connecting those areas in the hands of the Post

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Office. Special facilities for using the telephone in connection with the telegraph and postal services are placed at the disposal of the public, whether subscribers of the Company or not. After considerable labour the experts appointed by the Post Office and the National Telephone Company to value the trunk wires of the Company brought their work to a successful termination, the price agreed upon being £459,114. 3s. 7d. This amount was paid to the Company on April 4th last. The length of trunk line taken over was 2,651 miles, and the length of wire about 29,000 miles. It has not yet been found practicable to transfer the working of the whole of these wires to the Post Office, as the special arrangements for leading in the wires, and fitting the necessary switchboards, &c., must necessarily occupy some time. The only wires the working of which has at present been transferred are those in the South of England. It is anticipated that the working of the whole of the remaining wires will be in the hands of the Post Office by the end of the summer. The telephonic service on the main system of trunk lines erected by the Department itself between the principal business centres of the United Kingdom to supplement those which it has now acquired from the National Telephone Company, was successfully inaugurated on June 12, 1895. On July 16, 1895, the system was thrown open to the public, and there has since been a steady development of the business. During the year additional telephone circuits between London and Bristol, London and Southampton, London, Lowestoft, and Yarmouth, and London and Guildford have been completed, while further circuits between London and Birmingham, Liverpool and Manchester, Manchester and Carlisle, and Newcastle and Carlisle are in course of construction.

Amongst other interesting items of information scattered up and down the Postmaster-General's report we note the following:—In 1871-72 the telegraph revenue amounted to £754,634, and the expenditure to £600,926; for the year 1895-96 the respective totals are £2,879,794 and £2,914,581, resulting in a book-keeping deficit of £34,787, as against £178,439 in 1893-94. In the telegraphic money order business there has been an increase of 20,861 in number, and of £58,573 in value, the total number of orders transmitted by telegraph in 1895-96, amounting to 153,318, of a total value of £515,304.

## A SIMPLE MERCURIAL PUMP.*

BY R. W. WOOD.

The accompanying illustrations represent a mercurial pump of extreme simplicity, designed for restoring the vacuum in Röntgen

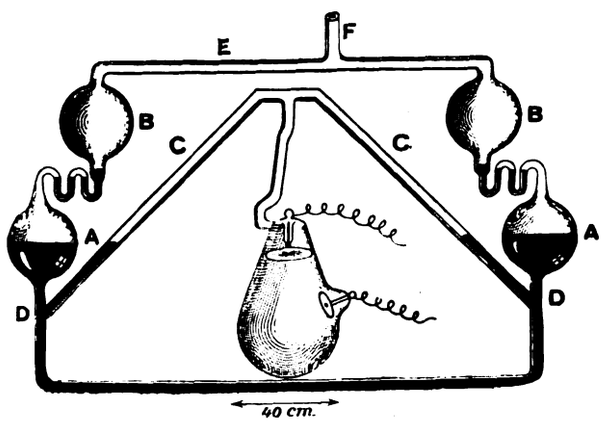


FIG. 1.

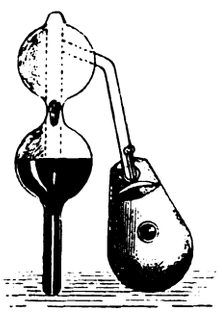

FIG. 2.

tubes after it has been impaired in course of time. The pump is double acting, and rubber tubes and valves are avoided. The working will be immediately understood from the diagrams.

* *Wied. Ann*, Vol. LVIII., No. 5, p. 205, 1896. Abstract.

Fig. 1 is a front view and Fig. 2, a side view of the apparatus. A A are two reservoirs half filled with mercury. By making the whole apparatus oscillate about its centre, so that A A are alternately filled and emptied, any traces of air are pumped out of the Röntgen tube into the reservoirs B B. The mercury is originally introduced through the tubes F and E. F is then made to communicate freely with the Röntgen tube by inclining the apparatus until D is above the level of the mercury. A mercury pump is attached to F, and F is fused after exhaustion. Fig. 3

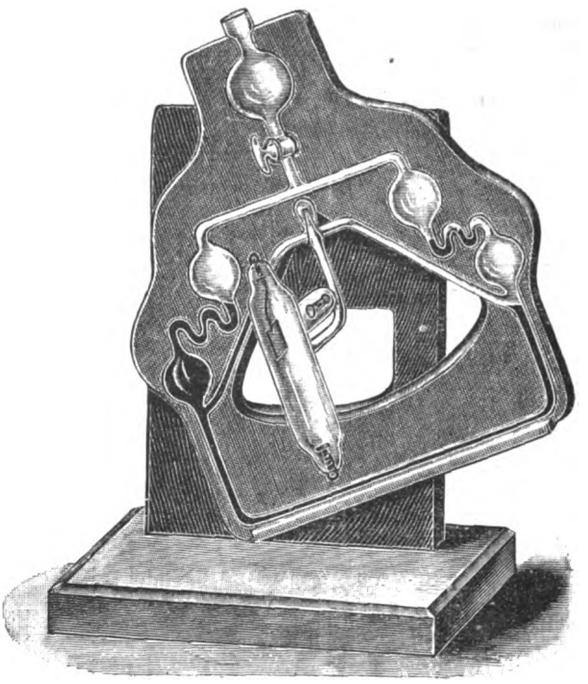

FIG. 3.

is an improved form of the apparatus, in which a reservoir is attached to F to contain the mercury, to be introduced when required into the exhausted tube system. A trap is also attached to the Röntgen tube to prevent mercury accidentally entering it through C (Fig. 1).

The author is working out a larger pump on the same principle.

## LEAKAGE ON ELECTRIC TRAMWAYS.

At the International Congress of Electricians, recently held at Geneva, Prof. E. Gérard, during the discussion on Dr. Wietlisbach's Paper on "The Telephonic Disturbances caused by High-Voltage Currents" (see *The Electrician* of March 27, 1896, p. 725), said he knew of an electric tramway in Belgium where the authorities at first insisted upon the English rules as regards fall of potential in the rails being observed. In order not to go beyond the maximum of seven volts it would have been necessary to increase the conductivity of the rails by adding a copper conductor costing no less than £20,000. The cost of the overhead conductor of the line was only £3,000. In view of this disproportion the observance of the English rules was obviously impossible. Mr. Kapp, who followed in the discussion, said the use of heavy return conductors was unnecessary, and a small return cable connected to a small dynamo, which automatically drew sufficient current out of the rails to correspond with the momentary load, was all that was required. With such an arrangement the English rules could not only be observed but the potential difference between the rails and earth could be made as small as desired. Upon this M. Thury said that in the Geneva electric tramways this arrangement had been adopted, and all the additional cables for the return were put down when the line was first constructed.

**The Origin of the 110-Volt Standard.**—According to the *Electrical Review* of New York the question why 110 volts became the standard for lighting circuits may be solved as follows:—Edison, in his early work on the lamp, always allowed 10 per cent. for errors, leakage, &c., and when one of his assistants suggested 100 volts Edison said, "We'll add 10 per cent., as usual, and make it 110 volts." That settled it.



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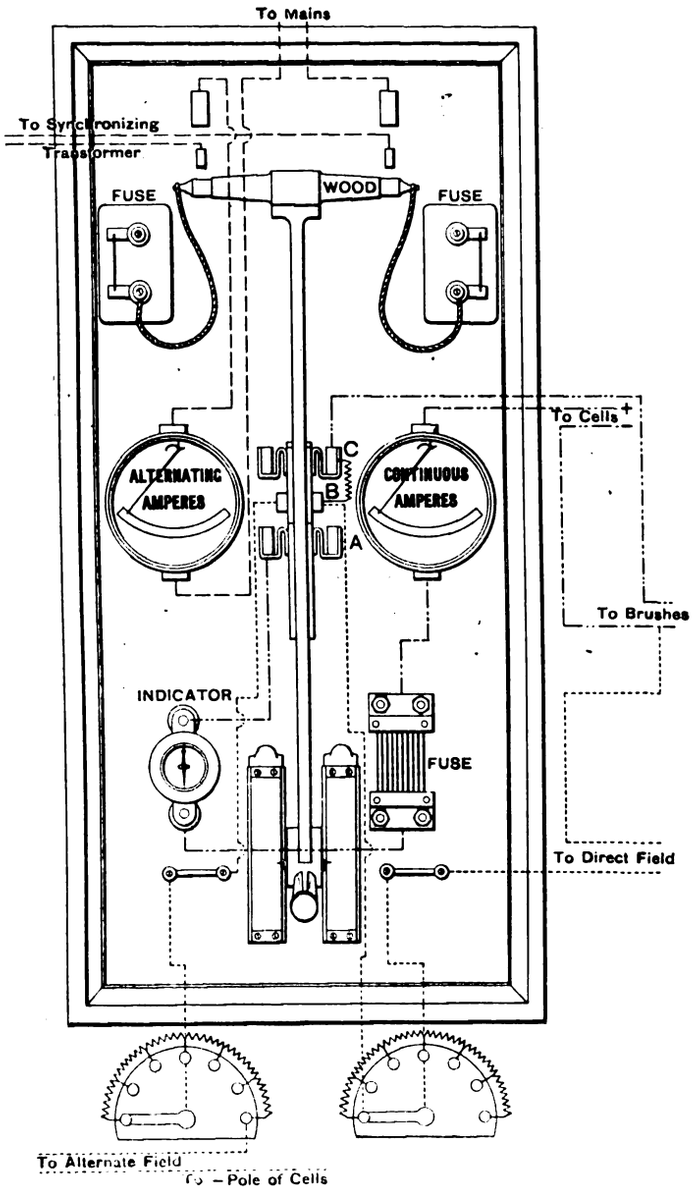
## THE COMBINED ALTERNATING AND CONTINUOUS-CURRENT DYNAMOS AT WOOLWICH.

BY F. J. MOFFETT, B.A.

The object which the designers of these machines had in view was to secure, in the case of an alternating dynamo, the same elasticity of output which is possessed by a direct-current machine when running in parallel with a set of storage cells. This elasticity Messrs. Pritchett and Low have secured at the station of the Woolwich District Electric Light Company, by constructing a combined alternating and continuous-current dynamo. Two machines of this type were built by Messrs. Swinburne and Co., and have been running for some years.




Diagrams of Connections of Compound Switch.

They consist of two sets of 4-pole field-magnets placed side by side on the same bed-plate, and two armatures, one alternating and the other continuous, both keyed on a common spindle. The high-pressure alternating armature consists of four flat coils fixed on the outside of a gun-metal drum, the core being formed in the usual way of laminated iron discs. It is wound for a current of 17 5 amperes at 2,000 volts, and the periodicity is 50 $\sim$ per second. The low-pressure armature is designed to give 400 amperes, at from 100 to 130 volts. The commutator has 130 segments, and the current is collected by four sets of brushes. The bearings are of the self-lubricating type, the distribution of oil being effected by means of brass rings, which have their internal diameter slightly larger than the journal on which they rest, and which are carried round by the rotation of the spindle. They dip into an oil well at their lower extremity, and carry a supply of oil up to the point where they are in contact with the spindle.

Naturally, machines of this novel type required special switching arrangements, and Messrs. Pritchett and Low designed for the purpose the compound switch of which the connections are shown in the accompanying plan. The switch consists essentially of a vertical steel bar running in guides, and capable of being moved into different positions by means of a hinged lever attached to the bar by a connecting link. The central part of the bar has two flat copper plates fixed one on either side, the function of which is to connect the three double-spring contacts, A, B, C. Between B and C a set of resistance coils is joined up to prevent an excess of current from the cells flowing through the continuous armature when it has not run up to full speed. At the top of the vertical steel bar a T-piece of hard wood is secured, at either end of which are brass collars connected by short lengths of flexible cable through shunted safety-fuses to the collectors of the alternating armature. Vertically above these collars are two brass spring contacts, which are joined up to the primary of one of the synchronising transformers. Still higher on the panel are two double spring contacts connected to the terminals of the street mains. The alternating current passes through the ammeter on the left of the panel, and its pressure is shown by an electrostatic voltmeter on another panel. Both the alternate and continuous fields are excited by current from the cells, the strength of field in both cases being varied by means of step-by-step rheostats, which are shown underneath the panel in the plan of connections.

The method of starting up these machines is as follows : Steam is opened on to the engine, and the armature is run up to approximately the right speed. The switch is then moved up so as to connect the two contact springs A and B, the direct-current armature being now in circuit with the cells through a resistance.

As soon as the current indicator shows that there is no discharge from the cells, the starting resistance is cut out by moving the switch up so as to connect the spring C. If it is desired only to charge the cells, the switch is left in this position, and the field circuit of the alternating end is broken. If, however, it is intended to put the alternator on the mains, the switch is raised till the brass collars on the wooden T-piece make connection with the synchronising springs. The open circuit E.M.F. is determined by a voltmeter placed in the secondary circuit of one of the synchronising transformers, and if a simple change-over is to be effected, the switch is now raised to the last position, in which the terminals of the machine are joined up to the top brass contacts, and connection made with one pair of terminals of the change-over switch.

If it is required to synchronise with another machine, the terminals of which are in direct connection with the top spring contacts, the speed of the alternating armature is regulated by means of the rheostat in the direct field circuit, until it is seen from the lamps on the secondaries of the synchronising transformers that the right periodicity has been reached ; the open circuit E.M.F. is regulated by the rheostat in the alternating field circuit, and the switch is raised to the last position at the moment when the synchronising lamps show that the machines are in phase. It will be gathered from the above description that all the speed regulation is done from the switchboard, thus obviating the necessity of interfering with the engine stop-valve or governor, and rendering the operation of throwing machines in parallel much more simple.

We will now indicate one or two of the valuable qualities of this type of compound machine. Probably the first point which will strike a central-station engineer is that it is possible to always run the engine at full load. If the alternate current being generated at any time is insufficient to fully load the engine, the balance of the load is made up by the continuous current generated in and sent from the continuous armature through the cells ; and, of course, even if no alternate current at all is being generated, the full power of the engine may be used in charging the cells, which, in addition to supplying the lighting current at the station and the exciting current for all the alternators, is used to run a motor-generator during light load. If the alternate current required is greater than the engine alone can generate, the continuous end of

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the machine begins to act as a motor, since as soon as the load on the alternating end becomes too large for the engine alone to deal with, the speed of the latter begins to drop, causing the E.M.F. of the continuous end to fall, and allowing current to pass from the cells through the continuous armature. These dynamos are driven by engines of 20 B.H.P. Consequently about 7 amperes can be generated by steam, and the remaining 10·5 amperes, which make up the total output of the alternating end to 17·5 amperes, are supplied by power derived from the cells. Thus it will be seen that the alternating end of the dynamo is capable of dealing for some time with a much greater load than the engine alone could negotiate, a quality which is of the greatest value when the load is coming on or going off, and which enables the engineer-in-charge to safely ascend for some little distance the base of the peak with a small steam unit, instead of being obliged to run a large engine while the load is still small. In case of a sudden fog or thunderstorm these machines are very convenient, since darkness comes on very often so unexpectedly that there is no time to start a fresh unit. With the ordinary small steam unit, used in most stations to take the day-load, the limit of output is soon reached; but with these double machines more than twice the output of the engine alone can be managed at a pinch.

The power is transmitted from the engines to these machines by means of belting, and it will be readily believed that a considerable sense of security is developed in the breast of the engineer by the knowledge that even if a belt should give way there will be no interruption in the supply; under such circumstances current will be taken from the cells by the continuous armature, and the E.M.F. kept constant while another engine is being warmed up and started in order to take the load. If direct-driven machines were constructed on this principle it would be quite feasible to arrange for the total disconnection of the engine from the dynamo by means of a clutch in case of any accident happening to the engine.

Within the limits of their normal output the regulation of the E.M.F. is almost perfectly automatic. The continuous part of the machine, being excited from the cells, runs at a practically constant speed whatever the load may be, unless the voltage of the cells should get low owing to a heavy discharge, when it becomes necessary to alter the field of the continuous end. The governor of the engine is arranged only to come into action in case of the load being suddenly taken off, to prevent the engine from racing.

These dynamos are very frequently disconnected from their engines and used as motor-generators. If a large steam unit is started at light load, one of these machines is run up to speed from the continuous end, synchronised and run in parallel with the large machine. The alternating half of the machine now acts as a synchronous motor, while the continuous half sends current through the cells. In this manner the large machine may be always run at nearly full load. As the outside load increases, the charging current from the continuous end of the combined machine decreases, and the pressure on the mains is automatically kept constant. If it happens that the steam pressure drops for any reason during heavy load, one of these combination machines is run as a motor-generator in order to take a part of the load, and is most effective in relieving the strain on the boilers during the peak of the curve. Of course, in this case the continuous end is acting as a motor and the alternating end generating.

It is hardly necessary to point out that there is no part of the day's run at which these machines are not of value, since it has been shown that they are equally effective when the load is light and when it is heavy, when it is coming on and going off.

## THE WORK OF THE REICHSANSTALT.

A report on the work accomplished at the Physikalisch-Technische Reichsanstalt (the German Imperial Physico-Technical Institute at Charlottenburg) appears in the July number of the *Zeitschrift für Instrumentenkunde*. The report covers the period from April 1, 1895, to February 1, 1896, and is an extract from the official report to the Board of Management. The staff is the same as last year, and consists of 71 members. Some of these took part in the deliberations of electricians and mechanicians in congress, or visited the larger industrial centres. The following table of the subjects investigated will give an idea of the ground covered by the workers in this National Physical Laboratory.

FIRST DEPARTMENT (PHYSICAL).

A. *Thermal work*—
1. Expansion of water.
2. Density of steam.
3. Influence of temperature on elasticity of glass.
4. Standard barometers.
5. Expansion of quartz, Fizeau's method.
6. Conduction.
7. Measurement of very high and very low temperatures.
8. Melting points of metals.

B. *Electrical work*—
1. Standards of resistance.
2. Helmholtz's electro-dynamometer.
3. Disturbances in electric street railways.

C. *Optical work*—
1. Platinum unit of light.
2. Spectrum of the platinum standard.
3. Radiation in absolute measure.
4. Perfectly black bodies.
5. New contrast polarimeter.

SECOND DEPARTMENT (TECHNICAL).

1. Standards of length, and testing of scales and screw threads.
2. Inequalities in rotating machine parts, measured by Braun's gyrometer and by the writing tuning fork.
3. Testing of tuning forks.
4. Electrical routine testings: cells, primary and secondary, arc carbons, galvanometers, electrometers.
5. Resistances and working standards.
6. Insulators.
7. Properties of magnetic materials.
8. Testing of thermometers and pyrometers.
9. Manometers and barometers.
10. Petroleum and viscosity meters.
11. Transmission of heat through metals.
12. Photometric testing of lamps.
13. Saccharometers.
14. Purity of steel, zinc, and cadmium.

In this long list of work there are a few items deserving of special attention.

The experiments in producing air thermometer vessels from highly refractory substances showed that the porcelain produced in the Royal Porcelain Factory could be completely fired at a temperature of 1,700°C., and that this material answered every purpose. Tests made with the water gas furnaces of Pintsch, in Fürstenwalde, proved that the smaller vessels fired in these furnaces exhibited no change of volume after firing, and the porosity of the walls had also disappeared. The temperatures were compared with those indicated by various thermo-couples. The melting point of nickel was found to be 1,484°C., of palladium 1,587°C., and of platinum 1,780 C.

A good deal of work has been done upon standards of resistance, and we have translated various reports which have appeared from time to time.* The excellence of the manganine resistance makes it possible to dispense with the mercury standards for routine comparisons.

The platinum standard of light has been satisfactorily fixed. It will be remembered that certain practical difficulties were encountered in adopting the Paris definition of the unit, viz., the amount of light emitted by 1 sq. cm. of platinum at its melting point. The Reichsanstalt defines the temperature by the proportion between the total radiation from a standard surface to the radiation transmitted by a layer of water 2cm. thick between quartz plates with a total thickness of 0·2cm. The standard temperature is taken as that at which this proportion attains the value 10:1. The radiating surface is a circle of 2cm. radius, cut off by the diaphragm. The absorbing layer of the bolometer has a total surface of 8 sq. cm., and the platinum block is prepared from a standard electrolyte, consisting of 1 part platinum chloride and 30 parts water, with the addition of one-fortieth per cent. of lead acetate. This is electrolysed at a temperature of 20°C. by a current of 0·25 ampere at 4 volts. The current is passed for 2min. Each bolometer strip is placed between two positive electrodes, so that it is blackened from two sides at a time. The bolometer, when fixed in position, is 50cm. from the diaphragm.

The above definition of the platinum black might be obviated by the preparation of an "absolutely black" bolometer, on the principle of the absolutely black radiating bodies employed by Lummer and Wien. These consist of hollow spheres or other bodies with a small opening, through which the radiation from within is allowed to emerge. Since such a body absorbs all kinds of radiation which penetrate into its interior, it answers to the definition of an abso-

* *The Electrician*, Vol. XXXVI., p. 513, 1896.



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lutely black body, and its employment provides a definite basis which is unattainable with a Leslie cube.

The Lippich polarimeter has been improved upon by the construction of a new contrast polarimeter based upon the equal contrast between the two varying patches and their common background, thereby gaining largely in sensitiveness and accuracy. The work of the Technical Department has proceeded on somewhat parallel lines, with an emphasis on the practical side of the physical questions investigated.

An important investigation was that of the vibrational inequalities of a flywheel shaft by various gyrometers, checked by the records of the writing tuning fork. It was found, as might have been expected, that the rim of a flywheel can be made to revolve more uniformly by increasing its weight; but that with the same number of impulses per revolution the vibrational irregularities of the shaft remain the same, and produce an increased strain upon the spokes.

In the testing shops, 75 standard cells, 12 accumulators, 46 galvanometers and 39 electrometers were examined. Weston cells, and other cadmium cells with a practically insensible temperature coefficient, were also tested; and when the amount of cadmium was 16·7 parts to 100 parts mercury in the amalgam, the E.M.F. was found to be 1·019 volts on the average. The important question of the disturbance of physical institutions by earth currents, due to electric railways, was elucidated by measurements of the conductivity of cement and concrete. It was found that the present mode of laying the rails gives rise to a good deal of leakage, and that the substitution of "asphalte concrete," with its high resistance and waterproof character, would be a great improvement.*

Among the other apparatus tested were 9,870 thermometers, 16 spring manometers, and 20 barometers. The thermometers were examined at a special testing station at Ilmenau. The number of medical thermometers was 8,470, and these therefore furnished the largest proportion of those sent in.

An interesting piece of work was undertaken at the instance of the Society of German Engineers. It dealt with the transmission of heat through plates of Siemens-Martin steel and through wrought iron. It was found that the amount of water evaporated in a given time by a boiler with a bottom made of these materials was practically independent of the state of the internal surface and the thickness of the plates. The amount of heat transmitted, as calculated from the simple conductivity of the iron, is from 25 to 230 times as large as the amount actually transmitted. The "transition resistance" between the hot gases and the metal on one side, and between the metal and the water on the other, is so great as to make the intermediate resistance almost vanish in comparison. The outside resistance is less when the surface is rough.

In the photometric department 56 Hefner lamps, 232 electric incandescent lamps, 110 incandescent gas lamps, 12 spirit incandescent lamps, and 4 petroleum lamps were tested. As regards the spirit lamps, they were evidently in the experimental stage as yet. The greatest luminosity was 68 "Hefners." For absorption tests the rotating sector was extensively used. It was soon found that a serious error was introduced by the adjustment being made during the rotation of the sector, and the reading taken after it had come to rest. The size of the sector could not be strictly controlled, and a method was therefore devised of determining its size during rotation.

In the course of some work on the preparation of pure zinc it was found that Lorenz's method of electrolysing the fused chloride with carbon electrodes gave very good results. Cadmium could be obtained in a state of extraordinary purity by electrolysis of the neutral sulphate and sublimation in a vacuum. The impurities do not exceed one part in 100,000.

In the workshop of the Institute, 233 pieces of work for the various departments were executed during the period covered by this report.

* See *The Electrician*, April 10, 1896, p. 788.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August 14, 1896.*

**A Submarine Torpedo Boat.**—Information comes from Baltimore to the effect that a submarine torpedo boat is now in process of construction in the yard of the Columbia Iron Works, at Baltimore, which *promises* some wonderful things. It is calculated that this boat will be able to maintain a speed of eight or nine knots per hour when submerged to a depth of 60ft. The motive power will consist of a boiler heated by petroleum, supplying steam to three triple-expansion engines capable of developing 1,800 H.P. A battery of accumulators and an electric generating set will also form part of this boat's equipment. The operation of the vessel is briefly as follows: When it is desired to go under water the smokestack is housed and the top covered over. The engines will be kept at full speed, and by turning the rudder the craft may be submerged to any desired depth. The speed is afterwards maintained by the dynamos running as motors and supplied by the accumulators which were previously charged. It is calculated that the battery plant will enable the boat to maintain a speed of twelve knots per hour for short distances. Air for the crew will be stored in reservoirs, and the supply may be replenished by a pump connected to a rubber tube terminating in a float on the surface of the water. This novel craft will be launched in September next.

**Statistics of Arc Lighting.**—The National Electric Light Association has prepared for its members a preliminary report on arc-lighting statistics. The report embraces about 400 cities and towns of the United States having a population of 5,000 or more. The figures are very interesting. It shows that the rates in four cities are more than $180 per year, while in one it is above $170. In five the rates are between $170 and $160; in six between $160 and $150; in nine between $150 and $140; in ten between $140 and $130; and so on down the list until it comes to the lowest prices, which are between $40 and $50 in nine cities. These prices are, of course, for arc lights. The statistics thus supplied will be of great value to electric lighting interests.

**Utilising Old Horse Cars.**—When the trolley system was introduced in the various cities in Connecticut, the question arose as to what disposition could be made of the old horse cars. These vehicles became an incumbrance to the various street railway companies until one day a brilliant mind evolved a novel plan of utilising these once useful conveyances. What the plan was may be inferred from the fact that now all along the Long Island coast may be seen the bodies of the old cars doing service as summer cottages, hunters' camps, lodges, &c. They are found on the top of the breezy bluffs, on sandy shores, and in quiet shady nooks, affording a temporary habitation during the summer weather for families, fishermen, hunters, &c. One gentleman employs in this way four cars arranged in a hollow square. One of them he uses as a kitchen and the others as sleeping and living apartments. This use of these retired street cars has created such a demand for them that the stock has been completely exhausted.

**Convention of Edison Companies.**—The Association of Edison illuminating companies held its annual convention at the Oriental Hotel, Coney Island, on August 11th and 12th. This is one of New York's popular seaside resorts, and proved to be a very enjoyable spot for the meeting. The various committees read their reports, and papers were submitted on the selection of alternating current-apparatus for central-lighting stations, and the experience of large Edison stations in this direction. The recent developments in new underground systems and the use of cables as auxiliaries thereto were exhaustively treated, and the actual results obtained from the operation of large storage batteries in New York and Boston, and the "demand" system of charging for current also received attention by the members. Other Papers of interest to all Edison licensees were read. It has been the practice of this Association not to make public any report of the proceedings of these meetings, the discussions and Papers being used exclusively in the printed minutes for distribution among the members. The delegates were very generously entertained by the local Edison concerns, and on August 13th the General Electric Company conveyed the members in a special train to its Schenectady works, where the day was very enjoyably spent in making a tour of the various buildings of the great plant.

**Electrical Credit.**—The representatives of the electrical trade in Chicago held a meeting on July 30th to consider the advisability of organising a credit association similar to those now existing in Boston, New York and Philadelphia. A temporary organisation was effected, and a committee was organised for the purpose of drawing up by-laws, &c., for a permanent organisation.

**Meeting of Military and Old-Time Telegraphers.**—The Society of the United States Military Telegraph Corps and the Old-Time Telegraphers' Association will meet in joint session

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in Pittsburgh on September 9th, 10th and 11th next. These associations are of a social character, and hold meetings once a year in different cities. Among the members of the Old-Timers' Association are Mr. Thomas A. Edison, Gen. T. T. Eckert (President of the Western Union Telegraph Company), Mr. Albert B. Chandler (President of the Postal Telegraph and Cable Company), Mr. James D. Reid (United States Consul at Dunfermline), Mr. Andrew Carnegie, and other prominent men who were once telegraphers.

## CORRESPONDENCE.

### THE DECIMAL-METRIC SYSTEM AND NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been surprised to find that Mr. Heaviside's wise words on the choice of fitting English names for the metric units have not called forth any expressions of welcome from practical men. For the last 15 years I have used almost exclusively metric measurements in testing and constructive work; and I have always found the needlessly long names awkward to use, and I have felt them to be a defect in a system otherwise so handy. Teachers of word-lore tell us that the real soul of language is the spoken and not the written word; and truly what the people need are short, clear words which, while joining well (in speech) with our numerals, will yet keep quite distinct from one another. Now, what could be more muddling, in speaking, than *millimeters* and *milliliters*, decigrams and dekagrams? Let us set side by side with these attempts at word-building the following interesting fact. No one of the words *one, two, three, four, five, six, seven, eight* has the same vowel sound as any of its neighbours; so also are most names of units which have grown up and have outlived others by reason of their clearness, such as *inch, foot, yard, pole, perch, mile: pound, shilling, penny, ha'penny, farthing; gill, pint, quart, gallon.* In fact, by running through these one could get an almost complete list of the English vowel sounds. The consequence is that, if the words are said faintly, or are even shouted from far off, there is no doubt about the meaning. If, therefore, someone skilled in word-lore would come to our aid, and give us a set of good clear terms for dekagram, kilogram, kilometer, centimeter, and a few other such, a drawback to the use of the metric system would be taken away, and we should be saved from all risk of such a state of things as that described by your correspondent of August 21st, where practical men, by reason of the greater handiness of short names like *lieue* and *once*, continue to use stupid and confusing weights and measures.—Yours, &c.,

ALBERT CAMPBELL.

Londonderry, August 25, 1896.

### THE TEMPERATURE ATTAINED IN THE ELECTRIC FURNACE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am obliged by your letter of 24th inst., and have since seen the interesting article on "Electric Furnaces" in your issue of August 23, 1895. I do not see, however, that any record has been taken of the number of degrees of heat (Centigrade) generated in the electric furnace. It would no doubt be interesting to your numerous readers to be informed thereof, and whether it would be possible to melt strong refractory Ganister firebricks (of Sheffield make) into a liquid state, and whether it has ever and by whom and when been effected.—Yours, &c.,

EDWIN N. HENWOOD,
Naval Architect and Engineer.

22, Great St. Helens, E.C.

### BOOK RECEIVED.

"Early Work in Photography." By W. Ethelbert Henry. (London: Dawbarn and Ward. Price 1s.)

## LEGAL INTELLIGENCE.

### National Telephone Company (Limited) v. Annand.

This case was heard on Wednesday by Mr. Justice Chitty. It was a motion on behalf of the plaintiff Company for an injunction to restrain the defendant till judgment in the action from using or communicating in breach of confidence and to the detriment of the Company any information obtained by him while in their service; and restraining him from cutting, destroying or damaging any of the telephone wires or posts of the Company.

Mr. BAKER, for the plaintiffs, stated that the defendant had been employed by the Company as wayleave officer, his business being to obtain permission for carrying their wires over private property, and he had been for over twelve months acting in that capacity. The District Superintendent on the 23rd of July last gave him notice to terminate his engagement on the 30th; and thereupon he wrote to the General Manager, asking that the matter might be looked into and re-considered. The General Manager, however, refused to interfere with the decision of the District Superintendent; but he offered the defendant a situation as canvasser, at a salary of 25s. a week. In the letter to the General Manager the defendant intimated that if the decision was not re-considered he should assume an attitude of bitter antagonism to the Company; and since then he had threatened to cut down the wires unless a certain rent was paid for the wayleaves he had obtained for overhead wires.

The DEFENDANT, in answer to the Judge, said he had filed no evidence; and his LORDSHIP said he could not allow him to make a statement except it was covered by evidence.

After some discussion, in which the defendant was ruled out of court,

His LORDSHIP said he must grant an injunction until judgment or further order.

Mr. BAKER: I would suggest to the defendant that if he would submit to a perpetual injunction we would not ask for costs against him.

Mr. ANNAND: No; I cannot do that.

His LORDSHIP: Then there will be an undertaking in damages against the defendant, and an order in terms of the notice of motion until trial or further order. I warned the defendant at the outset. The result is that the case stands wholly undefended, and the inference to be drawn is that the information was obtained in the way suggested by the plaintiffs; but the whole question will be opened, of course, at the trial.

Order accordingly; plaintiffs' costs to be costs in the action.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged is quite up-to-date, and includes the new Board of Trade Regulations**

### NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the atest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

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TENDERS INVITED.—The Edinburgh Town Council invites tenders for supplying and erecting at the electricity supply station, Torphichen-street, (1) coil hoist, gantry and capstan, (2) coal hoppers, measuring gear, and shoots, and (3) hauling gear in coal store. Specifications, &c., may be obtained from the resident electrical engineer, 5, Dewar-place, and tenders must be sent in to the Town Clerk (Mr. Thomas Hunter, W.S.), City Chambers, Edinburgh, by September 22nd. Further particulars appear in our advertisement columns.

——— The Blackpool Corporation requires tenders for the supply, laying and maintenance of high-tension and low-tension lead-covered cables and the supply of all necessary jointing materials. Specifications, &c., may be obtained from the borough electrical engineer (Mr. Robert C. Quin), and tenders should be sent to the Chairman of the Electric Lighting and Tramways Committee, Corporation Electricity Works, Blackpool, by September 8th. Additional particulars are given in our advertisement columns.

——— The Cork City Council invites proposals from persons willing to carry out the terms of Cork Provisional Order (1896). Offers to the Town Clerk (Mr. Alexander M'Carthy), Municipal Buildings, Cork, by 11th September.

——— The Oldham Town Council invites tenders for extending the electricity supply station building. Tenders to the Town Clerk, Town Hall, by September 16th.

——— The Brigg District Council invites tenders for the lighting of the town for the forthcoming season or for a number of years. Tenders to the Clerk (Mr. G. S. Sawter), Council Offices, Brigg, by the 31st inst.

——— Tenders are invited by the municipal authorities of Motril (Granada), Spain, for the concession for the electric lighting of the streets for 99 years. Tenders to El Secretario del Ayuntamiento de Motril (Granada).

——— The Consul-General of the South African Republic requires tenders for the supply of copper wire and insulator arms for iron telegraph poles for the Telegraph Department of the Republic. Tenders for the wire should be sent by September 1st, and for the insulator arms by September 6th to Doelenstraat, Amsterdam.

TENDERS RECEIVED.—Ten tenders have been received by the Town Council for the supply of cable for the electric light extensions in Overgate, Wellgate and Whitehall-street. The electrical engineer (Mr. W. H. Tittensor) and the Convener of the Gas Committee have been requested to prepare a report upon the matter.

APPOINTMENTS VACANT.—From our advertisement columns it will be seen that the Hammersmith Vestry requires a resident engineer to supervise (under the consulting engineer) the erection of the electric lighting plant, and afterwards to undertake the management and control of the electric light department. Salary £200 per annum, to be increased to £250 when the installation is in working order. Applications must reach the Vestry Clerk (Mr. W. P. Cockburn), 57, Fulham Palace-road, Hammersmith, London, by 4 p.m. on September 2nd.

——— The Blackburn Town Council invites applications for the appointment of assistant engineer at the electricity works. Salary £125 per annum. Applications to the Town Clerk (Mr. Robert E. Fox), Town Hall, Blackburn, by September 18th. Further particulars appear in our advertisement columns.

——— A Science Demonstrator is required by the Liverpool School Board. Salary £100 per annum, rising to £120. Applications to the Clerk to the Board (Mr. M. Hance), by September 8th.

PLANT FOR SALE.—Particulars are given in our advertisement columns of some electric lighting plant, consisting of a Norwich D-type dynamo, meters, switch, belting, &c., which Messrs. Lewis P. Garrett and Co., 58, Broomielaw, Glasgow, have for sale.

——— Our advertisement columns contain particulars of an electric lighting plant (consisting of a ½ H.P. gas engine, Elwell-Parker dynamo, and a battery of L type E.P.S. cells) which is for disposal. The plant can be seen at Mr. F. R. Docking's, George-street, Croydon.

BANKRUPTCIES.—The first meeting of creditors in the failure of Edward James Paterson and Charles Friend Cooper, trading as electrical engineers under the style of Paterson and Cooper, at European Works, Pownall-road, Dalston, N.E., and Prince's-mansions, Victoria-street, S.W., London, and at Glasgow, will take place at Bankruptcy-buildings, Carey-street, W.C., on September 1st, at 2:30 p.m. The public examination has been fixed for October 16th at the same place.

——— The first meeting of the creditors of George Ludwig Schultz, lately trading as iron and steel merchants under the style of George Schultz and Co., at 90, Cannon-street, E.C., will take place at Bankruptcy-buildings, Carey-street, W.C., on September 2nd. The examination has been fixed for October 13th at the same place.

LIQUIDATIONS.—A meeting will be held at noon on September 22nd, at 15, Copthall-avenue, E.C., for the purpose of receiving an account of the winding-up of the Vaughan-Sherrin Electrical Engineering Company (Limited).

——— At an extraordinary meeting of the River Plate Electricity Company (Limited) on July 31st it was decided to wind up the Company voluntarily. This resolution was confirmed on August 20th, when Mr. J. H. Duncan and Mr. T. S. Hamilton, 39, Coleman-street, E.C., were appointed liquidators. A new Company, entitled the River Plate Electric Light and Traction Company (Limited) was registered on July 7th for the purpose of purchasing the undertaking of this Company.

TARIFF CHANGES.—Under the revised tariff regulations of British Guiana, electric light machinery and apparatus, electric light wires and cables, telegraph wire and instruments, steam boilers, patterns, &c., are admitted free of duty.——Under the new tariff law of Victoria incandescent lamps, arc lamps without globes, carbons, storage batteries, transformers, are duty free. Steam engines are subject to an ad valorem duty of 15 per cent., and electroliers to a duty of 30 per cent.

LABOUR-SAVING TOOLS.—Messrs. Honeywood, Austin and Co., makers of specialities in labour-saving engineering tools, have removed to larger premises at Grove Works, Harleyford-road, Vauxhall, London.

CITY AND GUILDS OF LONDON INSTITUTE.—The programme of technological examinations of this Institute for the session 1896-97 has just been published by Messrs. Whittaker and Co. It contains a number of additions and alterations in the Institute's programme, and is on sale at 10d. per copy.

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AN ELECTRIC CLUB.—A company entitled the Electric Club (Limited) has been registered with a capital of £1,000, in £1 shares, to acquire and carry on the Electric Club, at 44, King William-street, E.C.

BELFAST.—At the last meeting of the Electric Light Committee a letter was received from the proprietors of a large printing establishment in the city, stating that they had decided to employ electric motors for working their printing machinery, and asking for a special quotation for a supply of electric current. In the absence of the Chairman of the Committee, the matter was adjourned for a week.

BELGIUM.—The executors of the late Colonel North have now decided to proceed with the construction of an electric railway along the Downs between Ostend and Middlekerke. The concession was granted about twelve months ago by the Belgian authorities, but owing to the death of Colonel North the matter has been in abeyance for some time.

BRIGHOUSE (YORKS).—For some time past the Town Council has been in treaty with Mr. A. B. Brook (a local engineer) for the acquisition of his electric lighting works. At the last meeting of the Council the Gas Committee recommended the purchase of the works for the sum of £1,535, on the understanding that Mr. Brook should continue to work the plant at his own risk until the Council had obtained electric lighting powers from the Board of Trade, and that afterwards the Council should take over the plant and pay Mr. Brook £100 per annum for the use of the overhead wires until the Corporation was in a position to lay underground mains.

DUBLIN.—The Dublin United Tramways Company, which recently acquired the electric tramways of the Dublin Southern Company, has decided to electrically equip the Clontarf section of their line. No time will be lost in carrying out the work, and it is anticipated that the section between Annesley Bridge and Clontarf will be equipped by the end of the year. The Company cannot employ electricity on their trams within the city, but powers are being sought to enable an electric line to be laid to the Pillar

EXHIBITION.—The Fourth Annual "Laundry, Sanitary, and Engineering" Exhibition is now being held at the Agricultural Hall, London, N., and among the exhibitors are the Blackman Ventilating Company, who show their complete system of rapid drying for laundries, which consists in an effective arrangement of their well-known fans. Messrs. Bagshawe Bros. and Co., of Upper Thames-street, have an effective display of their "Dodge" standard wood-split pulleys, machine beltings, &c. Messrs. Doulton, of Lambeth, have a good show of sanitary appliances and other goods for which they have earned a high reputation. The few electrical exhibits include the "Dovetail" dynamo brushes, manufactured by Messrs. F. W. Potter and Co., of Phipp-street, Great Eastern-street, E.C., which have been previously noticed in this journal. This firm also show Wing's electric fan for continuous-current, which is noiseless, and offers special facilities for being fitted vertically or in any other position to suit special varying requirements. It is claimed that the wings of this fan cannot be seen when in action, and that therefore no light is obstructed. Messrs. Potter have recently succeeded in obtaining important awards for these fans. Messrs. New and Mayne have taken the galleries at the hall, where exhibitions are given of the motor

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car in actual work, as well as the working of this firm's patent electric rudder motor which is fitted to a full-sized rowing boat, to accommodate which a long water tank has been erected. The object of Messrs. New and Mayne in selecting a Laundry and Sanitary exhibition for the display of this apparatus is, we presume, to familiarise the public with the practical nature of this device. Included in this exhibit is a model tramcar driven by electricity, which appears to receive considerable patronage from visitors to the exhibition. A number of water-raising devices in the shape of artesian well pumps, windmills, &c., are on show; and Messrs. Babcock and Wilcox have an exhibit of their well-known water-tube steam boilers. The Cape Asbestos Company, of the Minories, E.C., show a quantity of blue asbestos non-conducting mattresses or jackets for boilers, cylinders, and steam pipes, which are claimed to be rot, fire, and acid proof.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from August 19th to August 25th, with the ports of destination:—

*Argentina*—Rosario, £457. *Australasia*—Albany, £211 (telegraph material); Auckland, £35; Fremantle, £741 (including £601 telegraph material and £68 telephones); Melbourne, £1,240 (including £783 telegraph material and £296 telephone material); Perth, £10; Sydney, £320; Wellington, £30. *British Guiana*—Demerara, £20. *Canary Islands*—Las Palmas, £80. *Chili*—Boca, £255 (telegraph poles). *Denmark*—Copenhagen, £2,500 (telegraph cable): Korsör, £5,000 (telegraph cable). *France*—Boulogne, £8. *Holland*—Amsterdam, £42; Flushing, £10; Rotterdam, £40. *Hong Kong*—£12. *India*—Bombay, £35; Calcutta, £47. *Italy*—Spezia, £50. *Mauritius*—£79 (telegraph stores). *Norway*—Christiania, £50 (telegraph wire). *Portugal*—Oporto, £53 (telegraph material). *South Africa*—Cape Town, £235; East London, £255; Port Elizabeth, £43. *Spain*—Barcelona, £390; Bilbao, £7. *Sweden*—Stockholm, £105. *West Indies*—St. Lucia, £10. Total £12,370.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows:—

*Australasia*—Fremantle, £9 (bells); Launceston, £56. *Sydney*—£164 (telephone apparatus). *Spain*—Pasages, £139. Total, £368.

FIRE.—An extensive fire occurred at Charleroi last week, which is stated to have resulted in the total destruction of the extensive works owned by the Société Anonyme Electricité et Hydraulique. The damage amounted to 400,000fr., which is entirely covered by insurance.

GLASGOW.—The greater part of the last sitting of the Town Council was devoted to the consideration of the accounts for the past year of the Gas and Electric Lighting Committee. The accounts of the Electricity Department were abstracted in our last issue, and they proved to be of a highly satisfactory character. Notwithstanding the many critics of the Committee, substantial progress seems to have been made during the year. Mr. Fife, in moving the adoption of the accounts, said that the Committee felt satisfied that it was working on sound financial lines, and this opinion was verified by the results of the past year's work. A deficiency of £1,527 last year had been turned into a surplus this year of £2,580, after providing amply and fairly for depreciation and sinking fund. The Committee believed they had in the Waterloo-street works one of the best electric lighting stations for its size in the country. In order to develop its utmost producing powers the Committee, after very careful investigation, recommended that meter rents be abolished; that the charge for current be 6d. per unit for the first hour of each day, and 4d. per unit for every hour thereafter; and that the price per arc lamp be reduced from £26 to £20, the lowest in the kingdom for a continuous light of the illuminating power now furnished. Mr. Bailie Burt said the Committee ought to encourage the use of electric motors during the day. He considered that they had been set back a little by the delay in settling the question of electric tramway traction. The Committee felt that, should the Council decide to adopt electric traction, it would present a solution of this electric lighting question that could not be found under existing circumstances. If the electric lighting was to be developed, he felt that the Council would have to face a very large extension of the generating station. The question for the Committee next year would be whether they should acquire more ground, and extend the station in Waterloo-street, or institute small stations throughout the city. The settlement of the tramway traction question would to a very large extent influence the Committee in its decision. The accounts were then passed.——The deadlock on the question of electric car traction still continues. At the meeting of the Tramways Committee on Wednesday the proposal to experimentally try the overhead system of electric traction of tramway cars on the Springburn—Mitchell-street route was again under consideration. The question discussed was whether the report already submitted to the Council on the subject should be reconsidered or allowed to lie on the table until additional information had been obtained by the general manager. On a division, nine members voted for each proposal, and the convener (Bailie Walter Paton) again declined to give his casting vote.

LEEDS.—The City Council has received 35 applications for the position of clerk of works in connection with the electrical equipment of the Roundhay-Kirkstall tramways. This number has been reduced to five, from whom a final selection is to be made by the Tramways Sub-committee. The selected names are: Messrs. J. Burbidge (until recently manager of the Roundhay electric tramway), F. B. Lea, E. K. Scott, C. F. F. Smith and H. G. Sprague.

LIGHT RAILWAYS.—A conference has been held between the Board of Trade and the Light Railway Commissioners (the Earl of Jersey, Col. Boughey and Mr. Fitzgerald), for the purpose of discussing the procedure to be adopted under the new Light Railway Act. Amongst other things it has been determined that a rule should be made providing that applications for the construction of light railways should be received by the Commissioners at two stated periods, namely, May 1st and November 1st in each year. Promoters desirous of submitting schemes during the present year will have, therefore, to deposit them at the office of the Commission on or before November 1st next. The proposals must be advertised in October in a manner to be prescribed by rules, which are at present in the course of preparation, and will be issued very shortly. Mr. Bret Ince, barrister-at-law, has been appointed secretary to the Commission, and the temporary offices of the Light Railway Commission are at 8, Richmond-terrace, Whitehall.

MELBOURNE.—The Railway Department has decided to erect an electricity supply station at the Spencer-street railway station, capable of supplying current not only to the Department, but also for lighting the Parliament House, General Post Office, the Public Library, and other public buildings. The Town Council already possesses well-equipped and successful electricity works.

MOTOR CAR NOTES.—Mr. Walter Bersey, electrical engineer, of Victoria-street, London, was summoned at Westminster Police Court on Wednesday for working a motor car at a greater speed than two miles an hour, and for failing to have it preceded by a person on foot. Defendant pleaded that he was electrical engineer to the Motor Car Club, and was under the impression that the new Act had come into operation. The Magistrate thought it was an important prosecution. People must learn that they could not drive motor cars in the streets except under stringent regulations. Mr. Bersey was fined 40s. and costs.

PORTSMOUTH.—The Special Committee recently appointed by the Town Council for the purpose of considering the question of improving the local tramway service has presented a report in which the Council is recommended to apply for a Provisional Order to authorise the purchase of the undertaking of the Provincial Tramways Company. The purchase price of the lines, rolling stock, &c., of the Company is put at £60,000, while the cost of equipping the lines electrically is estimated at about £90,000, making a total of £150,000. It is proposed to relet the lines to the Company at a rental which would allow of a profit. The Corporation would supply the necessary electric current to the Company for working the tramways, and it has been suggested that current should be supplied at the rate of 1½d. per unit.

SOUTHPORT.—An exhibition of alternating-current arc lamps, motors, &c., is being held this week in the Assembly Room of the Cambridge Hall. The exhibition has been organised by the Electricity Committee with a view to creating a greater demand for current for cooking and heating purposes. The present charge for current for motors and heating apparatus is 4d. per unit.

TELEPHONE TRUNK LINES.—The Postmaster-General notifies an extension of the time allowed for conversation on the trunk telephone lines, from three minutes to six minutes in certain cases. These cases include that of a Post Office subscriber who has a deposit account, who can secure the uninterrupted use of the trunk circuit by asking for possession for six minutes, a double fee being chargeable to his account. A National Company subscriber can exercise the same privilege on payment of the double fee. Where no request for extra time is made at the commencement, the operator is instructed to notify the subscriber of the expiry of the time for which payment has been made, and the subscriber is then allowed to continue the conversation for a second period on payment of the double fee. This new regulation will obviate the exasperating practice of cutting off the subscriber during conversation without notice, as the controlling operator is now officially instructed to notify that the connection is about to be severed. It is important to observe that the privilege of a six minutes' conversation does not apply to a "Call Office" call. Six minutes is the maximum period for which the use of the trunk circuit can be claimed. Trunks to which, however, the new six minutes' regulation does not apply are London-Paris (1 and 2), and London-Glasgow (1 and 2).

TRAIN LIGHTING.—The Caledonian Railway Company is making experiments in train lighting, and has fitted up one of the trains on the new Central Railway for the electric light.

VENTNOR (ISLE OF WIGHT).—Messrs. Edmundsons have submitted a proposal to the District Council for introducing the electric light into the town. It is suggested that the Council should obtain a Provisional Order, and transfer it to the firm,

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who undertake to bear all Parliamentary and other costs in connection with the Order. Messrs. Edmundsons have been invited to meet the Council, in order to further discuss the proposal.

WOLVERHAMPTON.—The half-yearly meeting of the local gas company was held on Tuesday. The Chairman (Mr. H. Ward) referred to the competition of the electric light, and spoke in a hopeful strain of the future. The use of gas engines was increasing largely; they had also a good demand for gas for cooking purposes, and consequently he thought the electric light would not hurt them much. This view, however, did not seem to meet with the approval of some of the shareholders, one of whom strongly protested against what he called the unnecessary interference with the Company by the Corporation in adopting the electric light. It was very hard and contrary to the principles of justice, for if the "new" light were a success it would be the Company's loss, and if it were a failure they would still have to bear the cost.

WREXHAM.—The Town Council has decided to apply for a Provisional Order.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

August 1, 1896.

17,124. H. H. LAKE. London. Improvements in and connected with conduits, more especially suitable for electrical conductors. (E. T. Greenfield, United States).*

17,125. H. H. LAKE. London. Improvements in conduit tubes more especially suitable for electrical conductors. (E. T. Greenfield, United States.)*

August 4, 1896.

17,161. S. HAMMACHER. London. The manufacture of an improved active material for the plates or electrodes of electric accumulators.

17,180. W. L. WISE. London. Improvements in combined typewriters and electro-telegraphic transmitters. (World Flash Co., United States.)*

17,187. C. D. TISDALE and J. D. GOULD. London. An improved electric cable or conductor for electric fire or other alarm systems.*

17,200. W. L. WISE. London. Improvements in and in connection with supports for electric lamp. (F. E. Kinsman, United States.)

17,203. H. B. GALE and C. T. THOMPSON. London. Improvements in methods and means for electric regulation of power.*

17,222. C. DE RICARIS. London. Improvements in portable telephones.

August 5, 1896.

17,257. E. BATAULT. London. Improvements in electric meters.

17,338. E. JOKL, W. M. CHRISTIAN, and G. KENT. London. Improved device for automatically throwing into circuit reserve electric lamps, motors, or resistances in case of breakdown, and for protective purposes.

August 6, 1896.

17,346. F. F. E. HEYSE and W. H. AKESTER. London. Improvements in or connected with secondary or storage batteries.

17,363. R. KENNEDY. Bradford. Improvements in electromotors.

17,389. A. T. SNELL. London. Improvements in electric rock drills, caulking, tools, and other reciprocating machines.

17,395. L. ANDREWS. London. Improvements in magnetic cut-outs.

August 8, 1896.

17,557. S. Z. DE FERRANTI. London. Improvements in continuous-current dynamo electric generators and motors.

17,558. S. Z. DE FERRANTI. London. Improvements in dynamo-electric generators and motors.

17,563. T. MEACOCK. London. Improvements relating to electric traction.

17,577. G. K. B. ELPHINSTONE. London. Improvements in electrical measuring instruments.

17,578. G. K. B. ELPHINSTONE. London. Improvements in electrical signalling apparatus.

17,579. D. MCL. THERRELL. London. Improvements in electric railway systems. (Date applied for under Patents, &c., Act, 1883, Section 103, January 9, 1896, being date of application in United States.)

17,608. THE COWPER-COLES GALVANISING SYNDICATE (LIMITED) and S. O. COWPER-COLES. London. Improvements in means or apparatus for effecting the electro-deposition of zinc or other metals upon tubes or other circular or analogous objects.

August 10, 1896.

17,640. E. SMITH. Blackburn. Auto-electric pneumatic action for organs.

17,643. R. A. SMITH and F. G. B. GREEN. Glasgow. A pocket electric lamp for use by surgeons and the like.*

17,657. H. KORTEN. London. Improvements in electrical indicators.

17,659. E. F. JONES. London. Receptacle for electric and other wires.

17,661. F. JONES. London. Improvements in electric pendulum indicators.

17,666. H. F. PARSHALL. London. Improvements in automatic maximum speed governors for electrically-propelled vehicles.

17,671. L. HOEPFNER. London. An improved method for obtaining porous metals by electrolysis.

17,701. H. EDMUNDS. London. Improvements in electrical switching apparatus.

August 11, 1896.

17,818. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED). London. Improvements in dynamo-electric machines. (D. P. Thompson and A. H. Armstrong, United States.)*

August 12, 1896.

17,832. H. G. COTSWORTH. Wimbledon. Improved arrangement for lowering the globes of arc and other lamps.

17,846. THE TELEGRAPH MANUFACTURING COMPANY (LIMITED), and J. TAYLOR. Warrington. Improvements in telephone switchboard plugs.

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

13,303. PELLETT. Arc lamps.

13,438. STAMM. Electric annunciators.

13,702. PIEPER. Apparatus for regulating electric currents.

14,134. LANGDON-DAVIES. Rapid telegraphic transmission on cable lines.

15,889. LA SOCIÉTÉ LES FILS D'ADOLPHE MOUGIN. Electric arc lamps. (Dated February 11, 1895.)

16,042. NORMAN. Compound electrical testing switch.

16,450. SYKES. Arc lamps for alternating currents.

16,491. LAKE (Goodwin). Supports for overhead electric conductors.

16,794. EVERSHED. Calibration of electric measuring instruments.

17,058. BERRY. Periodically ringing bells, and electrical apparatus therefor.

17,400. WOOD AND BRODIE. Electric tramways.

17,481. BEST. Electroliers.

17,526. BERRY. Electrical transformers.

17,655. DRAKE and GORHAM. Secondary batteries.

17,656. DRAKE and GORHAM. Spring-contact switches.

21,638. FIELDING. Electrical switches.

22,505. DANNERT, WINDOLFF AND ZACHARIAS. Active material for electric accumulators.

1896.

3,690. SHUTTLEWORTH. System of supplying power to electrically-propelled vehicles.

8,163. MESMER-WEBER. Alarm clock for automatically operating electric signals at definite hours.

9,480. KROTZ, ALLEN and KELLY. Collector for conduit electrical railways and the like.

11,419. FITZPATRICK (The Empire Self Lighting Oil Lamp Company). Electrically lighting oil lamps.

12,345. NAGLO. Automatic apparatus for the working of telephone stations.

13,074. MARQUAND and LOWDON. Electrical resistances.

13,079. THOMPSON (LESENBERG). Dry batteries, &c.

13,263. PREECE. Holders of electric lamps, &c.

13,295. THOMPSON (McBrien, Wayland and Fleming). Electrically-controlled railway signals.

13,521. JENSEN (Cappelen and Cappelen). Manufacture of carbon anodes for electrolytical processes.

# COMPANIES' MEETINGS AND REPORTS.

## Electric Construction Company (Limited).

The third annual general meeting was held at Winchester House yesterday, Sir Daniel Cooper, Bart., G.C.M.G., presiding.

The SECRETARY (Mr. James Gray) read the notice calling the meeting, the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN then said: I am happy to believe that the report and accounts your Directors have now the pleasure of presenting to you require few remarks or explanations to recommend them to your approval. The net profit for last year, you will observe, amounts to £16,450. 9s. 11d., and the Directors recommend dividends which will absorb £13,288. 0s. 5d., leaving undivided £3,162. 9s. 6d. of the profits of this year. But in addition we brought from last year undivided profits amounting to £10,134. 15s. 10d., so that, adding together the undivided profits of the two years, we carry forward no less than £13,297. 5s. 4d. I am confident this prudent and cautious policy will recommend itself to you as shareholders, and tend to establish confidence in the management of the Company. No doubt you would have preferred to receive the whole dividend at once, instead of, as

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your Directors propose, one-half now and the other half six months hence; but I think I shall be able to convince you that the proper course has been recommended. Shareholders nowadays dislike to wait so long as a year without touching any return for their money, and there is in consequence a pressure on boards to make half-yearly distributions. Now in a business such as ours, it is not always easy to determine whether the results of the first half of the financial year justify payment of an interim dividend, and the Directors may find themselves in this embarrassing position—they may be too sanguine and pay an interim dividend in anticipation of profits which are not realised, or they may be over-cautious and seriously prejudice the position of the Company by declining to pay a customary interim dividend, which the accounts when made up at the end of the year show would have been fully justified. Again, it is more convenient for the finances of the Company to divide the payment of the yearly dividend instead of having to make provision for the payment of the whole in one sum. These, gentlemen, are the reasons which influenced your Directors in proposing to postpone for six months the payment of the second half of the dividend; and when the object is to establish on a sound basis the system of half-yearly dividends, I trust you will cheerfully adopt our recommendation. Coming now to the figures of the profit and loss account, you will be gratified to observe a large increase in the manufacturing profit. I do not see why this increase should not go on, for since Mr. Blackburn has been in command at Bushbury the factories have steadily increased their output, and at the same time the work has proved more remunerative. Then the use of electricity is developing more and more rapidly, and we mean to maintain and strengthen our hold on the business by the superior quality and moderate price of our manufactures. The other sources of income show a decrease, but this is partly due to the conservative policy pursued by the Board. Turning now to the expenditure side of the account there is a moderate increase, chiefly in the charge for salaries, which I ought to explain includes the engineering staff at Bushbury, as well as the management both there and in London. Success in electric engineering depends largely on having the best talent available, and we must, of course, pay to secure it. But this branch of expenditure will not probably increase to any important extent, certainly not in proportion to the recent growth of the business; and the percentage of standing charges on the work turned out, largely made up of this item, will, in consequence, go on decreasing, and thus the margin of profit will be maintained even if prices should go lower. There is no material change in the balance sheet, as compared with last year. You will observe that we have expended about £7,500 in enlarging our buildings and in new plant. These outlays were to avoid overtime, which is always unprofitable, and also to enable us to provide for more work and meet the demands of our customers promptly as well as efficiently. I believe this expenditure will yield a good return in the saving of overtime, for which we have to pay an extra rate of wages, while naturally labour during overtime is not so effective as in the regular hours. We again appropriate £5,000 of the year's profits to depreciation account. This, although a serious burden in the present, will strengthen the Company's position in the future. The amount at the credit of this depreciation account is now £13,000, while at the same time we have, out of the profits of the year, replaced tools worn out and maintained the works in first-rate condition. The large increase on the item "work in progress" is not due to machines going into stock, but to increased orders, and the difference is some indication of the larger quantity of work now turned out by the factories. We have not yet been able to realise some of our interests in other companies, as we had rather expected to do; but the position of this account, as a whole, has improved during the year. We are exercising patience, and do not intend to sacrifice any of our assets by forcing them prematurely on the market. I think I have now dealt with all the items which seem to me to invite comment, and I shall now offer some general observations on the business. The Directors are happy to report that they are on the best terms with the staff and workpeople at Bushbury. This the Directors consider essential to the success of the business, as well as to comfort in carrying it on. In each of the last two years the Directors have, in token of their appreciation of good and zealous service, distributed a bonus among all the staff and employés who have been twelve months in the service of the Company, and the Directors believe that this recognition has had a beneficial influence throughout the establishment. The Directors will watch the results closely, and hope to be confirmed in their present conclusion. The factories have been full of work throughout the year, and there are now as many orders on the books as we care to have. In consequence of the keenness of competition for the supply of electrical plant the margin of profit is by no means large, and we must depend a good deal for our dividend on increased economy in production; and this, combined with excellence in design and high quality of workmanship, are the great objects aimed at throughout our establishment. I believe we have as fine, if not the finest works of the kind in the United Kingdom, and they are favourably located for obtaining material and transport on the most advantageous terms. With such advantages, I think you are entitled to expect that your establishment should hold its own against all comers. I am very pleased also to inform you that our manufactures maintain their high reputation. Where an industry is rapidly developing and new special machines have constantly to be designed to meet new requirements, there is great scope for the skill and ingenuity of our staff, and, I am glad to say, they are proving themselves equal to all reasonable demands. It is our policy to spare no effort to secure the confidence of our customers by giving them full satisfaction in the execution of their orders, and, judging by the results, our efforts have been attended with a large measure of success. Gentlemen, I conclude my remarks by observing that the Company is prospering, and that I know no reason why its prosperity should not go on increasing. I beg to move—

"*That the accounts and the report with the recommendations therein contained now submitted by the Directors be approved and adopted.*"

The DEPUTY-CHAIRMAN (Mr. J. W. Barclay) seconded the motion, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Dr. DALE, the retiring Directors, Sir Henry C. Mance, C.I.E., and Mr. Philip Beachcroft were re-elected to their seats at the Board.

The auditors (Messrs. Jas. Meston and Co.) having been reappointed,

The DEPUTY-CHAIRMAN, replying to a vote of thanks accorded to the Chairman and his co-Directors, said that there was no doubt that for the last two or three years the Company had had a very stiff fight, and had come through very great difficulties. Nobody knew better than himself how much they were indebted to the Chairman for the public-spirited manner in which he had come forward to help the undertaking out of its difficulties. If it had not been for that public-spirited support the Company would not have been in its present flourishing position. They had steadily progressed, particularly since the reconstruction of the Company. The management at Bushbury had the complete confidence of the Directors. In their manager, Mr. Blackburn, they had the right man in the right place. They had for the last two years given the men at the works what was to them a substantial bonus. He thought that that was a sound policy to carry out. When strikes occurred in connection with any concern such as theirs, it meant ruin both to workmen and shareholders. He hoped by their general policy that the Board would be able to build up a business which would not only be profitable to the shareholders and satisfactory to the workmen, but a credit to the Directors.

The proceedings then ended.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**NORTHERN ELECTRICAL ENGINEERING AND PLATING COMPANY (LIMITED).**—This Company was registered on August 24th, with a nominal capital of £1,000, in £1 shares, to carry on the business of electrical and general engineers, electroplaters, machinists, millwrights, wire drawers, metallurgists, galvanisers, enamellers, &c. The first subscribers, with one share each, are:—G. E. Spenceley (engineer), Mrs. Caroline Spenceley, R. W. van der Ben (engineer), D. Mackenzie, W. G. van der Ben, T. A. Gurr, and A. S. Fraser.

**J. C. HOWELL (LIMITED).**—The annual return to April 28th has been filed. Seven shares have been taken up out of a capital of £10,000, in £1 shares, and no calls have as yet been made thereon.

**KENNEDY STORAGE BATTERY COMPANY (LIMITED).**—Notice is given that this Company will be struck off the register unless the necessary returns are filed within three months.

**KESWICK ELECTRIC LIGHT COMPANY (LIMITED).**—The annual return to May 1st has been filed. 3,420 shares have been subscribed for out of a capital of £5,000, in £1 shares, and the full amount has been called and paid.

**LARNE ELECTRIC LIGHT WORKS (LIMITED).**—The statutory return to July 3rd has been filed. The nominal capital is £4,000, in 500 Five per Cent. Cumulative Preference and 3,500 Ordinary shares of £1 each. 105 of the former and all the latter have been taken up, and the Ordinary have been issued as fully paid. The full amount has been called and paid on the Preference shares.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30$\frac{1}{16}$d. per oz. (Aug. 27th). Consols (2$\frac{3}{4}$ per cent.) 112$\frac{1}{4}$—112$\frac{7}{16}$ for money, 112$\frac{1}{16}$—112$\frac{3}{16}$ for account; 2$\frac{1}{2}$ per cent. 107$\frac{3}{4}$—108$\frac{1}{4}$ (Aug. 27th). Stock Exchange Settling Days: Consols, Sept. 1st; Stocks and Shares Continuation Day, Sept. 14th; Ticket Day, Sept. 15th; Pay Days, Aug. 28th and Sept. 16th; Mining Share Carry-over Day, Sept. 12th.

**CITY AND SOUTH LONDON RAILWAY.**—The traffic returns of this Company for the week ended August 23, 1896, were £969, against £875 in the corresponding week of 1895, an increase of £94. The total receipts for the half-year amount to £7,498, against £6,883 for the corresponding period of 1895, an increase of £615.

**KNIGHT AND CROWTHER (LIMITED).**—The annual meeting of this Company was held last week at Birmingham. The Chairman (Mr. T. Tempest Radford) congratulated the shareholders on results which they did not anticipate even two or three months ago. A dividend at the rate of 6$\frac{1}{2}$ per cent. on the Preference and 7$\frac{1}{2}$ per cent. on the Ordinary shares was declared.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 23rd inst. amounted to £1,363. The amount for the corresponding week last year was £1,318. Increase, £45.

**LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—The half-yearly coupons, due September 1st, of the £100,000 Six per Cent. Debentures of this Company, will be paid by Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, London, E.C., on and after that date. Coupons must be left three clear days for examination.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the week ended August 21, 1896, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,605.

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# COMPANIES' SHARE LIST.

| PRESENT AMOUNT. | AMOUNT OF SHARE. | LAST DIVIDEND. | NAME. | PREVIOUS WEEK'S PRICE AUGUST 19. | Price Wednesday, August 26. | RATE PER CENT. YIELDED. | DIVIDEND DUE. | BUSINESS DONE DURING WEEK ENDING AUGUST 22. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS.** | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 52 54 | 52 54 | 4 12 7 | Jan., Apr., July, Oct. | .. | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 97½ 98½ | 97½ 98½ | 5 1 6 | " " | 98½ | 97½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 9 9½ | .. .. | " " | .. | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 4 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ 9½ | 8½ 9½ | .. .. | .. .. | 8½ | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15½ 15⅝ | 15½ 15⅝ | 4 8 11 | Mar., June, Oct., Dec. | 15⅝ | 15⅞ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 6 7 | June and December | .. | .. |
| 19,000,000 | $100 | 7% | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 2 9 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ 13½ | 12½ 13½ | 5 18 6 | February and August | — | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20 21 | 20½ 21½ | 4 13 0 | " " | .. | — |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ 4½ | 3½ 4 | 5 0 0 | April and October | 20¼ | — |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107⅞ 110⅞ | 107⅞ 110⅞ | 4 2 0 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9⅞ 10⅛ | 9⅞ 10⅛ | 4 3 0 | Jan., Apr., July, Oct. | 10⅛ | 9⅞ |
| 400,000 | 10 | 5/6 | Eastern | 18 18½ | 18 18½ | 3 10 3 | " " | 18⅜ | 18⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 1 6 | " " | 19¼ | 19¼ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 3 0 3 | May and November | 133½ | 132½ |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 104 107 | 4 13 6 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 18½ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅝ | 18⅛ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 2 | February & August | 133 | 132½ |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 4 16 7 | January and July | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 100 104 | 100 104 | 4 16 7 | " " | 102½ | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 109 | 106 109 | 3 13 5 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111¾ 114¾ | 111¾ 114¾ | 3 11 2 | May and November | 112½ | .. |
| 180,227 | 10 | 3 9 | Globe Telegraph and Trust | 11¼ 11⅝ | 11¼ 11⅝ | 3 15 7 | Jan., Apr., July, Oct. | 11⅝ | 11⅜ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 18 18½ | 18 18½ | 3 5 9 | " " | 18⅝ | 18 |
| 150,000 | 10 | 5/0 | Great Northern | 23½ 24½ | 24 25 | 4 0 0 | Jan., April, and July | 24½ | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 105 108 | 105 108 | 4 14 4 | March & September | .. | — |
| 17,000 | 25 | 37/6 | Indo-European | 53 56 | 53 56 | 4 9 3 | May and November | 53½ | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | 111 114 | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | .. .. | 111 114 | .. | March & September | — | — |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 103 111 | 108 111 | 3 12 5 | " " | .. | — |
| 11,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | .. | .. |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 140 145 | 140 145 | 4 2 9 | " " | 141 | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 6 | 5 6 | 6 0 0 | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 104 107 | 104 107 | 4 15 3 | March & September | .. | .. |
| 20,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. .. | January and July | 1 | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 99 101 | 99 101 | 7 15 0 | June and December | — | — |
| 88,321 | 10 | 0/6 | West India and Panama | 1⅛ 1⅜ | 1⅛ 1⅜ | .. .. | .. | 1⅛ | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 12 | 5 0 0 | May and November | 11⅝ | .. |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 10 6 | June and December | 111 | .. |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8½ 9½ | 8⅝ 9½ | 4 17 4 | May and November | 9½ | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 7 7½ | 7 7½ | 5 0 0 | — | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 2⅝ | 2½ 2⅝ | .. .. | — | — | — |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 107 | 103 107 | 5 12 2 | February & August | — | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 107 | 103 107 | 5 12 2 | " " | — | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 3 7 | May and November | 110 | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) | 104 107 | 104 107 | 5 14 10 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chili Telephone (fully paid) | 3½ 4 | 3½ 4½ | 4 8 11 | — | .. | — |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | ⅞ 1 | ⅞ 1 | .. .. | May and November | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅝ ¾ | ⅝ ¾ | 5 14 3 | Yearly | .. | .. |
| 484,597 | 5 | 2/6 | National | 7⅜ 7⅝ | 7⅜ 7⅝ | 3 11 0 | June and December | 7⅝ | 7⅜ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | " " | .. | — |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 18 | 17 18 | 3 8 7 | " " | 17⅜ | — |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅜ 7 | 6⅜ 7 | 3 11 5 | — | 6⅞ | 6½ |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 3 9 | January and July | 108 | .. |
| 58,000 | 5 | 4/0 | United River Plate | 3⅞ 4½ | 3⅞ 4½ | 4 14 2 | July .. | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 101 105 | 104 107 | 4 14 4 | January and July | — | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| .. | 5 | — | Birmingham Electric Supply | .. .. | 8 .. | .. | .. | .. | .. |
| .. | 5 | .. | Do. | .. .. | 4⅜ .. | .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 16 17 | 16 17 | 2 18 10 | February & August | 16⅜ | 16½ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17½ 18½ | 17½ 18½ | 3 4 10 | January and July | 18 | 17⅝ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 133 137 | 132 136 | 3 14 1 | June and December | — | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | — | .. | — |
| £30,000 | £5 | 2 6 | Charing Cross & Strand Electricity Supply Corp. | 8⅜ 9½ | 9½ 9⅝ | 2 16 5 | — | 9½ | 9 |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — — | — — | .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. | — | .. | — |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 13½ 14 | 13¾ 14¼ | 4 4 3 | — | 13⅛ | .. |
| 8,322 | £5 | .. | House-to-House Electric | — — | .. .. | .. | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. | January and July | — | — |
| 111,000 | 5 | .. | London Electric Supply | — — | ⅜ 1⅛ | .. | — | — | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13½ 13⅝ | 13½ 13⅞ | 2 18 2 | — | 13⅝ | 13½ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 119 123 | 120 123 | 3 13 4 | June and December | 121½ | 121 |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 11 12 | 11½ 12½ | .. | — | 12 | — |
| .. | .. | .. | Rand Electric | — — | 1⅛ 1⅜ | .. | — | — | — |
| 19,980 | £5 | 2/6 | St. James and Pall Mall | 12½ 13½ | 12 13 | 2 19 8 | — | — | — |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 6 8 | — | 10½ | .. |
| 59,900 | 5 | 3/0 | Westminster Electric Supply (fully paid) | 11 12 | 11 12 | 2 18 4 | — | 11⅞ | 11⅝ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1 1½ | 1½ 1⅝ | .. | — | — | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅝ 1⅞ | 1⅝ 1⅞ | .. | — | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 112 115 | 112 115 | 3 19 9 | March & September | 112⅜ | — |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) xd | 1⅞ 2¼ | 1⅞ 2¼ | 6 13 4 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 5 1 | January and July | — | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. — | .. .. | .. | — | — | — |
| 110,000 | 2 | .. | Electric Construction | 1⅝ 1⅞ | 1½ 1⅝ | .. | — | 1⅞ | 1⅝ |
| 12,845 | 2 | 2/9⅜ | Do. 7 per Cent. Cumulative Pref. | 2⅜ 3½ | 2⅜ 3½ | 4 6 2 | September | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ ¾ | ¾ 1 | .. | — | ¾ | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. | — | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 22 23 | 21 23 | 4 6 11 | February & August | 22½ | 22⅛ |
| £200,000 | 100 | 4% | * Do. 4 per Cent. Debentures | 107 110 | 107 110 | 3 12 9 | March & September | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | .. .. | ⅞ 1 | .. | — | — | — |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 39 42 | 39 42 | 4 5 9 | March and July | 41⅞ | 40½ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 102 105 | 103 106 | 4 15 0 | January and July | .. | .. |
| £100,000 | 10 | 10/0 | W. T. Henley's Telegraph Works Ordinary | 17½ 18½ | 18 19 | 4 10 1 | March & September | 18⅜ | 18 |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 11 10 | " " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 112 117 | 1·2 117 | 3 16 11 | February & August | 115 | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1⅞% | City and South London Railway Con. Ordy. | 46 48 | 50 52 | 2 8 0 | January and July | 49½ | 48½ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15½ | 14½ 15½ | 3 6 8 | " " | .. | — |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 138 | 136 138 | 2 18 0 | May and November | 138½ | — |
| 37,500 | £10 | .. | Liverpool Overhead Railway | .. .. | 13½ 13⅝ | 2 8 7 | — | — | — |
| 10,000 | 10 | 5% | Do. 5% Preference | .. .. | 16⅞ 17⅜ | 2 17 7 | — | — | — |
| 125,000 | Stock | 4% | Do. 4% Debenture | — — | 112½ 114½ | 3 9 10 | January and July | — | — |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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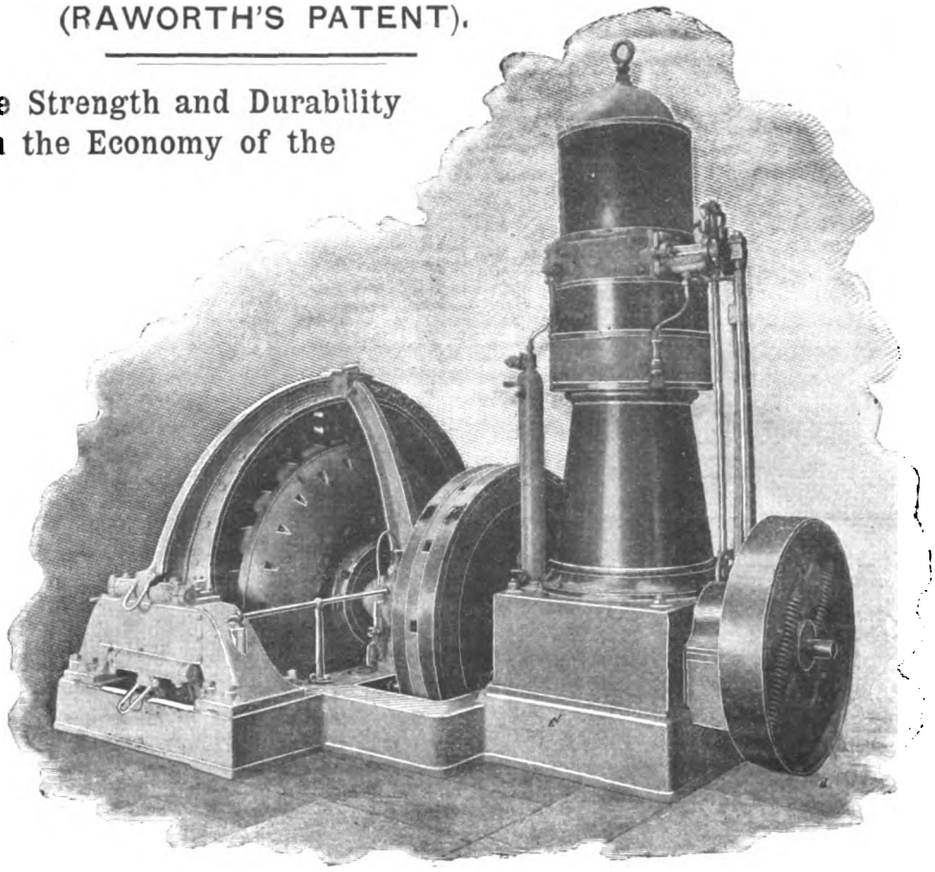
# THE UNIVERSAL ENGINE

(RAWORTH'S PATENT).



This Engine combines the Strength and Durability of the Corliss Engine with the Economy of the High Speed Engine.

••••••••••••••••

***Small Space,***
***Small Cost,***
***High Efficiency,***
***Perfect***
***Governing.***

••••••••••••••••

*For Prices and Particulars apply to*

THE

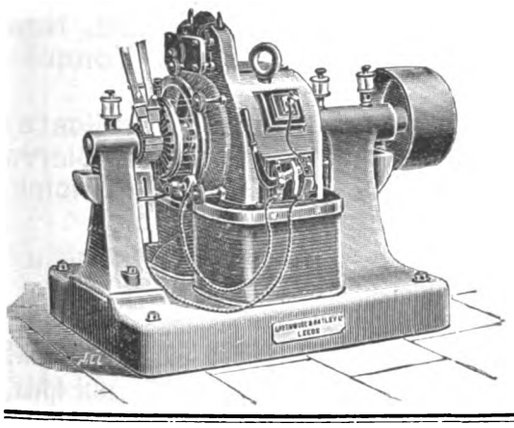
## BRUSH ELECTRICAL ENGINEERING CO.

LIMITED,

49, Queen Victoria Street,

**LONDON, E.C.**

# GREENWOOD & BATLEY, Ltd.,



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## General Electrical Engineers.

MANUFACTURERS OF

**ALTERNATORS, INCANDESCENT and ARC-LIGHT DYNAMOS for ELECTRIC LIGHTING, ELECTRIC MOTORS for Tram Cars, MINING MACHINERY and as applied to Machine Tools.**

**FACTORY ENGINES and HIGH-SPEED ENGINES for Electrical and other Purposes.**

*MANUFACTURERS of SPECIAL and GENERAL TOOLS for ELECTRICIANS.*

London Office: 16, GREAT GEORGE ST., WESTMINSTER, S.W.

## UNDERGROUND MAINS.

# CALLENDER'S CABLE & CONSTRUCTION CO., LTD.

MANUFACTURERS OF

## ELECTRIC LIGHT CABLES, MAINS, CONDUITS AND ACCESSORIES.

**Engineers and Contractors. Ironfounders and Coppersmiths. Makers of Lead Tube and Pipes. Bitumen Refiners**

**Head Office: 90, CANNON STREET, LONDON, E.C.**

Telephone No. 15133. Telegraph Address: "CALLENDER LONDON."

**Factory—ERITH MARSHES, KENT.**

**LIVERPOOL—Oldham Place, Renshaw Street.** **BIRMINGHAM—58, Water Street.**

**NOTTINGHAM—King John's Chambers, Bridlesmith Gate.** **GLASGOW—Great Western Road, Kelvinside.**

Also Contractors for underground Mains at ABERDEEN, COATBRIDGE, BURNLEY, LANCASTER, HUDDERSFIELD, SHEFFIELD, HULL, OXFORD, HANLEY, CHELSEA, &c., &c.

The CALLENDER COMPANY is prepared to undertake the laying of Underground Mains, including all excavation and reinstatement of paving, building boxes, feeder points, or transformer chambers, erecting lamp posts, pillars and all other accessories required for the complete equipment of the distribution network of a Central Station, for either HIGH or LOW TENSION with CONTINUOUS or ALTERNATING CURRENTS —

1. **With Vulcanised Bitumen Cables laid solid in Bitumen.**
2. **Or Drawn into CALLENDER-WEBBER or CALLENDER-RAWORTH Conduits, or into Pipes.**
3. **With Lead-Sheathed Cables either Single Conductor, Concentric, or Triple Concentric, armoured and laid direct in the earth.**


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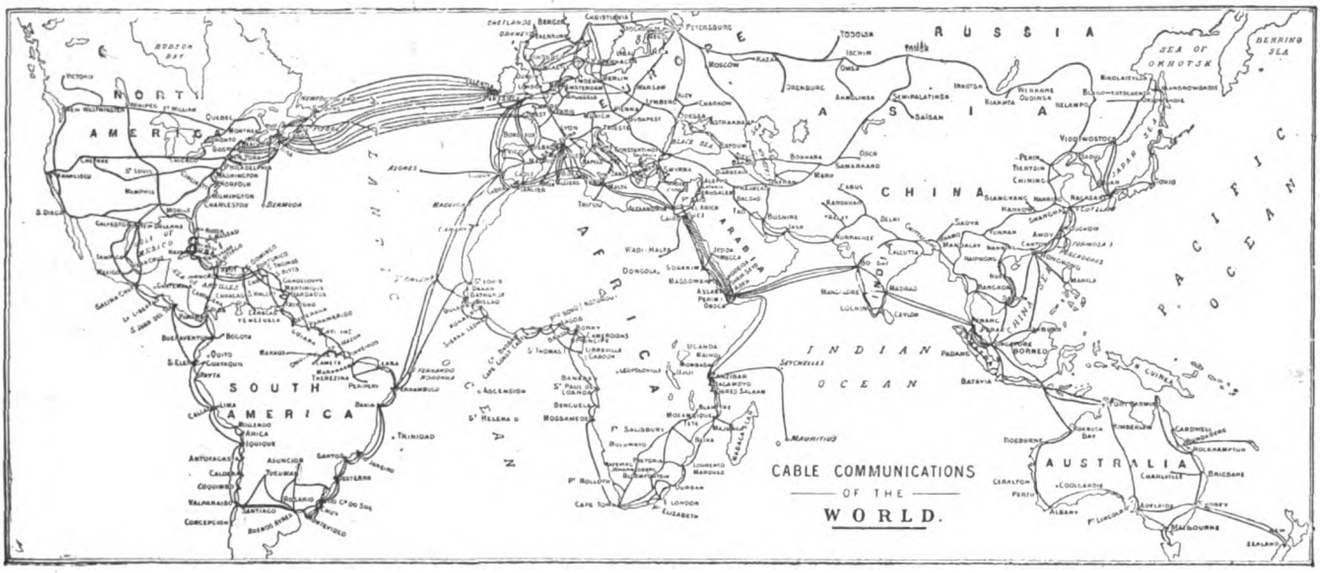
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

# EASTERN TELEGRAPH COMPANY

IN CONNECTION WITH THE (LIMITED),

EASTERN EXTENSION (AUSTRALASIA AND CHINA), BRAZILIAN SUBMARINE, EASTERN AND SOUTH AFRICAN, EUROPE AND AZORES, WEST AFRICAN AND AFRICAN DIRECT TELEGRAPH COMPANIES.

By DIRECT TRIPLICATE CABLES, to Spain, Portugal, Gibraltar, Malta, Egypt, Aden, and India.

By DIRECT DUPLICATE CABLE ROUTES to Madeira, St. Vincent, Brazil, Argentine Republic, Uruguay, also to Peru, Chili, and other parts of South America; and to Suakin, Perim, Penang, Malacca, Singapore, Labuan, Java, Australia, New Zealand, Tasmania, New Caledonia, Bangkok, Cambodia, Saigon, Tonquin, Hainan, China.

By ALTERNATIVE CABLES to Zanzibar, Mombasa, Mozambique (duplicate) Lourenço Marques (Delagoa Bay), Durban and Capetown; Bathurst, Sierra Leone, Accra, Lagos, Bonny, Bolama, Bissao, Cameroons, St. Thome, Principe, Loanda, Benguella, Mossamedes, Conakry, Grand Bassam, and Gaboon.

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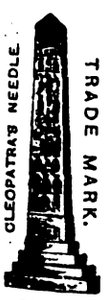


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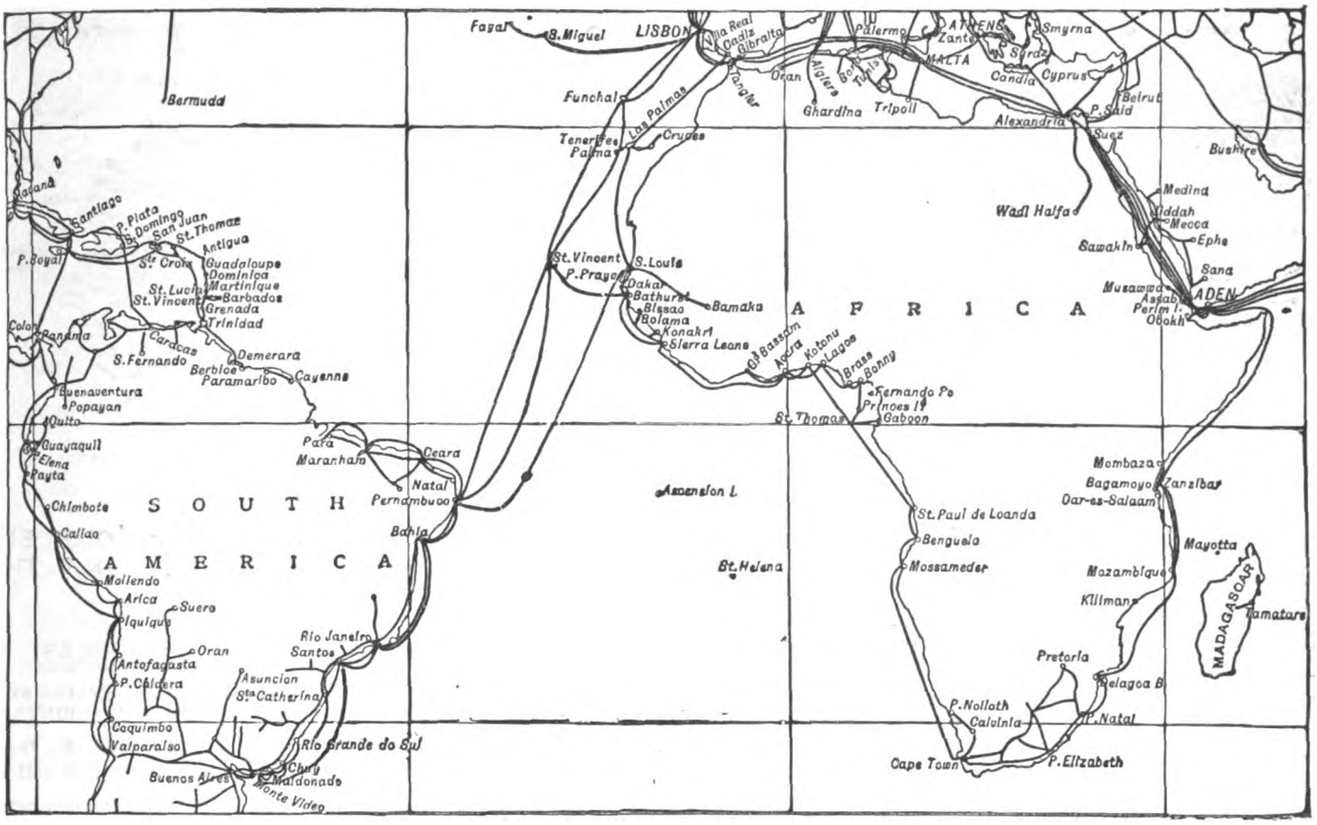


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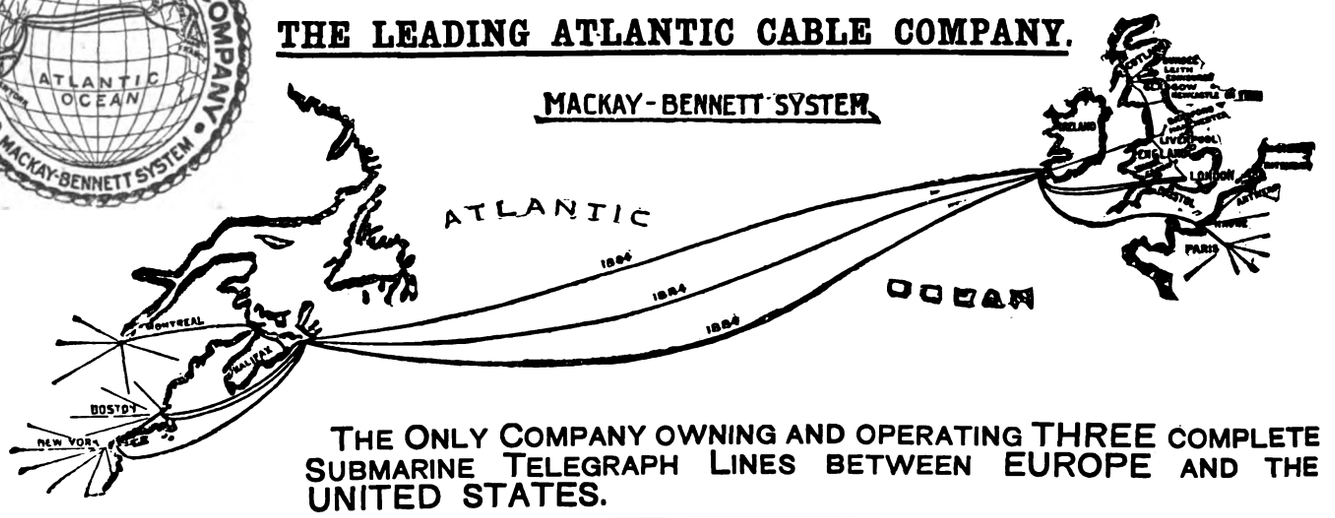


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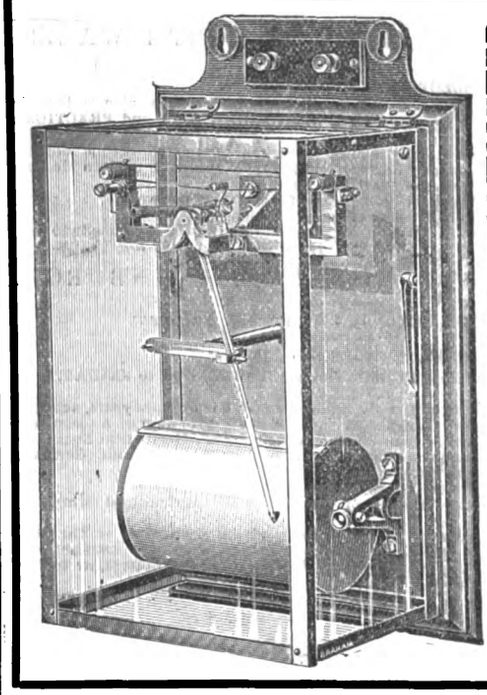

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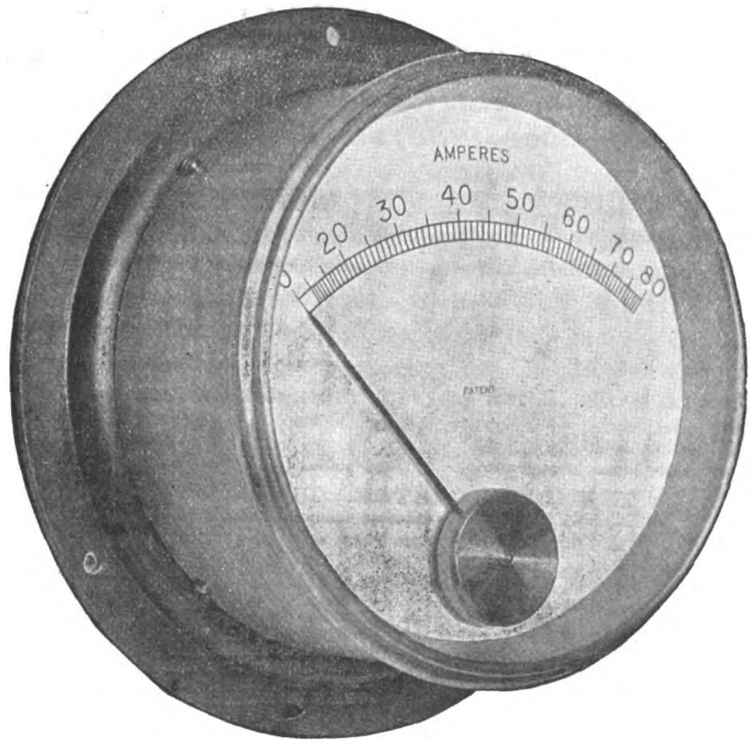


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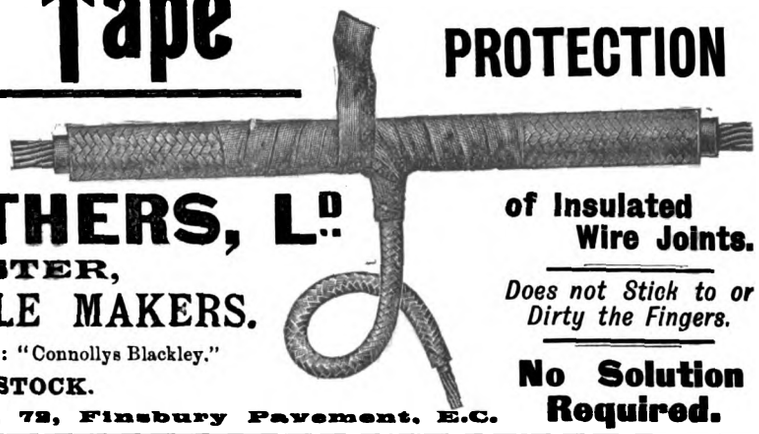

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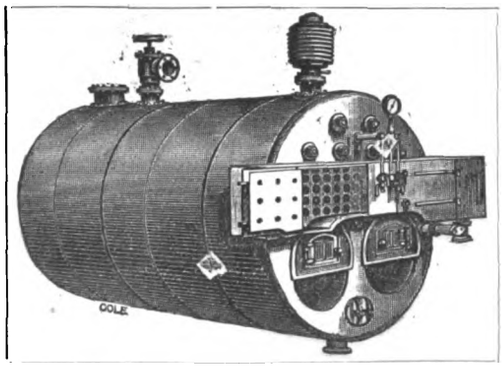

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 955. [Vol. XXXVII. No. 19.] FRIDAY, SEPTEMBER 4, 1896. PRICE SIXPENCE.

## NOTES.

An important and interesting point of law was raised at Exeter last week, when the Exeter Electric Light Company, now in process of liquidation, was summoned (in the person of Mr. KNILL, who has been appointed by the Court of Chancery Receiver on behalf of the debenture holders) for the non-payment of rates amounting to about £4, which were due and owing up to the time of the transfer of the Company's undertaking to the Exeter Corporation. On behalf of the Rating Authorities, it was stated that a summons against the Company had been granted, and that, therefore, the police had served Mr. KNILL, who, it was pleaded, was the only representative of the old Company upon whom such a summons could be served, the staff of officials having been disbanded. It was contended on Mr. KNILL's behalf that, whoever else might be served, he was certainly not the proper party; and this view was upheld by the Bench, and the case was dismissed. This particular case has an interest from the fact that in time to come many of the electric lighting undertakings now owned by public companies will be bought up by the Local Authorities, and the position of debenture holders and other priority creditors will have to be defined by the Courts. The present case appears to us to be somewhat similar to that of "GASKELL and ANOTHER v. GOSLING and ANOTHER," reported in *The Electrician* for December 6, 1895, and February 14, and April 24, 1896, except that in this case the liability was incurred before the appointment of the Receiver. The ease with which at present limited liability companies can vanish into thin air is one upon which considerable restrictions might well be placed, and that without "injuring the trade of the country,"—the usual bogey whenever proposals are abroad for increasing the stringency of Company law.

THE danger to which water-tube boilers are rendered peculiarly liable by feed water containing a large quantity of mineral or organic matter is well known to steam engineers; and it is scarcely a matter for surprise that the report of the Board of Trade on the explosion of a water-tube boiler, at the Bankside station, last February, gives the closing of the down-take tubes by calcareous deposit as the direct cause. In consequence of the stoppage of circulation the horizontal water-tubes expanded excessively, and, putting a severe strain on the front and back cast-iron headers, fractured three of the former and five of the latter. The sudden discharge of steam and water from the boiler, through the boiler front, unfortunately caused the death of a fireman. We believe that Messrs. BABCOCK and WILCOX have abandoned the use of cast-iron headers; at any rate, these are now being largely made of forged steel. It is possible that had the boiler in question been fitted with headers of this stronger and more reliable material, it might have given warning of something amiss before actual fracture occurred; but, on the other hand, actual explosion would probably have been more disastrous. The immediate source of danger was the choking of the tubes, and the only really satisfactory remedy is to use feed-water practically free from calcareous matter. Merely using anti-incrustation compositions injected with the feed-water is, in a case of this sort, but an imperfect makeshift; and, if hard water is the only water obtainable, it should be thoroughly softened, and the mineral matter completely settled in a tank before the water is injected into the feed-heater. We are inclined, however, to accept the opinion of those engineers who believe that, where the feed-water is very hard or impure, it is best to use a shell type of boiler, which is free from the narrow water passages that are so liable to be choked in water-tube boilers.

THE table of data relating to a certain group of Continental electric supply concerns, which we reprint in a condensed form to-day from a German contemporary, presents several points of interest to English central-station engineers. Apart from purely engineering differences, such, for instance, as the use of slow-speed direct-connected instead of high-speed direct-connected engines, the two most striking points are the great use which is made of accumulators and the large arc-lamp connection. Vienna, with its 7,775 arcs, and Hamburg and Elberfeld with 1,105 and 2,540 respectively, are but exaggerations of a very general state of things. Vienna, with its output of 6¼ million units, and Hamburg, with its output of 3½ million units, are also calculated to make mouths water. The Hamburg station, thanks to its huge output and to the fact that it supplies current to the electric tramway system of that port, is able to turn out the kilowatt-hour for the abnormally low figure of 1·12d. That brings us to the figures for total cost given in the table. It would be interesting to know exactly what is included under that heading. *Zinsen* (interest) is a somewhat elastic phrase; and if we assume that it comprises items equivalent to the sums set aside by us

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for repairs and depreciation, we must admit that the total engineering cost of the kilowatt-hour is lower in Germany than in England.

In an article by Prof. Du Bois and Mr. Taylor Jones, which we print *in extenso* to-day, our knowledge of the current sorts of iron and steel now in the market is brought up to date. They confirm the observation of Prof. Ewing that a soft iron or steel which has a very high permeability does not necessarily show a very small hysteresis, and hold that these qualities, indeed, are, to a certain extent, mutually exclusive. The material of very low hysteresis suitable for transformer stampings does not possess generally the high permeability desirable in the field-magnets of dynamos. Hence the processes of manufacture for these two qualities are becoming differentiated the one from the other. A third kind of steel is needed for permanent magnets, and here the newer kinds of steel appear to be inferior to that produced twenty years ago and used in the famous Haarlem magnets. Not the least valuable part of this Paper is the concluding section dealing with the construction and ageing of permanent magnets, about which the manufacturers still maintain a sort of mystery.

Incidentally it may be remarked that Prof. Du Bois and Mr. Taylor Jones have employed the term *hysteresis* in a somewhat novel sense. As originally employed by Prof. Ewing, it denoted the general physical phenomenon of the magnetic residual effects which lag behind their causes. In these cycles of effects energy was invariably lost. It is now proposed to define the amount of energy lost per cycle per cubic centimetre as "the hysteresis," which, therefore, now becomes capable of being expressed in numerical values.

At one time Faraday gave considerable attention to the composition of steel, in the hope of producing an alloy which should resist oxidation. This he attempted to attain by the introduction of small quantities of platinum and other non-oxidising metals. Though the research came to nothing, he produced several excellent steels, of which razor blades were made. In later life he used occasionally to present to friends razors of the steel so made with his own hands. It would be matter of some interest to know whether any of these razors are still in existence. The magnetic properties of these steels would also be a matter of more than passing interest.

We have received a letter from Prof. Dugald C. Jackson, of the University of Wisconsin, enclosing a copy of a Paper read by him and Mr. Arthur W. Richter before the American Society of Mechanical Engineers in June, 1895. We reprint this Paper elsewhere in the present issue. Prof. Jackson considers that his exhaustive tests of the plant of the combined lighting and traction station of the Four Lakes Light and Power Company "make manifest" the erroneous nature of a claim put forward in the Paper by Messrs. Hesketh and Rider on "Combined Electric Lighting and Traction Plants," which appeared in our issue of July 24th. These gentlemen, having in view English central stations in general and municipal central stations in particular, argued that by *properly* combining under one and the same roof the business of supplying current to lamps, and of supplying current to tramcars, a great reduction in the cost of the Board of Trade unit would ensue. From their Paper it is evident that what Messrs. Hesketh and Rider deem to be the proper way of adapting an existing plant to traction work involves the use of motor-generators combined with accumulators to tide over the "peak," and to act as a sort of electrical buffer between the cars and the generating plant. No doubt where a three-wire system was about to be laid down they would, if traction work were in view, advise 200 or 250 volt lamps, and 400 or 500 volt generators, thus still further simplifying the station arrangements.

What possible bearing the results of the tests of the very heterogeneous and distinctly American plant gathered together at Madison (Wis.) can have upon this proposal we entirely fail to see. To run up a generalisation upon the strength of a single instance is scarcely scientific; and we doubt if the adverse conclusion arrived at by Prof. Jackson is valid even for the United States of North America, since it is grounded upon the fallacy that "when a railway and a lighting station are combined, *we are forced by the conditions to use separate machinery (excepting boilers) for the two classes of service.*" The whole basis of the arguments adduced by Messrs. Hesketh and Rider is that we are *not* bound to use separate and special machinery for the two separate circuits; and it is obvious now that a 500-volt 3-wire system is permitted by the Board of Trade, and 200 and 250 volt lamps are within the sphere of practical electrical engineering, there need be nothing distinct and separate in a combined light and power station except the switchboards and feeders.

Prof. Jackson's Paper, however, is a good example of a central-station test, and is valuable as showing how very far a typical "old-time" belt and counter-shaft station falls below the high ideals put forward by Mr. Crompton in his memorable Paper on "Cost of Electrical Energy," read before the Institution of Electrical Engineers in April, 1894.

Storage batteries, Prof. Jackson writes us, have been tried in America in connection with street railway plants, and have been abandoned. We can only reply that in this country they are being tried, and have not, so far as we are aware, been found altogether unsatisfactory. As to their value in regulating the load on the engines, there is little doubt in the minds of the traction engineers who have tried them; and since it is also evident that nine-tenths of the savings expected from a combination of lighting and traction business depends upon the use of accumulators to tide over the "peak;" the sooner reliable figures are forthcoming as to the actual cost of upkeep of batteries so used, the sooner will the day of the traction day-load arrive.

**Electric Traction in Germany.**—A narrow-gauge light electric railway is to be constructed between Sterkrade, Oberhausen, and Merderich.

**University College, Liverpool.**—The 1896-7 session commences on October 6th. Some particulars of the courses in civil, mechanical and electrical engineering appear elsewhere.

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**A Canadian Electric Locomotive.**—A 400 H.P. electric locomotive has been built at Peterborough (Ont.), and is designed to haul 15 cars at 30 miles an hour. This locomotive will probably be put into service on the Hull and Aylmar railway, in Canada.

**Heat Wave Fire Alarms.**—Such is the fidelity and promptness of some American thermostat fire alarms that during the recent heat wave, in the United States, several of these went into action and turned on the water sprinklers placed in readiness for an outbreak of fire.

**British Association.**—The usual B.A. lecture to working men will be delivered this year on Saturday, September 19th. The subject will be "The Earth: a Great Magnet," and the lecturer Dr. J. A. Fleming. The lecture will be copiously illustrated by experiments and lantern slides.

**Damage by Lightning.**—During a thunderstorm which passed last week over the Isle of Wight, Atherfield Coastguard station was struck by lightning, and considerably damaged. The telephone instrument was struck, and the officer using it at the time was injured.

| Cable Interruptions. | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique ..... ..... | Dec. 19, 1895. |
| Monte Alegre—Santarem ..... | May 5, 1896. |
| Para—Maranham ..... | Ang. 6, 1896. |
| Zanzibar—Mombasa ..... | Aug. 23, 1896. |

**City of London College.**—The Michaelmas term of this City polytechnic commences on October 1st. The classes in mechanical engineering are under Mr. H. Adams, and those in experimental physics, magnetism, electricity, &c., and laboratory practice are in the hands of Mr. J. S. Scart and Mr. C. A. West.

**A Flattened Glow-Lamp Bulb.**—A temperature high enough to soften glass will naturally enable atmospheric pressure to flatten a glow-lamp bulb. The *Electrical Engineer* of New York recently mentioned an instance of a bulb being "badly flattened and folded upon itself, very much in the style of a dried pear," the lamp having been in a room which was burned out through the explosion of a stove.

**Appointment.**—Mr. Jno. F. C. Snell, A.M.I.C.E., M.Inst.E.E., A.M.Inst.Mech.E., is vacating the post of resident engineer at King's-road, St. Pancras, to become borough electrical engineer at Sunderland. Mr. Snell was formerly chief assistant engineer at Stanhope-street Station; was chief assistant to **Gen. Webber**, C.B, in his consulting practice, and was formerly an assistant on Messrs. Crompton's engineering staff at various central stations in England and abroad.

**Glow-worm Radiations.**—M. Charles Henry, in a recent communication to the Académie des Sciences (*Comptes Rendus*, Vol. CXXIII., No. 8, p. 401), states that he lately had occasion one evening to place some glow-worms for from half an hour to two hours upon a properly-protected photographic plate, and on developing black and white lines were found which corresponded tolerably accurately to the itinerary of the subventral lights of the worms.

**Magnetic Units.**—At the recent electrical gathering at Geneva, M. Hospitalier championed the propositions with regard to magnetic units adopted by the American Institute of Electrical Engineers (see *The Electrician*, Vol. XXXII., April 6, 1894, p. 645). There was "opposition irréductible," and to prevent "rejet définitif," which would have been awkward, M. Hospitalier gave his adherence to the proposal of Prof. Mengarini, and allowed the Congress "to pass to the order of the day."

**Royal Photographic Society.**—The forty-first annual exhibition of the Royal Photographic Society is now in course of preparation, and will open to the public on Monday, September 28th. On the Saturday previous there will be a private view, followed in the evening by a *conversazione*, at which the President, Capt. W. de W. Abney, C.B., D.C.L., F.R.S., and Council will receive the Fellows, members, and their friends. Exhibits have to be delivered at the Society's offices, at 12, Hanover-square, W., not later than 9 p.m. on the 10th inst. The Exhibition will be open daily from 10 to 5, and on Monday, Wednesday, and Saturday evenings (when lantern slides will be shown) from 7 to 10, and will close on November 12th.

**Electric Tugs for the Spree.**—A plan is on foot to establish a regular service of electric tugs on the river Spree at Berlin. The idea is to set up along the 7½ miles of river which passes through the capital a trolley line supplying current to electric tugs. There are a large number of bridges crossing the river, and ordinary barges are unable to use their sails. The present charge for towing the distance in question is 30s., but it is estimated the electric tugs will be able to do the job for 15s. The plan has been worked out by some well-known engineers, and Messrs. Siemens and Halske were contemplating putting the idea into practice. An experimental line 2½ miles long will be built shortly.

**Telephone Trunk Lines.**—At the special meeting of the Association of Chambers of Commerce of the United Kingdom, to be held at the Hartley Hall, Southampton on the 15th and 16th inst., the following resolution will be put forward:—"That in the opinion of this Association, the utility to the mercantile community of the trunk telephone cables between mercantile centres is very materially decreased owing to the great delay in securing a turn, and the executive are respectfully requested to press upon the telegraph department of the Government the necessity of promptly increasing or improving the main cable connection."

**Obituary.**—We have to record the death of Mr. F. W. Lilly, chief electrician of the Eastern Telegraph Company's cable steamer "Chiltern," which occurred in hospital at Suez from enteric fever, after an illness of only ten days. Mr. Lilly joined the Eastern Company's electrical staff in 1880, was third electrician in the "Volta" in 1883, second in the "Chiltern" in 1885, and went through the bombardment of Alexandria, under the late Charles Phillips, who was chief electrician of the "Chiltern" at that time. Mr. Lilly became chief electrician to the ss. "Great Northern" in 1889. He was only 34 years of age on the 17th of this month.

**Refractive Indices for Electric Waves.**—The refractive indices of a number of substances for electric waves of very small length have been determined by Dr. A. Lampa. The experiments, which form the subject of a communication to the *Wiener Sitzungsberichte*, were made with electro-magnetic radiations of 8mm. wave-length. The wave-length in question corresponds to the frequency $N = 37{\cdot}500 \times 10^6$, and Dr. Lampa gives the following values for the index $n$: Paraffin, 1·524; ebonite, 1·739; crown glass, 2·381; flint glass, 2·899; sulphur, 1·802; benzole, 1·767; glycerin, 1·843; oil of turpentine, 1·782; oil of vaseline, 1·626; oil of almonds, 1·734; absolute alcohol, 2·568; and distilled water, 8·972.

**Electric Lighting in Australia.**—The following table, compiled by Mr. Henry J. Spencer, shows the net annual profit on the capital expended upon five Australian electric light undertakings. By the side of these portentous figures our own maxima of 6 per cent. and 7 per cent. look modest indeed. Electric lighting under the Southern Cross would appear to be as profitable as gold mining.

| Central Station. | Net profit per cent. |
|---|---|
| Edison Lane (Brisbane) ..... | 33⅓ |
| The Strand (Sydney) ..... | 40 |
| Perth (West Australia) ..... ... ..... | 23 |
| Ballarat (Victoria)..... ..... | 10 |
| Redfern (New South Wales) ..... ..... | 7¼ |

**The Submarine Telegraph Memorial.**—The following is a translation of a letter from Dr. von Stephan, head of the German Telegraph Service, to the Marquis of Tweeddale:—"My Lord Marquis: Whilst having the honour of acknowledging the receipt of your favour of July 31st, permit me to sincerely congratulate you upon your intention of honouring those men who, with great foresight as well as untiring energy, created the Submarine Telegraphs, and steadily continued to develop them. I feel myself honoured by being asked to join the Committee which has for its object the carrying out of this plan; and place with great pleasure, my name and person in the service of this matter; at the same time I shall be glad to know in what way I can be useful."

**Electric Traction at Cairo.**—The recently-opened Cairo tramway comprises 10 lines of a total length of 14 miles, of which about 10 miles have double track and 4 miles single The gauge is 1 metre, and the system employed is the over-

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head trolley. The trolley wire is held in position by span wires, which in the centre of the town are fastened to ornamental wallplates or wrought-iron posts, while outside impregnated wooden posts are used. At present the service is carried out by 40 motor cars and 20 trailers. Each motor car is equipped with two G.E. 800 motors, and capable of drawing two trailers. In consequence of the mild climate all cars are of the open type, and they are divided into two parts, one for the Europeans and one for the natives. The power-house is situated near the Nile. There are three Cornish boilers of 400 H.P. each (system, Tosi, of Legnano), working at 150lb. pressure. The engine-room contains three 225-kilowatt dynamos, generating at 500 to 550 volts, and connected direct to horizontal compound engines. Under normal conditions the steam engines work condensing. The water for this purpose is pumped out of the Nile by three electrically-driven centrifugal pumps.

**X-Ray Screens.**—In the *Comptes Rendus* for August 24th (Vol. CXXIII., No. 8), M. Charles Henry makes the following remarks on the superiority of sulphide of zinc over all other materials for use in connection with X-ray screens: "I substitute for the purely fluorescent screens of platino-cyanide of barium, tungstate of calcium, &c., a screen of my phosphorescent sulphide of zinc, covered with a sheet of stiff paper, and I lay the object to be radiographed upon the paper. After a few minutes' exposure to the radiation from a Crookes tube I take the screen into the dark room. The thick parts of the object, opaque to Röntgen rays, come out dark; the transparent parts come out light, and I can study at leisure for at least a quarter of an hour the smallest details of the image. If I heat the screen slightly with a source of dark heat I can continue my examination longer. This method, which allows of a great economy of electric energy and of tubes, is to be recommended for demonstration purposes, and whenever it is not desired to preserve the radiograph. Phosphorescent sulphide of zinc is far more sensitive to Röntgen rays than sulphide of calcium. If we expose a screen of sulphide of calcium and a screen of sulphide of zinc for 5min. to the same radiation, the former scarcely glows, whilst the latter has almost attained its maximum luminosity."

**Electrical Developments in Japan.**—The Japanese, says *Engineering*, "have not been slow in adopting the various applications of electricity, and they have made considerable progress, not only in electric lighting, but also in the use of electricity as a motive power. For a considerable time past the vernacular Press has stated that a system of electric tramways was being projected for Tokyo, and it now is being supported by well-known and rich men. The horse tramway company's charter, however, having still some years to run, the electric tramway company will, to begin with, confine its enterprise to districts where other trams do not exist. Some of the newspapers are expressing regret that some arrangement cannot be made with the horse tramway company, so as to bring the whole of Tokyo within the range of the electric system; for the use of ponies to draw heavy tramcars, and the execrable state of the streets through which the lines run, are veritable eyesores in Tokyo. In view of the developments which are taking place in the applications of electricity, the Minister of State for Communications has issued regulations for the control of the arrangements connected with them. They are of considerable length, comprising 111 in all, but their chief points are as follows:—The matters controlled by these regulations include electric light, electric railways, and other electric appliances, but electric railways constructed in accordance with the Private Railway Regulations are excepted. Whenever an application to start electrical works, whether for business or private use, is sanctioned by the Minister of Communications, the work must be started within six months, computed from the date of such sanction, and when work is not begun within that period, or is not completed within the prescribed limit, or is not applied to the practical uses for which it was intended, within six months from the date of the issue of the sanction, it may be annulled. Electric currents must be completely insulated from the ground, and lightning rods must be erected at suitable places. The temperature of electric wires through which currents are transmitted must not rise above 20°C., and must not affect any of their surroundings. Wires suspended in the air must be covered, and posts supporting them must be on the roadside. At places where wires cross the road they must be suspended over 20ft. above the ground, and over 16ft. in all other cases. When electric light wires are to be conducted side by side with electric motor wires, the space between the two must be over 6ft. Electricity supplied to a dwelling-house must be of low-pressure. Detailed regulations are given with regard to electric railways. They provide that, according to circumstances, the Minister of Communications may forbid the use of ground-laid return wires. Wires used for electric railways, when suspended in the air, must, except in cases specially sanctioned, be over 25/100 sun (fully ¼in.) in diameter, and extremely durable; and the return wires, except those laid in the middle of the track or rails, must be insulated from the ground. But when in places where non-insulated wires are employed metallic substances are buried underground, the return wires, excepting in cases where the consent of the owners of these metallic substances has been secured, must be separated from the others by not less than 6ft. Electric railway wires, with the exception of electric car wires, must be conducted along one side of the roadway whenever any electric light wires or electric motor wires are conducted along the same side. The new regulations came into force from June 1st last, and the reconstruction of those parts of existing electric plants that do not correspond with the conditions laid down in the regulations, must be undertaken within a prescribed limit of time."

**Photometric Units, Symbols, and Nomenclature.**—At the recent Electrical Congress at Geneva, M. Palaz brought forward M. Blondel's proposals with regard to photometric units, symbols, and nomenclature, which have already been published in these columns (see *The Electrician*, Vol. XXXIII., September 28, 1894, p. 633). According to M. Hospitalier in *l'Industrie Electrique*, a battle royal thereupon ensued between M. Mascart and Herr von Hefner-Alteneck. The final outcome of the deliberations of the Special Committee of the Congress, which consisted of Herr von Hefner-Alteneck (Chairman), Herr Kapp, Sig. Riccardo Arno, and MM. Hospitalier, Paul Janet, de Kowalski, Palaz, and Rousseau, was the following string of resolutions. 1. The international photometric magnitudes have as a common basis the luminous intensity of a point source. They are summarised in the following table:—

*Photometric Magnitudes.*

| Names. | Symbols and equations defining the magnitudes. |
|---|---|
| Intensity of light ..... | $I$ |
| Flux of light ..... | $\phi = I\,\Omega$ |
| Illumination ..... | $E = \frac{\phi}{S}$ |
| Brightness ..... | $e = \frac{I}{S}$ |
| Quantity of light ..... | $Q = \phi\,T$ |

In the above equations $\Omega$ represent a solid angle, $S$ a surface, and $T$ a time.

2. The unit of luminous intensity is the *bougie décimale* as defined by previous Congresses. 3. Provisionally the *bougie décimale* may be represented for industrial purposes by the horizontal intensity of the Hefner lamp, provided connections are made. 4. The names adopted for the other units are as follows:—

*Photometric Units.*

| Magnitude. | Unit. | Definition. |
|---|---|---|
| Intensity of light. | *Bougie décimale.* | 1/20 Violle Pt. standard. |
| Flux of light. | *Lumen.* | *Bougie décimale* steradian.* |
| Illumination. | *Lux.* | *Lumen* per sq. m. |
| Brightness. | *Bougie décimale*, per sq. cm. | *Bougie décimale* per sq. cm. |
| Quantity of light. | *Lumen* hour. | —— |

* The *steradian* is unit solid angle. It is the solid angle which cuts unit surface on a sphere of unit radius. It is a simple numerical ratio independent of the units of length and surface adopted, provided the two are coherent.

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# THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 502.*)

If the position of the fault, as indicated by these tests, is at a feeding point—*i.e.*, if, for instance, on testing between $H_3$ and $H_4$ the balance position of the slider is at the extreme right-hand side, and on testing between $H_4$ and $H_5$ it is at the extreme left-hand side—the fault may be in the feeder (in the above case, the feeder $H_4$). Then the galvanometer is put across the stretched wire or resistance box terminals $M_4$ and $M_5$, instead of between $P_4$ and $P_5$ (Fig. 35). On balance being

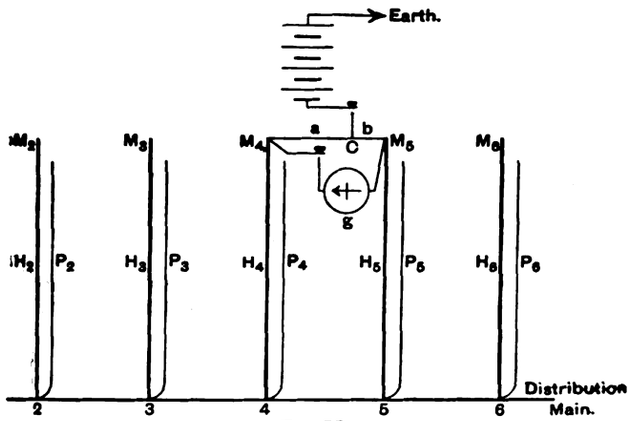


FIG. 35.

obtained, the equivalent length of the circuit $H_4$, 4, 5, $H_5$ must be taken for $l$ in the expression $\frac{a}{a+b}l$. That is, if, for instance, $H_4$ be 400 yards, $H_5$ 500 yards, and the length of the section of distributing main 100 yards; and if the sizes of cable be respectively 19/16, 19/16 and 37/16, $l$ must be taken as 950 yards. If $\frac{a}{a+b}$ is then 0·340, say, the distance of the fault from $M_4$ would be $0{\cdot}340 \times 950$ yards $= 328$ yards. If this second test thus confirms that the fault is in the feeder, the feeder and its fellow on the opposite main are disconnected from the network at the junction-box end, and are there connected tightly together. This connection must, of course, not be allowed to touch the sides of the junction-box or anything

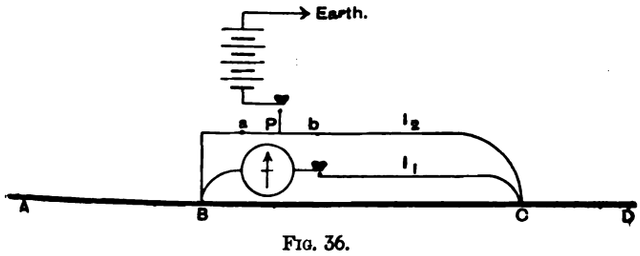


FIG. 36.

else. Then a loop test is carried out in the usual way from the station, and the fault localised accurately, such a simple loop with only one joint and throughout of the same sectional area coming near to the ideal.

If the fault is in a distributing main and not in a feeder, one may proceed as follows:—

*Method* 10.—The position of the fault having been approximately determined by method 9, a further test may be made in the street between the two connection-boxes bounding the section indicated as faulty. The ends of the feeders and testing-wires in the station are left free. The connections are made as on Fig. 36. The thick line B C represents the cable between the two boxes. $l_1$ and $l_2$ are temporary leads between the two. $l_2$ must be a moderately large size of cable, so that its resistance can be neglected in comparison with that of the stretched wire or resistance coils $a$ $b$. $l_1$ must be directly connected to C, not to some other point in $l_2$, otherwise a contact resistance is introduced in the cable arm of the bridge. The same applies to the galvanometer lead to B; it must be connected to B directly, not simply to the terminal of the stretched wire or resistance box.

If for balance the sliding contact P is at the end of the scale, a similar test is made between the next two boxes—between B and A or between C and D, according to which end of the scale the balance position is.

If there are spare cables running between the street boxes, the inconvenience of running leads in the streets can be avoided. The box B (Fig. 37), which is judged to be nearest to the fault, is chosen, and the instruments are set up there. The spare cables are used as leads to the connecting points A and C in the boxes on either side. The galvanometer may be connected to A′ and C′ instead of to A and C. Then the cable loop is A′ A C C′ instead of simply A C. The connections in the diagram are, however, preferable if there are enough spare cable or wires, as then there are no contact resistances in the cable loop itself.

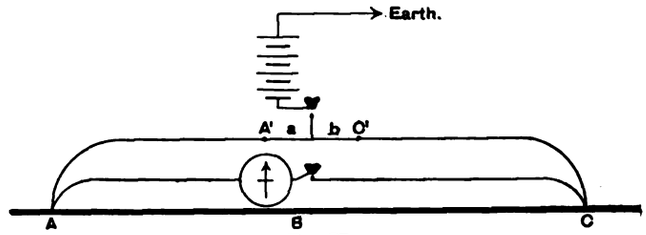


FIG. 37.

The faulty section having been found, the houses are switched off, and an accurate localisation test can be made. In the case of a drawing-in system, the section of cable which is now isolated can be tested to make sure it is faulty, and then withdrawn.

*Method* 11.—This is another method of street testing that has been suggested from time to time.* It may be used instead of method 10. A loop is joined up, including the faulty section A B (Fig. 38). A current is sent through this loop by means of a battery at the end. A bare piece of cable or wire, C D, is then laid on insulators from A to B, parallel to the faulty cable. A C and B D are well connected together. It is of more importance that there should be no contact resistance between A and C and B and D than between A A

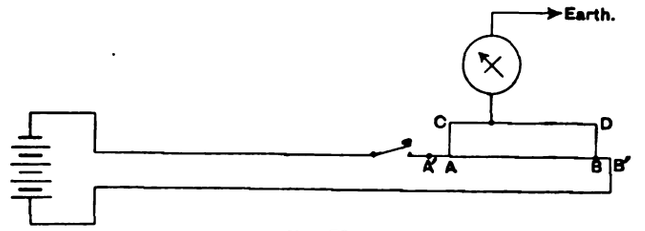


FIG. 38.

and B B′. A galvanometer is now connected with one terminal to earth and the other to a flexible wire. The other end of this wire is now moved up and down C D until the position of balance is found. Each time the battery key must only be depressed after the galvanometer connection has been made, as the bridge must be balanced to false zero. The wire making the movable connection must be held by the insulation; the copper must not be touched by the hand. The fault in the cable will be directly beneath the balance point. The great drawback to this method is that it is a false zero one; there will usually be a considerable current through the galvanometer before the battery key is depressed.

It should be noted that any localisation tests taken without isolating the faulty cable from the rest of the network are only

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* *See* a letter to *The Electrician* of March 9, 1894, from Mr. W. H. Collis, of Liverpool.

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of use if the resistance of the fault is much smaller than the insulation resistance of the remainder. If this is not the case no accuracy is obtainable, and often the results of tests are misleading.

*Short Circuits.*

If two cables are short-circuited any of the methods described in this chapter are applicable, if one of the cables be considered as "cable" and the other as "earth." To use a loop method a third cable is necessary; a loop simply made up of the two short-circuited cables will not do.

When no return wire is available, so that neither a loop nor fall of potential method can be used, it is necessary to slightly modify methods 7, 8, 7A or 8A as follows, in order to employ them to localise short circuits.

*Method* 12 (*Overlap Method*).—The resistance between the two cables is measured with a Wheatstone bridge, the far end being free in each case.

Then, if $r_1$ and $r_2$ are the results of these measurements,
if $l$ be the distance in yards between the testing-points,
and if $s_1$ and $s_2$ be the resistances of the cables per yard respectively,
the distance of the fault from end 1 is

$$\frac{r_1 - r_2 + l(s_1 + s_2)}{2(s_1 + s_2)} \text{ yards.} \quad . \quad . \quad . \quad . \quad (35)$$

If the two cables be of the same size, this formula becomes

$$\frac{r_1 - r_2 + 2ls}{4s} \quad . \quad . \quad . \quad . \quad . \quad . \quad (36)$$

*Method* 13 (*Blavier's Method*).—Test from one end only. The resistance between the two cables is measured, first ($r_1$) when the far ends are free, and then ($r_2$) when the far ends are connected together.

Then the distance of the fault from the testing end is

$$\frac{r_2 - \sqrt{(r_1 - r_2)(lk - r_2)}}{k} \text{ yards,} \quad . \quad . \quad . \quad (37)$$

where $k$ is $s_1 + s_2$, $l$ the length of the cable in yards, and $s_1$ and $s_2$ the resistances per yard of the two cables respectively.

If a stretched wire bridge be used, the connections must be made as in Fig. 33 with the difference that each of the points A and D must be connected to one of the short-circuited cables, instead of to cable and earth respectively. Then, using the same notation as before, we have for the overlap method,

(*Method* 12*a*). Distance of fault from end 1 is

$$\frac{\left(\frac{a_1}{b_1} - \frac{a_2}{b_2}\right)c + l(s_1 + s_2)}{2(s_1 + s_2)} \text{ yards.} \quad . \quad . \quad (38)$$

For Blavier's method,

(*Method* 13*a*). Distance of fault from testing end is

$$\frac{d_2 - \sqrt{(d_1 - d_2)(lk - d_2)}}{k},$$

$d_1$ being $\frac{a_1}{b_1}c$,

$d_2$ being $\frac{a_2}{b_2}c$,

and $k$ being $s_1 + s_2$, as before.

*Method* 14.—Blavier's method and the overlap method can be employed when the short-circuit to be localised is at the same time an earth-fault. When it is only a short-circuit pure and simple, and the insulation of the cables remain intact, the following method will give the best results.

The connections on Fig. 39 are first made, one of the cables M N being put to earth at the far end, and the other cable being left unconnected. The bridge is balanced and the values of $d_1$, $b_1$, and $a_1$ are noted. Then the battery wire is disconnected from C and connected to the end H of the cable H K, and the arm B C of the bridge is plugged up. This gives the connections on Fig. 40. The bridge is again balanced, and the readings $d_2$ and $b_2$ are noted, $a_2$ being O.

Then the resistance of the cable from M to the short-circuit is

$$x = \frac{d_1 d_2}{b_1(b_2 + d_2)}a_1. \quad . \quad . \quad . \quad . \quad . \quad . \quad (39)$$

If $s$ is the resistance per yard of the cable M N, the distance in yards from the station to the short-circuit is

$$\frac{x}{s} = \frac{d_1 d_2}{b_1(b_2 + d_2)}\frac{a_1}{s} \quad . \quad . \quad . \quad . \quad (40)$$

The two arms M A B of the bridge may be resistance coils or a stretched wire.

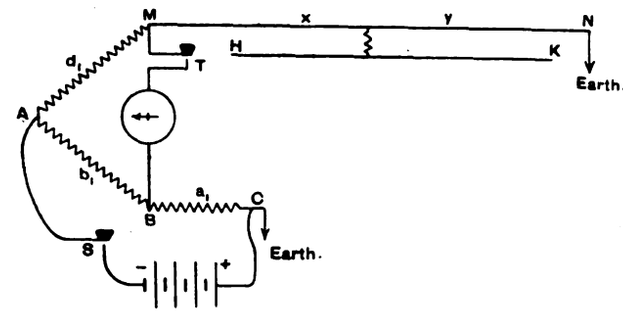


Fig. 39.

Fig. 41 shows the connections for a Post Office pattern bridge, the + pole of the battery being connected first to C and then to H.

When a stretched wire bridge is used, a piece of spare cable should replace the resistance $a_1$, the earth wire being connected

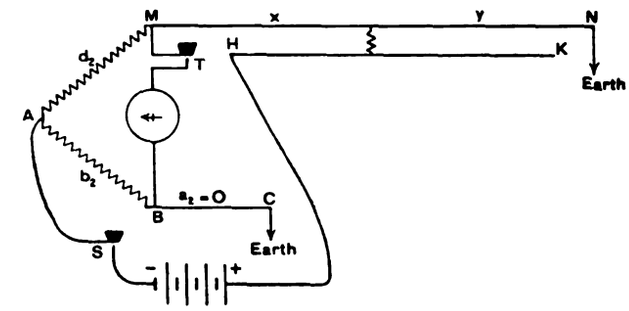


Fig. 40.

directly to B in the second part of the test. The equivalent length $l_1$ of the piece of spare cable is substituted for $\frac{a_1}{s}$ in the equation (40), so that this equation now becomes:—

$$\text{Distance of short-circuit from station} = \frac{d_1 d_2}{b_1(b_2 + d_2)}l_1 \quad (41)$$

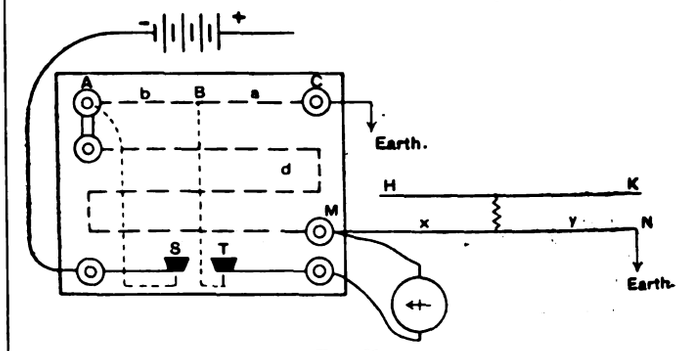


Fig. 41.

If the lead sheathing or iron armouring of the cable run right through without any metallic discontinuity, one of these may with advantage be used as earth. The wire from the bridge to earth should be as short as possible; but it must not be shortened or lengthened between the two tests, as the equations assume that the resistance of the earth connection remains unaltered.

The beauty of this method is that it is entirely independent of the resistance of the short-circuit itself, which is often very

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unsteady, and only depends on the resistance of the two earth connections remaining constant. It is best to balance to false zero in this method.

The question is often asked:—How bad must a fault be so that it can be accurately localised? It is impossible to give a hard and fast rule, as it depends on circumstances. The resistance of the fault must be so low that the following two conditions are fulfilled:—

1. With the battery power available it must be possible to send enough current through the fault to carry out the test.
2. The resistance of the fault must be small compared with the insulation of the rest of the cable and connections.

With regard to the former of these two conditions, the method of calculating the accuracy obtainable with a given battery power and galvanometer in localising a fault of known resistance will be given later. With a fairly sensitive galvanometer and a potential difference of 200 volts, faults up to a few thousand ohms resistance can be accurately localised by loop tests if condition 2 is not violated.

The influence of the second condition on the accuracy of the test can be seen by applying the following formula:—

If $x$ is the distance of the fault from the testing point, as calculated by any of the methods already given,
K the previous insulation resistance of the cable loop before the fault has occurred,
F the insulation resistance of the faulty cable at the time of the localisation test, and
$l$ the length of the cable.

Assuming that the previous leakage was evenly distributed along the cable loop, so that the centre of gravity of it—so to speak—is at the middle point,

The correct distance of the fault from the testing point is

$$\frac{x\mathrm{K} - \frac{l\mathrm{F}}{2}}{\mathrm{K} - \mathrm{F}}, \quad \ldots\ldots\ldots \quad (42)$$

or this may be written

$$\frac{x - \frac{l}{2}\frac{\mathrm{F}}{\mathrm{K}}}{1 - \frac{\mathrm{F}}{\mathrm{K}}}. \quad \ldots\ldots\ldots \quad (43)$$

The "centre of gravity" of the leakage, above mentioned, is called *the position of the resultant fault.* If this is not exactly at the middle point of the cable circuit the equation is

Distance of fault from testing point

$$= \frac{x - y\,\mathrm{F}}{\mathrm{K} - \mathrm{F}}, \quad \ldots\ldots\ldots \quad (44)$$

or

$$= \frac{x - y\frac{\mathrm{F}}{\mathrm{K}}}{1 - \frac{\mathrm{F}}{\mathrm{K}}} \quad \ldots\ldots\ldots \quad (45)$$

where $y$ is the distance of the resultant fault from the testing point.

To get an idea of the error caused by this resultant fault we can consider a mean case. Suppose the resultant fault was at the middle point of the cable-loop ($\frac{l}{2}$ from the testing point); and the position of the new fault, as given by the localisation test, is a quarter way along the cable ($\frac{l}{4}$ from the testing point). Then if F be $\frac{1}{10}$th of K the test is 10 per cent. wrong; if F be $\frac{1}{100}$th of K the test is 1 per cent. wrong—that is to say, the actual error is $\frac{1}{4}$ per cent. of the length of the cable.

The difficulty is to fix the position of this previous resultant fault. Sometimes it may be guessed or "estimated," and sometimes it is correct to assume it at the middle point. A localisation test can only be *absolutely* relied on when the resistance of the rest of the cable and connections is very great compared with the resistance of the fault. If a loop is made up of several pieces of different-sized cable, a distinction must be made between the actual middle point of the loop and the centre of the equivalent length. The former would be assumed to be the position of the previous resultant fault in many cases, and then its equivalent distance from the end must be calculated, and equation (44) or (45) must be employed.

Another difficulty is that if the insulation of the rest of the cable is low, so that it is comparable with the resistance of the fault, it is not at all easy to balance the bridge owing to the constant change in the position and value of the resultant fault.

The same also holds good when there are two faults in the cable, in which case the position worked out from the test will lie between the actual positions of the two faults and nearer to the worse one.

If the supply is on the continuous current system, it is possible, in all the methods described, to tap current from the 'bus bars or from the supply network to work the tests. The two supply mains will thus take the place of the battery in the connection diagrams. It is, however, usually preferred, when possible, to use an independent battery or dynamo, so as not to earth the supply. But, when the tests have to be carried out away from the station, it is often not possible to obtain an independent current. Then current must be tapped from the network through fuses, and a resistance should be included between the supply main and earth, so as not to make a dead earth on the network. Varley's method (method 2) should not be employed under these conditions; Murray's method (method 1) may always be substituted for it.

In the fall of potential methods there may be difficulty in keeping the current constant, so that the scheme on Fig. 29 must be used. With the other methods there will be no inaccuracy if the connections are always made in accordance with the instructions already given in each case. The deflections may be a little unsteady, but this does not matter in the case of these null methods.

If the supply is on the alternating system current for the tests might, in the same way, be tapped from the secondary circuits, a telephone replacing the galvanometer. But this should only be done when absolutely no other means of obtaining current are available; such tests are often false, owing to capacity effect.

*(To be continued.)*

## THE MAGNETISATION AND HYSTERESIS OF CERTAIN KINDS OF IRON AND STEEL.

BY H. DU BOIS AND E. TAYLOR JONES.

Under the above title we communicated, on May 1st this year to the Physical Society of Berlin, the results of measurements on different materials which we had occasion to make during the past year.

In metallurgy much progress has recently been made in this direction, chiefly in consequence of the introduction and well-known application of rational methods of magnetic measurement, which have in recent years found their way from the laboratory into the ironworks. It is therefore of interest both to the physicist and to the technical electrician to look round and see how much has so far been accomplished.

Of the material obtained for examination we choose, on the one hand, five "soft," on the other three "hard," kinds, which appear to us to be characteristic. These are given in Table I. in increasing order of magnitude as regards hysteresis.

For various reasons we considered it of little value to carry out chemical analyses of the specimens; in the present state of technology it seems to us that the best way of defining a material is to give its source, without which a communication such as the present one would be of much less use. This definition is certainly very imperfect, for sometimes materials—especially such as are not easily fusible—nominally of identical quality show striking differences, as is well known and was often observed by us.

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**Table I.**

| No. | Material. | Source. |
|---|---|---|
| I. | Swedish wrought iron. | Sweden. |
| II. | Dynamo cast steel (Dynamo-Stahlfaçonguss). | Friedr. Krupp, Essen. |
| III. | Dynamo cast steel (Dynamo-Stahlguss). | Bergische Stahl-A.-G., Remscheidt. |
| IV. | Styrian wrought iron (Steirisches Walzeisen). | Gebr. Böhler and Co., Vienna. |
| V. | Dynamo cast steel (Dynamo-Stahlguss). | Oeking and Co., Düsseldorf. |
| VI. | Haarlem magnet steel. | N. van Wetteren, Haarlem. |
| VII. | "Special very hard" magnet [steel. | Gebr. Böhler and Co., Vienna. |
| VIII. | Wolfram steel. | Bergische Stahl-A.-G., Remscheidt. |

The results given here refer, therefore, strictly speaking, only to the specimens which were kindly placed at our disposal by the various firms; the reader can form his own opinion as to the relative qualities of the materials. Of course, it is by no means impossible that iron or steel can be obtained which we have not examined, and which gives better results as regards any particular quality.

For Iron No. I. we are indebted to the Physikalischtechnische Reichsanstalt; for Steel No. VI. to the kindness of Prof. Bosscha, of Haarlem. The measurements on the latter specimen were carried out by one of us in the laboratory of the Polytechnikum of Delft, through the kind permission of Prof. Snyders. To the above we wish here to express our best thanks.

*Apparatus.*

At rather low fields, up to ± 250 C.G.S., the measurements were made with the magnetic balance * described by one of us; this instrument had been tested and set up at the Phys.-tech. Reichsanstalt; the method of using the instrument is explained with all detail in the description cited. The hysteresis † in the above-mentioned range of field-strength has almost reached its greatest value corresponding to a complete cycle between the limits $-\infty < H < +\infty$. With the softest kinds of iron it was never necessary to go so far, provided that the range of magnetisation was nearly ± 1,500 C.G.S. With the hardest steel, on the other hand, the hysteresis could still be increased by a small percentage by increasing the range of field-strength to ± 500 C.G.S. (see below). We thought it unnecessary to determine "incomplete cycles" with narrower range and less hysteresis, since these are only interesting in connection with transformer-plate, and it was not part of our object to study this. Very complete and interesting results have moreover been given quite recently by Ewing,* which he obtained with his new hysteresis-tester; in these the hysteresis corresponded generally to the normal range of inductions $B = \pm 4{,}000$ C.G.S., and the calculation for other ranges was made by means of a table, which reaches to $B = 8{,}000$ C.G.S.

For our purposes we calculated a more extended table from determinations by Baily;† in Table II. we have put the maximum hysteresis (corresponding to the saturation value $I = 1{,}700$ C.G.S.) equal to unity, and expressed the hysteresis for smaller ranges of magnetisation as fractions of this.

**Table II.**

| ± I | u | ± I | u |
|---|---|---|---|
| 400 | 0·09 | 1,100 | 0·44 |
| 500 | 0·12 | 1,200 | 0·56 |
| 600 | 0·16 | 1,300 | 0·71 |
| 700 | 0·20 | 1,400 | 0·85 |
| 800 | 0·25 | 1,500 | 0·95 |
| 900 | 0·31 | 1,600 | 0·99 |
| 1,000 | 0·37 | 1,700 | 1·00 |

If the former is measured therefore for a material which is not too hysteretic, the latter can be approximately calcu-

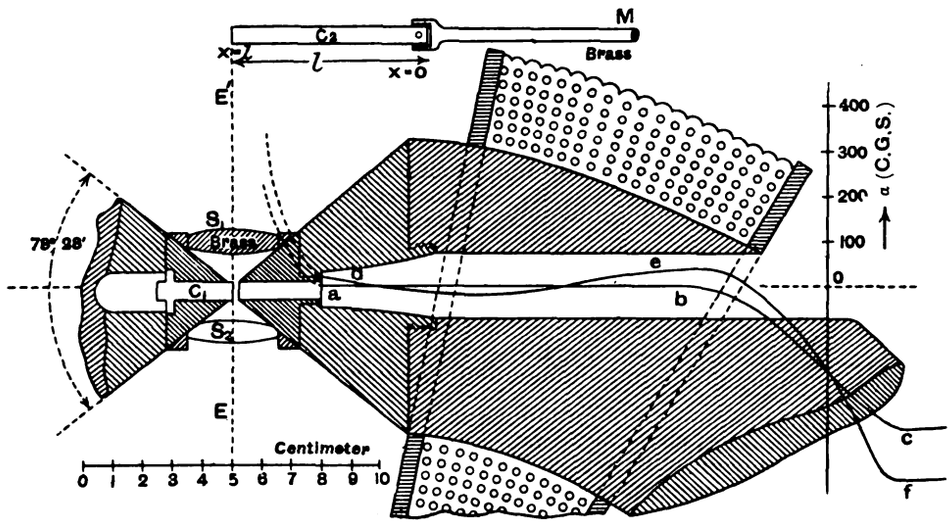


FIG. 1.

lated. The iron examined by Baily certainly had rather great maximum hysteresis ($u = 30$). For softer material a given approximation to this will exist at some smaller value of the magnetisation. We agree, moreover, with Baily in saying that the hysteresis is more rationally considered as a function of the magnetisation than of the induction.‡ As regards the purely empirical exponential expression given by Steinmetz,§ this only represents the hysteresis at the most within a narrow range.

We further tested a number of specimens at strong fields, up to 15,000 C.G.S., by the isthmus method of Ewing and Low, using a ring electromagnet.‖ The chief parts of the apparatus are represented in Fig. 1 (axial vertical section); the left half is to be supposed symmetrical with the right. The pole-pieces were conical, and had a vertical angle of 78deg. 28min., so that the field near the vertex was as nearly uniform as possible. These were accurately centred and axially bored through, the width of the openings being about 5mm. The bar $C_2$ (*see* Fig. 1) was turned from the same

* Du Bois, Ber. El. Kongress, Frankfurt, 1891, p. 77; *The Electrician*, Vol. XXVII., p. 634, Oct. 9, 1891.

† In what follows we call the energy dissipated in consequence of hysteresis (expressed in kilo-ergs per cycle per cubic cm.) for short, although not strictly logically, the *hysteresis*, and denote it by *u*.

* Ewing, *Proc.* Institution Civil Engineers, Vol. CXXVI., May 19, 1896. See also H. F. Parshall in the same volume; the latter, unfortunately, uses mixed C.G.S. and inch units, which makes the interpretation of his results very tedious.

† Baily, *The Electrician*, XXXVI., p. 118 (Fig. 9), 1895.

‡ Since the integral $\int H\,dH$ taken round a closed curve must vanish.

§ Steinmetz, *The Electrician*, Vol. XXVIII., p. 384, *et seq.*

‖ Du Bois, *Wied. Ann.*, LI., p. 537, 1894 (*cf.* Fig. 11 there).

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**Table III.**

| H. | I. | | II. | | | III. | | IV. | | V. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | I. | B. | I. | B. | | I. | B. | I. | B. | I. | B. |
| | | | | *d*. B. & J. | Ewing. | | | | | | |
| Curve of increasing reversals : | | | | | | | | | | | |
| 5 | 1,000 | 12,550 | 840 | 10,600 | 10,900 | 710 | 8,900 | 760 | 9,500 | 730 | 9,200 |
| 10 | 1,140 | 14,300 | 1,050 | 13,200 | 13,320 | 910 | 11,400 | 980 | 12,300 | 930 | 11,700 |
| 15 | 1,200 | 15,000 | 1,130 | 14,150 | 14,350 | 1,030 | 12,900 | 1,080 | 13,600 | 1,030 | 12,900 |
| 20 | 1,230 | 15,400 | 1,170 | 14,650 | 14,950 | 1,120 | 14,000 | 1,140 | 14,300 | 1,090 | 13,700 |
| 30 | 1,275 | 16,000 | 1,230 | 15,450 | 15,660 | 1,200 | 15,000 | 1,220 | 15,300 | 1,160 | 14,600 |
| 40 | 1,310 | 16,450 | 1,275 | 16,000 | 16,150 | 1,240 | 15,600 | 1,260 | 15,800 | 1,220 | 15,300 |
| 50 | 1,325 | 16,650 | 1,305 | 16,350 | 16,480 | 1,280 | 16,100 | 1,300 | 16,300 | 1,260 | 15,800 |
| 60 | 1,345 | 16,900 | 1,325 | 16,650 | 16,780 | 1,310 | 16,500 | 1,330 | 16,700 | 1,290 | 16,200 |
| 70 | 1,365 | 17,200 | 1,345 | 16,900 | 17,000 | 1,340 | 16,800 | 1,360 | 17,100 | 1,320 | 16,600 |
| 80 | 1,380 | 17,400 | 1,360 | 17,150 | 17,200 | 1,360 | 17,100 | 1,390 | 17,500 | 1,340 | 16,900 |
| 90 | 1,390 | 17,550 | 1,375 | 17,300 | 17,400 | 1,380 | 17,400 | 1,410 | 17,800 | 1,360 | 17,100 |
| 100 | 1,400 | 17,700 | 1,385 | 17,450 | 17,600 | 1,400 | 17,700 | 1,430 | 18,100 | 1,370 | 17,300 |
| Isthmus : | | | | | | | | | | | |
| 5,000 | 1,800 | 27,500 | 1,625 | 25,250 | ... | ... | ... | 1,780 | 27,400 | ... | ... |
| 10,000 | 1,830 | 32,900 | 1,750 | 31,900 | ... | ... | ... | 1,820 | 32,800 | ... | ... |
| 15,000 | 1,850 | 38,200 | 1,770 | 37,200 | ... | ... | ... | 1,850 | 38,200 | ... | .. |
| Cycle : | | | | | | | | | | | |
| Range | 1,380 | 17,400 | 1,420 | 18,000 | ... | 1,450 | 18,400 | 1,460 | 18,400 | 1,430 | 18,100 |
| Residual | 550 | 6,900 | 650 | 8,200 | ... | 600 | 7,500 | 550 | 6,900 | 650 | 8,200 |
| Coercive force | 0·8 | | 1·8 | | | 1·7 | | 2·0 | | 2·1 | |
| Hysteresis | 6·6 | | 12·5 | | | 13·5 | | 14·5 | | 17·0 | |

piece* as that used in the balance, to a diameter of 5mm., and fitted accurately into the opening in the pole-pieces, from which it could be quickly withdrawn by means of the brass rod M†.

Two small induction coils were used for the measurement of the induction and field-intensity, after the method of Ewing and Low. The area of the smaller coil was only slightly greater than that of the isthmus, while that of the other coil was considerably greater : these were in circuit with an Ayrton-Mather ballistic d'Arsonval galvanometer. From the throws observed on withdrawing the two coils the mean value of the induction within the isthmus and the field-intensity just outside it were calculated ; the latter is, by the principle of tangential continuity, equal to the intensity just inside the isthmus, which may be taken as the equal to the mean value.

*Magnetically Soft Material.*

In Table III. are given the results obtained with the five soft kinds of metal ; we thought it unnecessary to reproduce the corresponding curves, as these are, of course, very much alike. The bars of Nos. II., IV., and V., were prepared in the laboratory and then carefully annealed, in which process the temperature fell in 4 × 24 hours from 900deg. to 50deg.—quickly at first, then more slowly. The isthmus-bars of Nos. I., II., and IV., were also annealed after they were turned down. The first 12 rows of Table III. contain the values of the magnetisation **I** and of the induction **B** for the corresponding values of the abscissæ **H** in the curve of increasing reversals. The next three rows give the results of the isthmus measurements for the field intensities—5,000, 10,000, and 15,000 C.G.S. respectively. Finally, the last four rows show the chief characteristics of the complete cycles through which the material was taken—viz., the range of ordinates (**I** or **B**), the residual values of these quantities, and the coercive force and hysteresis (in kilo-ergs per cycle per cubic centimetre).

The numbers for the ascending curve are directly comparable with the results given by Ewing (*l. c.*, p. 28) ; and this comparison for a number of Continental and British products offers many points of interest. The Swedish wrought iron, No. I., tested by us, is inferior as regards permeability, in low fields at any rate, to the 99·9 per cent. Elswick pure iron (Ewing No. I.), which, however, is apparently only prepared for special purposes, and to the Jenkins' wrought steel (Ewing No. III.) ; its hysteresis and coercive force are, however, extremely small, and it is probably inferior to none in these respects.

In general, it follows from the results of Ewing and Parshall that very high permeability does not necessarily accompany very low hysteresis, but that these qualities rather, to a certain extent, exclude one another. It is the knowledge of this fact that has caused the processes of manufacture of dynamo-metal on the one hand, and transformer-plate on the other, to become so different. There are cases, however, though not very many, where the greatest possible union of these two properties is desirable—*e.g.*, the yokes used in some measuring methods, and shields used to protect galvanometers from disturbance, &c.

The Krupp cast steel No. II. has also been examined by Ewing (Ewing No. VI.), and we give his numbers along with ours ; as will be seen, the agreement is very close, and this speaks well for the uniformity of the material and the trustworthiness of the methods of measurement. A determination made at the Physikalischtechnische Reichsanstalt also gives approximately the same values.* Of the specimens of cast material examined, No. II. has the greatest permeability at low fields and the least hysteresis. The coercive force, however, is rather less in No. III.† Nos. IV. and V. have no very special properties.

As long ago as 1889 Negbaur described experiments on "cast iron (Flusseisen), which, in the present specimens, at any rate, can be magnetised as strongly as the best soft iron. Since it can be easily fused, it seems to be particularly suitable for the construction of dynamo machines and transformers."‡ Since then, judging by the present results, metallurgy has made considerable progress ; so that, for instance, the classical distinction between the properties of soft wrought iron, medium cast iron, and hard steel is nowadays completely effaced.

In addition to the well-known superiority of all cast material in the construction of machines, and its much more general applicability, another advantage may be mentioned here which it has from a theoretical point of view. The mathematical theory of magnetic induction expressly assumes a homogeneous and isotropic ferromagnetic substance ; this, however, has been very difficult to realise in practice, and the effect of the non-fulfilment of this condition could not be overlooked. By using cast material as uniform as possible, and

* In one case (Steel, No. VIII.) Dr. Erich Schmidt kindly tested the homogeneity of the bar by the method of electrical conductivity (*see* Eveling, *Zeitschrift für Instrumentenkunde*, XVI., p. 87, 1896. *Wied. Ann.*, LVIII., p. 342, 1896.

† This apparatus was used by one of us (E. Taylor Jones, *Phil. Mag.*, March, 1896) in experiments on magnetic tractive force ; the second bar $C_1$ was removed for the present measurements. Further details of the apparatus are given in the Paper cited.

* *Cf.* F. Krupp, *Magn. Untersuch. über Dynamostahlfaçonguss*, Essen, 1896. It is to be remarked that the specimen examined by us was rather bubbly at its axis.

† Ebeling and E. Schmidt find a coercive force of only 1·2 C.G.S. in a very carefully annealed specimen of cast steel. *Zeitschrift für Instrumentenkunde*, XVI., p. 86, 1896 ; *Wied. Ann.*, LVIII., p. 340.

‡ Negbaur, *Elektrotechnische Zeitschrift*, X., p. 351, 1889.

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free from bubbles, it now seems possible to completely attain this end; such a substance can be decidedly recommended, therefore, for all measurements of theoretical interest, and offers, moreover, a wider field of application, and greater facility in shaping to any desired model.

*Magnetically Hard Material.*

The most recent and complete synopsis of the literature, and the most valuable collection of tabulated results in this case, is given by Silvanus Thompson.* In his table (*l. c.*, p. 382) the greatest coercive force is 51 C.G.S.; as regards the hysteresis, the greatest value given so far scarcely exceeds 200. We give below the measurements for only three kinds of steel, the constants of which exceed those quoted above. These results are exhibited graphically in Figs. 2, 3, 4, and the chief constants are contained in Table IV. In the figures both the curves of increasing reversals and the hysteresis loops are shown; for the higher field intensities (above 150 C.G.S.) the scale of abscissæ is suitably modified.

* Silvanus Thompson, "The Electro-Magnet," Second Edition, Chap. XVI., London, 1892.

Silvanus Thompson expresses the opinion (*l. c.*) that the kinds of steel examined by him would be inferior to the so-called "Haarlem steel," although no measurements had been made to test this.* Fig. 2 proves the correctness of this opinion. It may be added that according to N. van Wetteren the steel now provided by him is no longer as good as the classical Haarlem material. Whether the latter was as good as our present "No. VIII., very hard," would be difficult to decide.

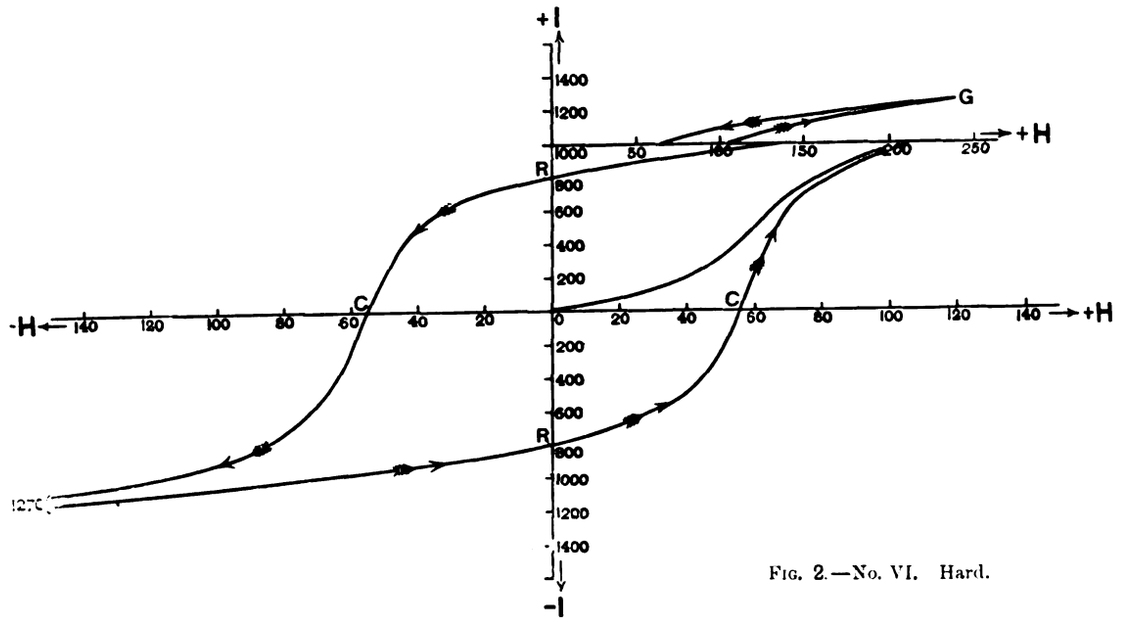


FIG. 2.—No. VI. Hard.

Fig. 3 shows clearly the characteristic effects of hardening: increase of coercive force, diminution of maximum and residual magnetism. The straight line through the point of intersection R″ of the two curves, which corresponds to the demagnetising factor N = 0·037, or the dimensional ratio 34 represents the limiting case in which the soft and hard material have the same amount of residual magnetism. For longer bars the soft steel is better; for shorter bars, the hard, except, of course, as regards constancy of the magnetisation.

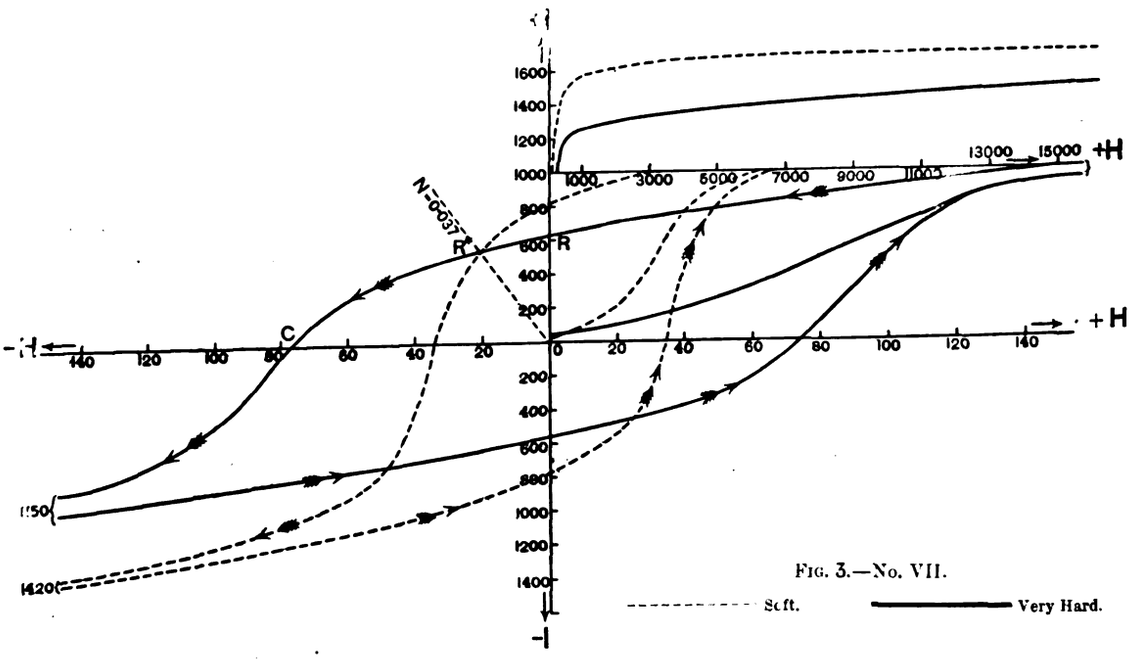


FIG. 3.—No. VII.

Soft. Very Hard.

Finally, the curves are shown in Fig. 4 for No. VIII. in three different states. The bar hardened in the factory has

* *Cf.* Van der Willigen, *Archiv. Teyler.*, Bd. 4, Haarlem, 1878

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**Table IV.**

| | VI.* | VII.† | | VIII.‡ | | | |
|---|---|---|---|---|---|---|---|
| | Hard. | Soft. | Very hard. | Soft. | Hard. | Very hard. | |
| Range of field | ± 240 | ± 240 | ± 240 | ± 240 | ± 240 | ± 240 | ± 500 |
| Range of magnetisation ... | ±1,270 | ±1,420 | ±1,150 | ±1,320 | ±1,320 | ±1,250 | ±1,280 |
| Residual magnetism ..... | 800 | 790 | 600 | 850 | 850 | 800 | 800 |
| Coercive force | 56 | 34 | 75 | 35 | 53 | 72 | 77 |
| Hysteresis .... | 210 | 145 | 225 | 140 | 205 | 265 | 275 |

* Hard; hardened in the factory. † Very hard; hardened in the laboratory. ‡ Hard; hardened in the laboratory. Very hard; hardened in the factory.

as far as we are aware, the greatest hysteresis ($u = 265$) ever observed. By increasing the range of field from ± 240 to ± 500 C.G.S., this quantity could still be increased a little ($u = 275$). As the thickly drawn curve (Fig. 4 on the left) shows, this is due to increase not of residual magnetism, but of coercive force from 72 to 77 C.G.S.

of the residual magnetism for the corresponding value N of the demagnetising factor, as follows immediately from a well-known construction.

Above the scale for N is another for the corresponding dimensional ratio $m$, for bars, according to the determinations of Riborg Mann.* It will be seen immediately from the figure that, for instance, with infinitely small demagnetising force the greatest possible residual magnetism is 800 C.G.S. for that specimen; with $m = 30$ this is reduced to 700 C.G.S., and with $m = 15$ is only 430 C.G.S.; in making strong magnets, therefore, it is better to have the length not less than 30 times the diameter. If the magnet is not a straight bar, but has a horseshoe form, for example, or any form of magnetic circuit, the corresponding demagnetising factor is to be used, and this can be calculated in a sufficiently well-known manner.†

If it is not so important to have high magnetisation as to have it constant—*i.e.*, absolutely permanent (two conditions which in a certain degree exclude one another), the coercive force must, of course, be made as great, and the demagnetising force as small, as possible; the former by properly choosing the material and by magnetising in a strong field—at least 500 C.G.S., according to the above measurements; the latter, expressed briefly, by arranging that the state of the magnetic circuit is represented not by a rather unstable point on the

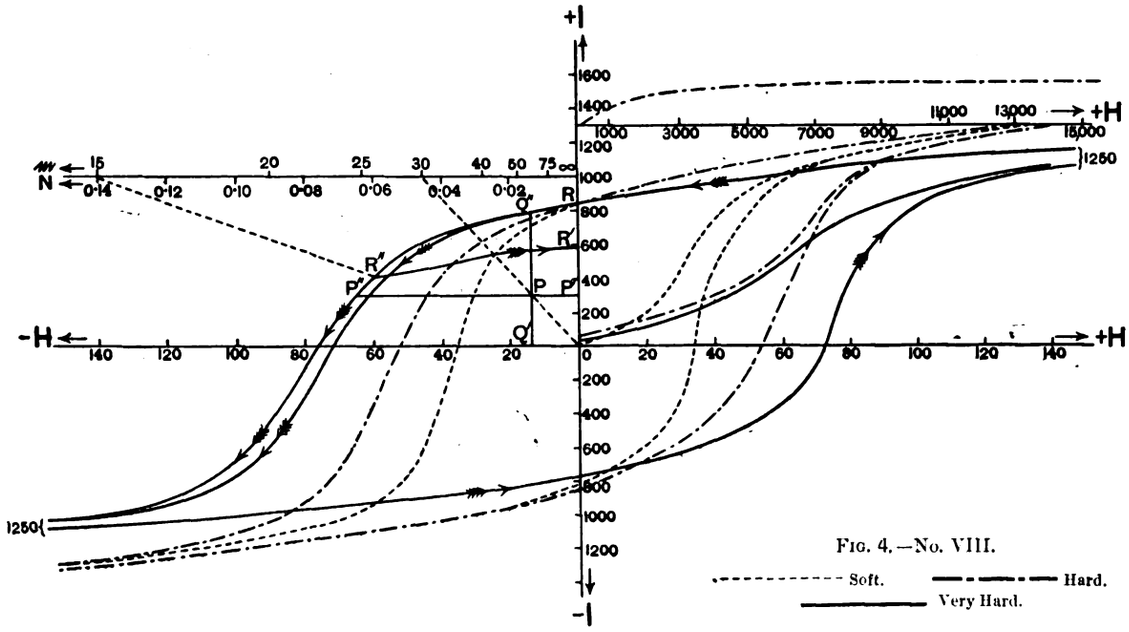


FIG. 4.—No. VIII.

Soft. Hard. Very Hard.

In this connection a communication by Abt§ should be mentioned; his results, when reduced to C.G.S. units, give for the coercive force of magnetite (magnetic oxide of iron $Fe_3 O_4$) about 50 C.G.S., for that of pyrrhotite ($Fe_7 S_8$) about 200 C.G.S., with a field-range of about 800 C.G.S.; the magnetisation in these cases is much less than that of steel. This peculiarity is shown in a still higher degree by the ferromagnetic amalgams; according to results about to be published, of measurements made in the laboratory of one of us, the coercive force of these substances may reach 400 C.G.S.

*Conclusions.*

Finally we would offer a few remarks which might explain a scientific and rational process for the construction of permanent magnets. This problem has, curiously enough, hitherto always been treated in a secret and empirical manner. When one has chosen the material to be used, and is clear about the method of hardening, tempering, and artificial "ageing," the next thing is to decide about the form of the magnet. To facilitate this we may draw an auxiliary axis to the left at the ordinate I = 1,000, and lay off along this the scale of abscissæ magnified a thousandfold (Fig. 4). If straight lines be now drawn from the origin to various points of this auxiliary axis, the point of intersection of one of these with the descending branch R P″ gives the greatest possible value

§ A. Abt, *Wied. Ann.* LVII., p. 139, 1896.

descending branch R P″ of the magnetisation curve, but by a point lying inside the loop, such as P (N = 0·046, I = 300, demagnetising force = 13 C.G.S., Fig. 4). Such a point represents a far more stable state. It may be mentioned that for a magnetic circuit in which there is no current the point always lies on the corresponding "line of demagnetising force" O P.

The magnetisation P Q′ is now less than the value Q″ Q′, which is also possible with the same demagnetising force; this may also be expressed by saying that the demagnetising force P P′ is less than the value P″ P′, which it may also have with the same magnetisation; the ratio $\frac{P''P'}{PP'}$ is, in the present example, $\frac{65}{13} = 5$. Houston and Kennelly call it the "factor of safety" of demagnetisation, and show that this varies in

* C. Riborg Mann, *Ueber Entmagnetisirungsfaktoren Kreiscylindrischer Stäbe, Dissert.* Berlin. 1895.

† Houston and Kennelly published in *The Electrician*, XXXV., p. 160, 1895, "A Contribution to the Theory of Demagnetisation," in the chief part of which we could find nothing more than the theory of a divided ring, which one of us published in 1890 (Du Bois, *Verh. Physik. Gesellsch.*, IX., p. 84, 1890; *see also* "The Magnetic Circuit," London, 1896); the introduction of an American magnetic nomenclature does not make any essential difference. The fact that this nomenclature has not been adopted appears to us to indicate that it is considered unnecessary and confusing; we make this remark here because there is still in Europe also some discussion about magnetic nomenclature.



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good magnets between 3 and 6. The above-mentioned stable state can be attained in the following ways.

Firstly, electrically, by applying a weak demagnetising current;* if, for instance, the specimen is demagnetised as far as R″ (Fig. 4) and the current then gradually removed, we arrive at a point on the curve R″ R′ which is within the descending branch R R″, and therefore represents more stable conditions.

Secondly, geometrically, by magnetising with a greater value of N than is intended, and then diminishing this, *e.g.*, by narrowing down the interferric space, or using suitable keepers or pole-pieces; if, for instance, the initial value of N is 0·14, then starting from the point R″ we can reach a point on the line through the origin corresponding to the final value of N.

Finally, mechanically, by artificially ageing the specimen, in which process the intentional bad handling of the magnet can be carried to any desired degree; in this case the specimen is taken along a straight line further into the region of stability towards the origin of co-ordinates.

We have good reasons for believing that the various more or less secret processes used in making permanent magnets depend on one or on a combination of these methods.

## THE SHEFFIELD TRAMWAYS.

The local papers have lately devoted considerable space to the tramway question at Sheffield. The exact position of affairs remains nevertheless somewhat of a puzzle to those not fortunate enough to reside in the city of cutlery. The following summary may, therefore, serve a useful purpose in showing exactly how matters stand, and what are the chances of the adoption of electric traction.

The tramways in Sheffield having recently come into the possession of the Corporation, owing to the expiration of the lease under which they had been worked by a company, the questions of the extension and remodelling of the system, and of an improved method of traction, are occupying the attention of the Corporation Tramway Committee.

The existing tramways run through nine miles of streets, and are cut up into three sections, the starting point of each section being several hundred yards apart. This disjointed system is probably due somewhat to the apathy of the late Company, whose headquarters and management were in London, but chiefly to the narrowness of the streets in the centre of the city, and to the heavy gradients. During the past few years extensive street improvements have been in progress, and these will shortly culminate in the widening of High-street into a thoroughfare 80ft. in width. On the completion of this work it will be possible to connect all the tram lines at a common centre, and to carry out such a scheme of extension as will more fully meet the public requirements. To what extent such extensions will take place must depend entirely on the system of traction to be adopted. The Tramways Committee has laid out on the map a very comprehensive network of tram lines running into most of the residential districts within the city boundary.

Sheffield lies in a basin, and the gradients of many of the streets are long and heavy. On the existing lines there are gradients of 1 in 20, and on the projected lines there are still steeper slopes, so that it is probable that some of the proposed extensions may have to be abandoned unless electrical traction or cable traction be adopted. On some of the projected routes horse traction is quite out of the question. The Committee has been inundated with recommendations and proposals with regard to the future method of propulsion, but the electric system is most in favour with the Committee and with the community. The popularity of the electric system may possibly be due to the fact that it is the least understood by the public. There is, of course, no doubt as to the suitability of electric power for taking the cars quickly up the gradients, and possibly full reliance may be placed on the system of brakes for letting the cars go safely down.

Electric traction, *per se*, is, of course, an accomplished fact; but the Committee—which has undertaken a great responsibility in this connection—has to carefully inquire whether electric traction, with its conductors either overhead or underground, can be used on the local gradients in a commercial sense, that is to say, whether it will pay with the fares at low rates, and even if so, whether such a system is more reliable and cheaper than the cable system or any other improved method of traction. With this end in view a Sub-Committee of the Tramways Committee has been appointed to make the usual trip to the Continent. It is a misfortune that this Sub-Committee should be composed chiefly of gentlemen of the legal fraternity. In an investigation of this nature, and of such magnitude in its consequences, some acquaintance with practical mechanics ought to have been a qualification for membership of the Committee of Inquiry; and if this was impossible, then the Committee should have been strengthened by the addition of an electrical adviser. The Committee, which is to be accompanied by the City Surveyor, will make its report in due course.

* According to Hookham, *Phil. Mag.* (V.), XXVII., p. 187, 1889; *Journal* Institution Electrical Engineers, XVIII., p. 688, 1889.

## THE PROGRESS OF THE SHOREDITCH SCHEME.

Seeing, a short while since, that the Vestry of St. Leonard, Shoreditch, had got so far with their novel electric-lighting undertaking as to decide upon the gentleman (Mr. R. F. Ferguson) who will have to look after the enterprise when once it is launched, we thought it advisable to make a few inquiries as to the exact position of affairs. Coronet-street, Shoreditch, is not exactly a well-known thoroughfare; but there at the present moment will be found the embryo of what promises to be one of the most interesting electrical ventures we know of. Mr. H. E. Kershaw, the Chairman of the Electric Lighting Committee and the energetic advocate of municipal electricity in Shoreditch, expects to see the station in operation by next Christmas. At the present moment, however, a visitor will find only the 150ft. chimney, a few bare walls, and a six-unit battery of half-erected Babcock-Wilcox boilers. Half the ducts for the cables, on the other hand, are laid, and the sub-stations are well-advanced. The iron-work for the roof is now coming in, and the buildings will be pushed on rapidly.

A brief summary of what the Shoreditch Vestry propose to do may be of interest. Having to dispose annually of some 20,000 tons of ashbin refuse at an annual cost of nearly £2,000, it occurred to the Vestry that it would be well, by combining a refuse destruction with an electric lighting scheme, to avoid this expenditure and to turn the refuse to useful account. Mr. Manville concurred in the idea, and drew up all plans. Shoreditchians are largely employed in cabinet-making; hence shavings, &c., are a drug in the market, and the calorific value of the Shoreditch trade refuse is abnormally high. Mr. Manville made exhaustive tests with unsorted refuse, and when burnt directly in a boiler found that one pound of it evaporated as much as 3lb. of water from and at 212°F., and advised the Vestry that *all* the steam required for the estimated output of the first instalment of plant could be raised without using any other fuel.

To-day, therefore, six Babcock-Wilcox boilers are in course of erection, and each is to be heated by a pair of cells arranged so that the hot gases can be shut off or turned into any boiler of the battery. The cells have each a grate area of 27 sq. ft., and together with the boiler furnaces are fitted with two systems of forced draught, one being an air blast, the other an induced blast produced by steam jets. Ten cells will suffice to dispose of the annual output of refuse. At the end of the flues is placed a dust-depositing chamber.

But the raising of all the steam required by an electric-lighting station from the combustion of the local refuse is not the only novel feature of the Shoreditch scheme. Mr. Druitt Halpin's thermal storage idea is to be tried, at first more or less tentatively, with a single cylinder 35ft. × 8ft., in which the working pressure will range from a maximum of 200lb. to

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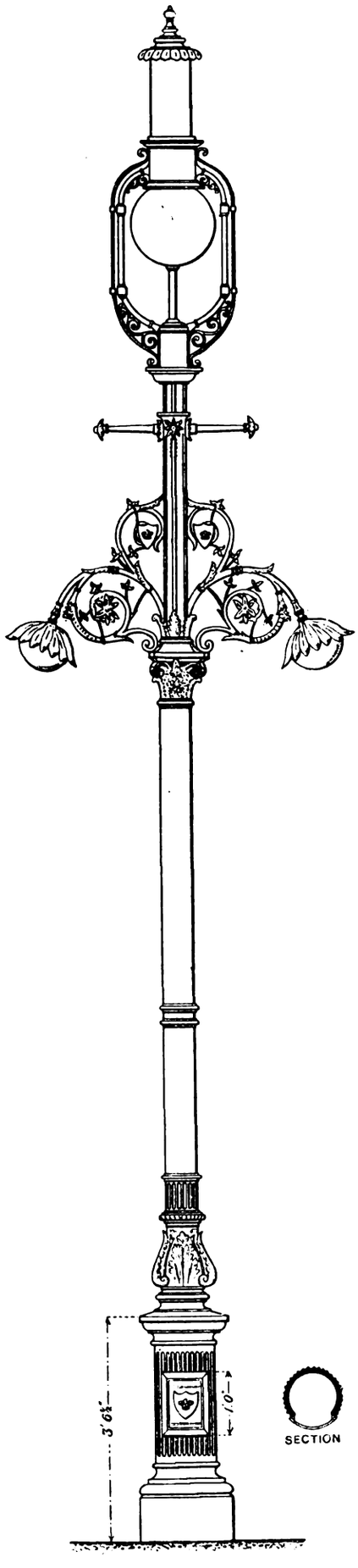


Fig. 1.—Sketch of Proposed Combined Arc and Incandescent Lamp Column.

the square inch down to 120lb. The Shoreditch Vestry have indemnified themselves against the worst consequences of a failure of the dust-destruction thermal-storage scheme by exacting heavy guarantees from the contractors, Messrs. Manlove, Alliott, and Co.

The generating plant will consist of three three-crank Willans engines, coupled to E.E.C. 165-kilowatt dynamos, giving 1,100 volts at 350 revolutions, and three three-crank Willans engines, coupled to E.E.C. 70-kilowatt dynamos, giving 165 volts at 470 revolutions.

Distribution will take place on the two-wire sub-station system, at 150 volts.

The street arc lamps, 57 in number, will be run off the 1,100-volt generators in three groups of 19 lamps in series. The arc lamps will be of the Brockie-Pell 12½-ampere type. They will be mounted on pillars 20½ft. high, of the elegant type shown in Fig. 1, and will be switched off from the station at midnight, the two 32 c.p. glow-lamps mounted on the side arms being simultaneously switched in, and run off the distributing mains. In the event of an arc lamp failing from any cause, the glow-lamps will be automatically lighted up. In addition to the arc lighting, all streets in which there are distributors will be lighted by 32 c.p. glow-lamps; each existing gas lamp being fitted, as shown in Fig. 2, with the effective arrangement of matte-zinc reflectors, devised by Mr. Arthur Wright for the minor streets of Brighton.

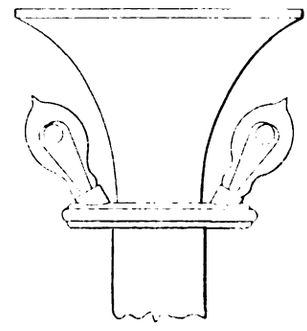

Fig. 2.—Sketch of Wright Reflector as used in Street Lamps for Glow-Lamp Lighting.

The mains are to be partly lead-covered paper-insulated cables by the Prescott Company, and partly lead-covered india-rubber insulated cables by Messrs. W. T. Glover and Co., all drawn into Doulton stoneware conduits (see *The Electrician*, Vol. XXXVI., p. 653, March 13, 1896). There will be 10 miles of conduit.

Accumulators of the Pritchett-Gold type will be used to light the station, and there will be four transformer substations, where E.C.C. motor-generators, driven by the 1,100-volt dynamos, will feed into the two-wire network.

The tariff will be arranged on the system devised by Mr. Wright, 6d. a unit being charged for the first two hours of the maximum demand, and 4d. being levied afterwards. Current for motors will be charged for at the rate of 3d. a unit, if used night and day, and at the rate of 2d. a unit if used only up to dusk. The supply of current to motors is expected to form a very large part of the business of the Shoreditch station. Shoreditch, we may add, is about one square mile in area, and nearly triangular in shape, the apex of the triangle pointing towards the City. The Coronet-street station is very nearly at the centre of the district.

The progress of a scheme involving such an unique concatenation of more or less novel features will be watched with the greatest attention by electrical engineers all over the world.

The Shoreditch Vestry also intend starting a wiring business. This, too, is more or less novel; but though we freely admit the idea is very tempting, we cannot commend it, for reasons already given in *The Electrician* of November 8th last year, p. 31.

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**The Electrical Equipment of the "Bouvines."**—The 6,600-ton coastguard ironclad "Bouvines" of the French Navy is, electrically speaking, very thoroughly equipped. With the exception of the revolving mechanism of the two big turrets containing the two 30-centimetre guns, all the auxiliary machinery of the "Bouvines" is driven by electricity; helm-indicators, ventilators, shot-hoists, &c., &c. The generating plant consists of four 400-ampere, 80-volt two-pole direct-coupled Sautter-Harlé dynamos, all situated in the main engine-room of the ship. The lighting is carried out by 460 10-c.p. lamps, 34 30-c.p. lamps and 17 50-c.p. lamps. There are five 70-ampere projectors, all electrically operated from a distance. The motors number 20, of which eight are allocated to ventilating fans, and the rest, with one exception, to shot hoisting. A 10-ampere servo-motor works the valve gear of the steam-steering engine. As the helm revolves, contacts are successively made which ring a bell and light up a group of glow lamps in such a manner as to indicate the position of the rudder. This curious method of indication has been, we may remark, subjected to considerable adverse criticism from competent naval men.



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## TITULAR HONOURS.

A foremost place in the Englishman's creed is occupied by the belief that he possesses in a peculiar measure the happy faculty of adapting old institutions to modern conditions, of pouring new wine into old bottles without disaster to the vessels or detriment to the vintage. Of the many instances that may be cited in support of this tradition, perhaps none is more to the point than the changes that have from time to time been made in the qualifications necessary for admission to the ranks of the peerage. For many centuries a capacity for giving and taking hard knocks, especially the former, was an indispensable requisite; then the stream of honours flowed more particularly towards those able to organise and watch over the welfare of the lands won by the hard fighters, towards the statesmen and lawyers, in short; and to-day probably the easiest course to take is to brew good beer, weave fine cloth, or contribute heavily to party funds. The "last scene of all that ends this strange eventful history" may seem somewhat unheroic, but it is distinctly businesslike; and do we not live in an age which prides itself upon being the age of business?

But the work of the world is coming more and more to be conducted on scientific lines; that is to say, it is upon those who devote their lives to sifting fact from fiction, to the minute investigation of known facts, to the discovery of new facts, and to the tremendous task of marshalling in orderly array the motley hosts of the kingdom of knowledge—it is upon these, we say, that the burden and heat of the day now mainly falls. Nevertheless, the showers of titles, stars and crosses which descend with clocklike regularity every New Year's Day and every Royal Birthday, fall as doth the rain from the heaven alike upon the deserving and undeserving soldier, sailor and successful merchant. The force of tradition was never better exemplified. Doubtless the "safety, honour, and welfare" of the State still depend in a very large measure upon straight shooting, tortuous diplomacy and commercial push; but although every year that passes renders these qualities less potent, there

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is no visible alteration in the direction of the semesterial shower. In the heroic days of modern science this neglect passed unnoticed both by the scientific world and by the public. An investigator was then invariably known as a "natural philosopher," a term which to this day connotes, in the minds of many, a wise-looking stately old gentleman surrounded by rows of mysterious-looking bottles, with a globe and compasses on his right hand and a furnace and balance visible in the dim distance. Stars, titles, crosses were obviously not wanted by such ROGER BACONS.

We have altered all that now. We no longer burn our *savants*, but endow chairs for them; and they in turn no longer hide their light under a bushel and affect mystery, but are as other men, appreciating to the full the outward and visible signs of popular admiration, as well as the more intangible appreciation of their co-workers. This is a very natural development. A foreign professor once complained to us, with considerable gesticulatory vehemence, that a powerful colleague, persistently and of malice prepense, refused to recommend him for a red ribbon. In the best OLLENDORFF French we endeavoured to make plain our opinion that it was, perhaps, a greater honour *not* to belong to a membership the name of which is legion. 'Twas in vain. It was explained to us, again with much gesticulatory vehemence, that to remain, after a certain age, without the magic red ribbon was to suffer seriously in public esteem; one's friends and relations all with one accord would exclaim, "*C'est une carrière manquée.*" In England we have not got quite so far as this; but it is noticeable that no scientific celebration is in these days thought complete without the presence of Royalty. View the matter as we may, certain it is that nothing would bring home more unmistakably to the minds of the multitude the fact that science has "arrived" than a diminution of the absurd disproportion which at present exists between the titular honours annually granted to the Army and Navy, to Commerce and Politics, and those bestowed upon men who have laboured long in the field of Science, and reaped abundantly therein.

## THE PART PLAYED BY THE DIELECTRIC IN THE DISCHARGE BY RÖNTGEN RAYS.*

BY JEAN PERRIN.

In investigating the discharge of an electrified body by Röntgen rays a phenomenon is brought out which determines in a precise manner the part played by the surrounding dielectric.

I. It is easy to ascertain that X-rays can discharge an electrified body in a few seconds without even so much as grazing the body in question, and this simply by traversing the gaseous medium which surrounds it. We must therefore only allow the rays to penetrate into the regions which we wish to investigate. This precaution taken, one very quickly sees that *the tubes of force encountered by X-rays behave as conductors*, provided the tubes of force are in a gas. Secondly, the electrified body placed in an atmosphere *in repose* discharges itself if some of the tubes of force which it emits are met by the rays. In the same way an insulated conductor without initial charge, but placed in an electric field, is charged when the rays cut the tubes of force.

I will only describe one of the experiments which justifies these conclusions.

A rectangular strip P', cut out of one of the plates of a condenser P Q, is joined to the needle of an electrometer. At the commencement of the experiments it is also joined to the rest of the plate P, which thus plays the part of a guard ring. The condenser is charged and the communication between P' and P is cut, and the rays are passed so as to touch neither of the plates of the condenser, which are 0·05 metre apart. The action is powerful when the rays, which are perpendicular to the plane of Fig. 1, pass at the point A, and it remains the same when they pass at the point B; but the action becomes practically zero when the rays pass at the point C. Now the distance B C is about equal to the width of the beam of rays, that is to say, about 0·01 metre. Anything, therefore, which may be due to convection and to the diffusion of the gas cannot be sensibly changed when this beam, instead of passing at B, passes at C; but in the latter case the tubes of force emitted by P' are no longer encountered by the rays.

II. In order to explain the part played by the tubes of force, it is only necessary to suppose that the rays dissociate certain molecules of the dielectric where they penetrate it, thus liberating positive and negative ions. If there is an electric field the positive ions are drawn in the direction of the field, and the negative ions in the opposite direction. If in addition the medium is gaseous, the two systems of ions may pass through each other, always, however, along the

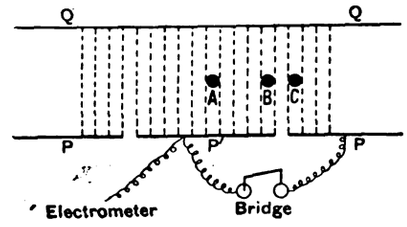


FIG. 1.

tubes of force. They travel in this way until they meet the charges which terminate the tubes, or, for instance, until they are mechanically arrested by a rigid obstacle. Electricity can thus traverse gases in a way totally different to ordinary electrolysis.

It does not seem necessary that the field should pre-exist. It is quite sufficient to bring it into play before the dissociated molecules have time to recombine. We can thus explain how J. J. Thomson and Röntgen have been able to discharge electrified bodies by passing over those bodies air which had previously been traversed by the rays. Speaking generally, the rays furnish the energy necessary to separate the ions, and the electric field the energy necessary for their transmission.

III. The electricity which traverses the gas under the influence of the field would, on this hypothesis, be almost equal to the quantity of neutral electricity dissociated by the rays, and, in fact, experiment proves that there exists a maximum rate of discharge (*débit*) independent of the field.

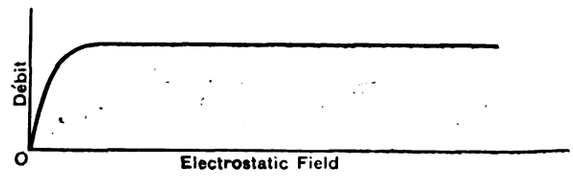


FIG. 2.

To assure myself of this, the condenser, P Q, already described, was employed. The distance of the plates was varied from 1cm. to 10cm., and their difference of potential from 2 volts to 220 volts, the field, therefore, varying in the ratio of 1 to 1,100. If we plot the values of the field as abscissæ, and the corresponding rate of discharge as ordinates, the curve shown in Fig. 2 will be obtained, and this curve clearly shows that a maximum rate of discharge is quickly attained.

This result may be obtained also by a zero method eliminating the influence of the variations of the Crookes' tube. Using one and the same electrometer we can employ two identical condensers P Q, $P_1$ $Q_1$, traversed by the same ray, but with the plates $P_1$ and $P_1'$, connected to the needle oppositely charged, so that the needle remains at zero if the total rate of discharge is zero. I have ascertained that the rate of discharge varied less than 1/200 when the field varied from 350 to 1,100. According to the hypothesis enunciated, it is this maximum

* From the *Comptes Rendus*, Vol. CXXIII., No. 6, p. 351.

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*débit* which is a measure of the quantity of neutral electricity dissociated by the rays.

IV. I investigated how this maximum varied according to distance from the source and volume influenced by the rays. When I sent through the condenser P Q conical beams having solid angles 1, 2, 3, and 4, I obtained rates of discharge proportional to 1, 2, 3, and 4. Similarly, employing the same cone, but with distances proportional to 1, 2, and 3, I obtained rates of discharge proportional to 1, 2, and 3. The quantity of neutral electricity dissociated by the rays inside a spherical layer, having for centre the source of emission, is therefore independent of the radius of this layer and proportional to its thickness. This law, analogous to the law of the inverse square of the distance gives meaning to the following definition :—*The quantity of X-rays* radiated inside a cone, the apex of which is the source of the rays, is proportional to the quantity of electricity dissociated in this cone per unit of length in a given gas and at a given pressure and temperature. The definition of the brightness (*éclat*) in a given direction immediately follows.

V. This definition is only admissible if the rays are absorbed but very slightly as they proceed. In order to see to what extent absorption might be neglected I connected two identical condensers, 25cm. apart, to the same electrometer, the condensers being traversed by the same beam. The discharge in the second condenser was found to be weaker to the extent of about $\frac{1}{25}$th. This weakening is probably due to the absorption by the medium.

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In the *Comptes Rendus* for August 24th, Prof. Righi has a note "On the Electric Convection along the Lines of Force caused by Röntgen Rays," in which he describes some pretty experiments tending to show that the action of X-rays results in convection movements along the lines of force of an electric field.

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## THE NEWPORT ELECTRIC LIGHTING WORKS.

In 1889 the Newport (Mon.) Corporation, having received notices from three separate companies of their intention to apply for Provisional Orders, an Electrical Committee was formed to deal with the subject. This committee, after a visiting tour to various stations, recommended the Council to apply for an Order themselves, which was obtained in 1891. They then visited the St. Pancras station, and had a conference with Prof. Robinson, who recommended their adoption of a low-pressure scheme, with distribution on the two-wire system, which was to be ultimately changed to a three-wire system, when the demand reached 5,000 lights. In the meantime, however, the Council had been converted in their views in favour of a high-pressure scheme. This entailed more visiting by the Committee, with the ultimate result that a high-pressure system was agreed upon, and Mr. Robert Hammond appointed consulting engineer.

In 1893 Mr. Hammond reported, and tenders were invited, those of Messrs. Fowler and Co., of Leeds, being accepted for the generating and distributing plant, including arc lamps and posts, but with the exception of the four large steam engines and the cables. The contract for the engines was placed with a local firm, the Uskside Engineering Company, of Newport; and that for the cables with Messrs. Siemens Bros. and Co., of London. Messrs. Gradwell and Co., of Barrow-in-Furness, were contractors for the buildings, &c., which were to the designs of Messrs. Conyers, Kirkby and Son, of Newport.

**Station Site and Buildings.**—The station is well situated on a plot of ground known as Friars' Fields, it being near the area of supply, and adjoining a siding of the Great Western Railway. A canal from which condensing water is obtainable is also in close proximity. There is ample room for future extension of the buildings, which at present include a boiler house 93ft. × 43ft., an engine room 93ft. × 50ft., and a separate room for a plant, the special duty of which is to supply the day load of the station.

The chimney is square, the net inside dimensions of the shaft being 5ft. 9in.; it has a fire-brick lining to a height of 50ft., the total height of the stack being 100ft. Ventilating grids inserted near the ground, and also near the upper limit of the fire-brick lining, connect the space between the lining and the main brickwork with the outside atmosphere.

**Steam Generating Plant.**—The boiler house at present contains four Lancashire boilers, each 28ft. long by 7ft. 6in. diameter, and capable of evaporating 4,500lb. of water per hour from a feed temperature of 60°F. The grate area is 36 sq. ft., and flues are 3ft. diameter. Mild steel, $\frac{23}{32}$in. thick, is used in the shell, each ring of which is in a whole plate; the longitudinal seams are butt-jointed with double-cover straps. The usual working pressure is 125lb.; but the boilers are capable of working at 150lb. per square inch. Procter's mechanical stokers, driven by a small horizontal steam engine, are used for firing the boiler furnaces; but they are not arranged to move the fire bars, as Meldrum's system of forced draught is also fitted. Hopkinson's fittings and mountings are used throughout.

The feed pumps are three in number, and are of Pearn's "Duplex" type, each capable of delivering 1,500 gallons of water per hour. They take their water from a reservoir, which can be fed from either the canal or from the town mains, and deliver into the boilers through either of two systems of feed pipes, the water, in the one case, passing through feed heaters, or, in the other case, direct into the boilers. The main feed-water pipes are of 3½in. cast iron, the branches to boilers being 2½in. diameter. There are three "Berryman" feed-water heaters, capable of raising the temperature of the feed water to 200°F. when the engines are working non-condensing.

In the adjacent day-load plant room above referred to is installed a semi-portable combined under-type engine and boiler, the working steam pressure of which is 140lb. per square inch. This plant is also fitted with a small feed-water heater, a donkey pump, and the necessary steam and exhaust piping.

**Steam and Exhaust Piping.**—The system of piping for conveying steam to the engines is not on the ring principle. On the large main stop-valve on each boiler standpipe a casting for three branch pipes is fitted. These pipes carry three corresponding valves. From two of these branches spring 5in. wrought steel connecting pipes to boilers on either side; and these, being of an arched form, the necessity for any further provision for expansion is obviated. The remaining branch feeds into a 5in. wrought steel pipe leading to one of the four main engines. A 3in. wrought-steel steam pipe fitted to the otherwise unoccupied branch of an outside boiler in the range, supplies No. 6 engine. A steam pipe connects the day-load boiler with the main range of boilers. The wrought-steel pipes have welded flanges, and were made by Messrs. Stewart, of Glasgow. A 3in. wrought-iron steam main is fitted for supplying stoker engine, feed pumps, &c.

The exhaust is carried from each of the four large engines by an 8in. cast-iron pipe, which communicates by means of 11in. and 14in. pipes with a main 16in. exhaust pipe running to the heaters and independent condenser. By means of bye passes and suitably placed valves the exhaust steam may be directed to the atmosphere instead of into the condenser, through a 16in. uptake on the outside of the chimney stack. No. 6 engine exhausts either into the atmosphere direct through a 6in. cast-iron pipe, or into its own condenser which is self-contained with this engine.

In the boiler room near the heaters is an independent Worthington self-acting jet condenser, capable of maintaining a vacuum of 27in., and of dealing with the exhaust steam for 750 H.P. It has the usual two steam and two double-acting air pump cylinders characteristic of the Worthington "Duplex" arrangements.

**Engines.**—There are at present installed four main engines and a slightly smaller engine by Messrs. Fowler and Co., which, though installed as a temporary plant, is now likely to be taken over by the town. The day-load engine, No. 5, has already been referred to as being a semiportable undertype

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combination with the boiler. This engine is capable of developing 50 I.H.P., and runs at a speed of 135 revolutions per minute. The four larger engines are of the horizontal compound-coupled type, and were made by the Uskside Engineering Company (Limited) of Newport. They are capable of a continuous load of 150 I.H.P., with 125lb. steam pressure, and, on emergency and with a slight increase of steam pressure, 180 I.H.P. These engines are arranged for working with the before mentioned independent condenser, and they run at a speed of 110 revolutions per minute. Their fly-wheels, which are grooved for 8—1¼in. ropes, are 12ft. diameter, and weigh over eight tons. The high-pressure cylinders are 13in., and the low-pressure cylinders 24in. diameter, with a stroke of 24in. Hartnell's vertical high-speed governors control the expansion valves of both cylinders.

The results of a 12 hours' official test of one of these engines and a boiler are as follow :—

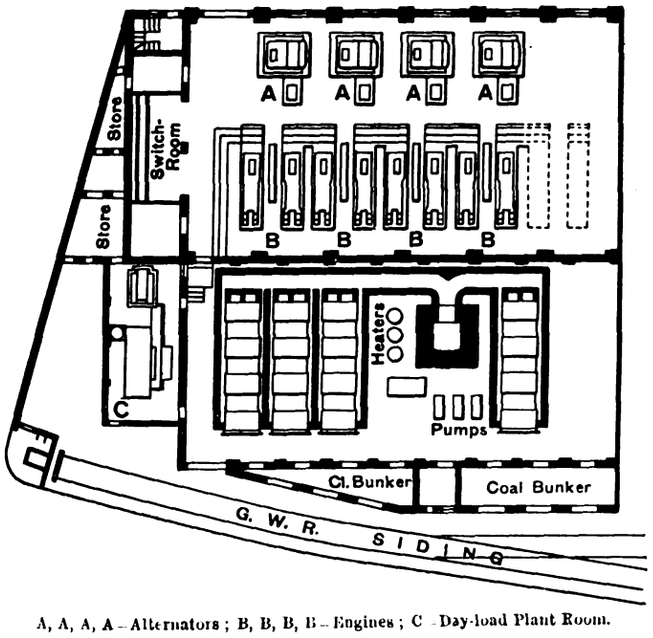
Mean indicated horse-power, 139.

Consumption of water per indicated horse-power hour, 18·4lb.

Consumption of water per kilowatt hour, 34·15lb.

Consumption of coal per indicated horse-power hour, 2·3lb.

Water evaporated per pound of coal by boiler was 9·52lb. from and at 212°F. The fuel used, we understand, was the Newport Abercarn "Black Vein" steam coal.




A, A, A, A—Alternators; B, B, B, B—Engines; C—Day-load Plant Room.

FIG. 1.—Ground Plan of Newport Electricity Works.

No. 6 engine—which occupies the site shown dotted in the plan, Fig. 1—is a 120 I.H.P. compound condensing engine, the condenser air pump being worked by the tail rod. The fly-wheel is 10ft. diameter, and is grooved for 5—1¼in. ropes, the speed is 120 revolutions per minute, and cylinders are 10in. and 18in. diameter respectively, with a stroke of 20in.

Spanning the engine-room transversely is a 10-ton travelling crane, by Messrs. T. Smith, of Rodley, Leeds.

**Alternators.**—Coupled direct to each of the four larger engines and to No. 6, by cotton ropes, is a 75-kilowatt 2,000-volt Hall alternator, made by the Leeds and London Electrical Engineering Company, of Leeds. Each machine is capable of working for an hour under a load of 90 kilowatts. The frequency is 87, at the normal speed of 525 revolutions per minute. The grooved pulleys are supported by outside bearings, and all the bearings are fitted with water-jackets for use in emergency. The centre distance between engine and alternator shafts is—in the case of the four larger engines—25ft., and in the case of No. 6 engine 22ft., approximately.

Driven from each alternator by means of four cotton ropes is a shunt-wound exciter for supplying the exciting current, which at full load is for each machine about 18 amperes at 100 volts. The combined weight of an alternator and exciter, with rails and bedplate, is about 12 tons, which is supported by a concrete foundation built up from a depth of 6ft.

No. 5 alternator, for the day-load service, is a 25-kilowatt Hall machine, with exciter on the same bedplate, and is driven by belt from the before-mentioned undertype engine in the day-plant room.

**Switchboard.**—The main switchboard—situated at one end of the engine-room—is of the Lowrie Hall type. It is built up of a number of sections of slate, supported upon a strong oak frame; those sections upon which the switches and instruments are mounted measuring about 15in. by 14in., while those carrying the fuses are deeper, being about 15in. by 20in. The main switches are of the usual Lowrie Hall pattern, consisting of four metal sockets, forming the terminals or contact pieces. These are fitted through the slate base, and are arranged so as to receive four corresponding metal plugs fixed to an ebonite hand block. The plugs, being connected in two pairs by copper strips, upon being pushed home they connect the two upper with the two lower sockets, thus forming a double-pole, double-break switch. The metal sockets are well protected and insulated by porcelain sleeves, having somewhat bell-mouthed openings, which guide home the plugs, making possible a quick and certain closing of the switch.

Referring to the diagram of the switchboard (Fig. 2), it will be seen that the 'bus bars are divided into two sections—an arrangement which permits of the alternators and circuits being divided into two distinct and independent sets. The two sections of the 'bus bar can be joined together by the coupling switch on the fourth slate section from the left and the second from the bottom. With the exception of this section, the four vertical rows of sections on the extreme left of the board are devoted to carrying the fuses, ammeters and main switches necessary for the distribution of the current from the 'bus bars to the five high-pressure public supply circuits and the two high-pressure circuits for the street arc service, which at present supply the town.

On the extreme right of the board are the three vertical rows of sections carrying the alternator fuses, the hand regulators or rheostats (for controlling the exciting currents, each rheostat being connected in the field circuit of the alternator it controls), the main switches between the alternators and the bars, and the alternator ammeters.

Around each main switch is built an enclosing box, across the open mouth of which can be set a locked vertical bar, which is found useful in preventing the accidental closing of a switch not in immediate use. The synchronising board—the connections to which are not shown—occupies the fourth and fifth sections from the bottom in the fifth row from the right. The 50-volt secondary terminals of each alternator converter (the converters having both 50 and 100-volt secondary terminals) are connected to its corresponding socket on this board, one pair of terminals to each socket. Then, by means of a couple of plugs and flexible cables, this board enables the 50-volt terminals of the converter of an incoming alternator to be connected with those of one already working on the bars, and with the synchronising voltmeter and lamps. On either side of this board are the sections carrying sockets, which enable any circuit to be run from any alternator independent of the 'bus bars—an arrangement termed "a hospital shunt."

To avoid unnecessary complication of the diagram, the permanent connections to these boards of only No. 1 alternator and No. 1 circuit are shown. By means of the ever-accommodating plugs and flexibles the two upper sockets of both boards (*i.e.*, of both machine and circuit "hospital" boards) may be put in connection with any pair of sockets below them, thus placing the selected circuit in connection with the selected alternator. Also, to avoid complication, the connections are shown omitted between the 100-volt secondary terminals of the alternator converters and the multiple contact switch seen on the section to the left of the machine voltmeter, and which enables it to indicate the pressure of any alternator (with the exception of No. 5, or day load machine).

Below this voltmeter, on a bottom section of the board, is shown the ammeter, which serves to indicate, by means of

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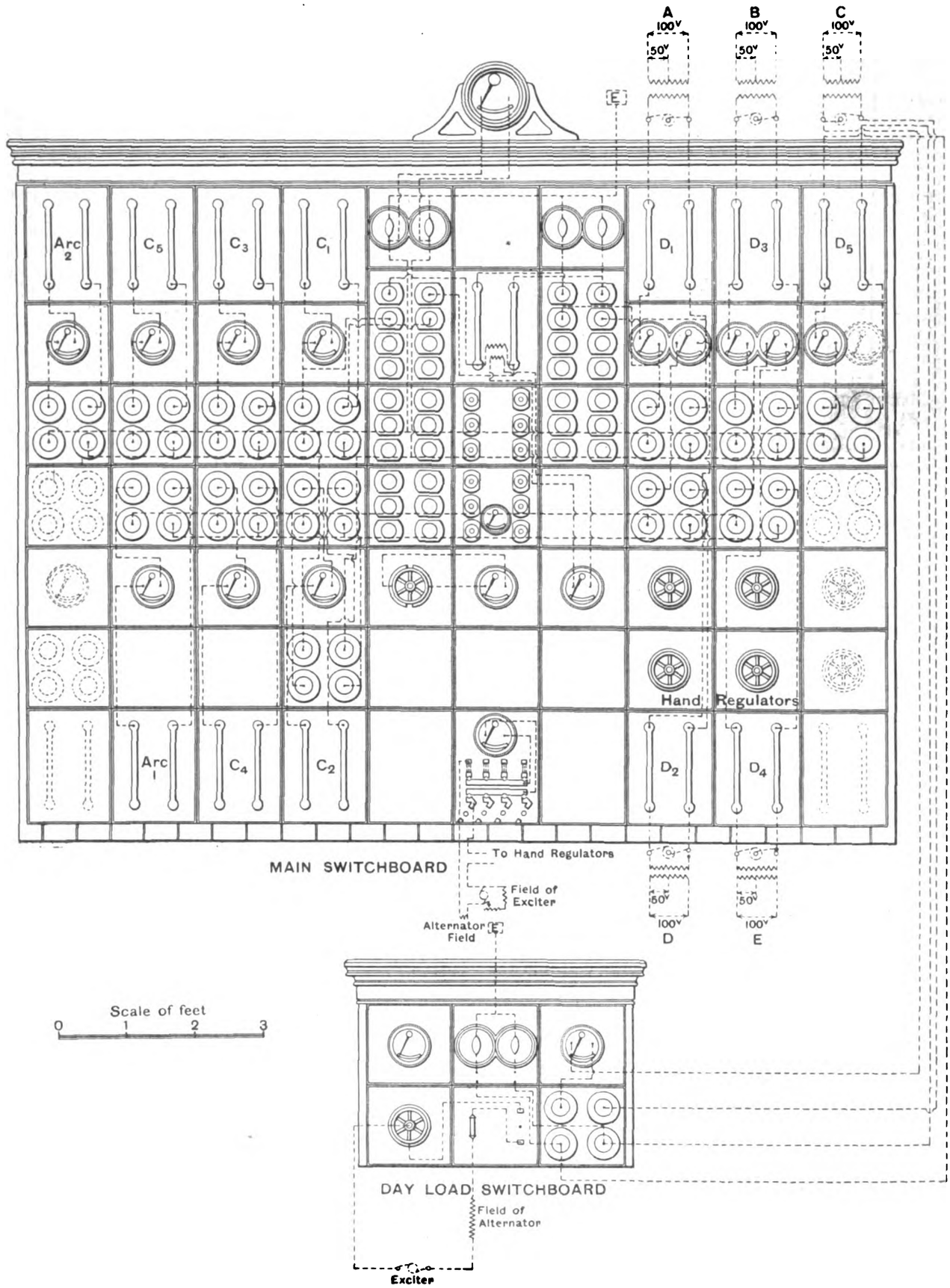
the switches shown in diagram, the exciting current of any alternator. The main fuses are mounted upon ebonite blocks, which, upon being thrust home in their places, throw the fuses into their respective circuits.

It may be noticed that the day-load plant, while it has a symmetrical portion of the main switchboard allotted to it, can also be controlled from a board of its own, situated in the day-load engine room, and connected electrically with the main board.




The 100-volt terminals of converters, A, B, D and E, to be connected to the Voltmeter Switch on main board, and those of converter, C, to the Voltmeter on day-load board. The 50 terminals of converters, A, B, C, D and E, to be connected to the Synchronising Board.

FIG. 2.—Newport Electric Lighting Switchboard.

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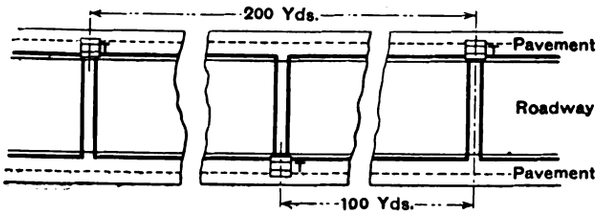
A Mengarini recording voltmeter is used, and half-hourly readings of the station current output are taken for log purposes. In connection with the fault detectors indicated near the top of the switchboard diagram, it may be mentioned in passing that it is intended to shortly start working with outer conductors of the high-pressure mains earthed. Placed in a conspicuous position, in full view of the engine drivers, are two indicators under the control of the switchboard attendant; one of these informs the driver whether he is required to increase or decrease the speed of the engine to which the other indicator refers.

Behind the switchboard is the usual passage about 3ft. wide, wherein may be inspected the switchboard connections, alternator measuring converters, &c., and beneath which is the trench containing the cables running to and from the board. The test room is adjacent to the recess in which the switchboard is placed, and contains the usual cells and instruments necessary for the testing work of a station.

**The Distributing System.**—The distribution of current for public supply is, in the main streets, effected by a system of low-pressure conductors at 100 volts, fed by transformers in cast-iron street boxes on 2,000-volt high-pressure mains. Outlying districts, where consumers are fewer and farther between, are, of course, supplied by the pioneer method, with the transformers in the consumers' premises.

The high-pressure cables for public supply are concentric, with conductors 19/18 and 34/20 respectively, insulated with vulcanised indiarubber. These are drawn into 3in. cast-iron




T = Transformer Boxes; ····· Dotted lines = High-pressure Mains; —— Full lines from transformer boxes = Low-pressure mains.

FIG. 3.—Diagram of Distributing Mains in Street.

pipes laid under the pavements. At street corners, and at intervals of from 80 to 100 yards in straight runs, are inserted cast-iron surface boxes, with the usual adjustable lid used in the Lowrie Hall system. The transformer boxes are also of cast iron, and virtually consist of a central oblong watertight transformer box proper, on to the sides of which are cast wings or smaller compartments, one on each side. Into one of these side boxes pass the high-pressure feeders, while the other side box protects the low-pressure distributing mains on their passage from the central transformer chamber. All the cables in their exit from the transformer box pass through stuffing glands, packed with indiarubber.

Each transformer chamber is capable of housing a 21-kilowatt transformer, and contains both high and low-pressure fuses and switches, and a Cardew earthing device. The switches are of a double-pole double-break type.

The system of low-pressure distributing mains is illustrated in Fig. 3, which is a diagrammatic sketch of a portion of a main street. From each transformer chamber issue four low-pressure cables. Two run up and two down the street. One of each pair follows one side of the street, the other immediately crossing and following the other side for a distance of 100 yards. The transformer boxes being placed alternately on different sides of the street, at every 100 yards of street-run the two cables above referred to rejoin on the low-pressure bars of the next transformer box to the one from which they started. Thus there is nowhere on the distributing mains a point above 50 yards distant approximately from a transformer, and in the event of a transformer failing, it can be cut out without materially affecting the supply. The low-pressure cables are armoured concentric, laid direct in the earth, the conductors of each being at present of the same size as those of the high-pressure cables.

**Street Lighting.**—The street lighting is carried out by alternating-current arcs, each fed by a 1 H.P. Lowrie Hall transformer installed in the lamp-post base. Two high-pressure concentric cables at present leave the station switchboard for this service, each having copper conductors respectively $\frac{7}{14}$ and $\frac{13}{20}$. The small transformers for the arcs are placed across these circuits in parallel.

There are at present 42 16-ampere "Lewis" arc lamps, each taking about 600 watts. The lamp supports are of cast-iron, and are of the overhanging bracket type. The total height is about 25ft., the distance between the arc and the ground level being about 20ft. The arc transformers are fed alternately from two different circuits, and the lamps are placed alternately on different sides of the street, at intervals of about 75 yards apart.

**Conclusion.**—Although the official opening of the Newport Electricity Works did not take place until October 14, 1895, the supply of electricity had been available for private lighting purposes for six months previously, having been generated by the day-load plant. In August of that year, however, it was found that this plant was incapable of meeting the demand which had grown upon it; and Messrs. Fowler were instructed to put down a temporary plant, which has already been referred to as No. 6 set. As a point of interest, it may be mentioned that though the order for this plant was not given till August 1st, the plant had been erected and was running on its load on the evening of the 17th.

The present demand upon the station may be estimated from the current output, which reached a total of about 70 amperes on a recent Saturday; of this about 50 amperes represented the proportion of the public supply, at the station pressure of about 2,040 volts.

The charge (subject to a 5 per cent. discount for early cash) per B.O.T. unit is 6d. to consumers of not more than 1,000 units per quarter. A minimum charge is made of 13s. 4d. per quarter. To consumers of above 1,000 up to 2,000 units per quarter, the charge is 5½d. per unit. Above 2,000 units per quarter, 5d. per unit. The meters in use are Thomson, Shallenberger and Hookham.

The total capital expenditure on the system up to the present has been about £37,000.

We must not conclude this short description of the Newport Electricity Works without expressing our acknowledgment of the courtesy we received at the hands of both Mr. R. H. Haynes, the Borough Surveyor, and Mr. C. D. Copland, the Borough Electrical Engineer. Our thanks are also especially due to the latter for kindly supplying us with information for the preparation of this article on the occasion of our visit to the Newport Station.

## THE RAWORTH "UNIVERSAL" STEAM ENGINE.

On Wednesday last, at the invitation of the Brush Electrical Engineering Company, we, in company with several other engineers, travelled down to Loughborough, the purpose of the visit being to inspect the new "Universal" steam engine which that Company is now manufacturing, and to subject a 45 H.P. engine of this type to a short trial of its capabilities. In a previous issue (see *The Electrician*, Vol. XXXVI., pp. 643 and 666) we described and commented upon this engine, which, as our readers are aware, is the invention of Mr. J. Raworth, of the Brush Company. On that occasion we wished the newly-born engine a long and prosperous life, and awaited with interest "the results of the *trials* which life inevitably had in store for it"—a phrase which may have seemed ambiguous to any but an engineer. However, we have now had an opportunity of subjecting the engine to one of these trials—doubtless others will soon follow. In a future issue will be given more detailed particulars of the tests, and of other trials to which the "Universal" engine has been subjected; at present we shall only briefly describe what took place during our visit to the works, which are being extended for its manufacture.

Before commencing the testing operations, an opportunity was afforded of examining the construction of the engine and the



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machine shops and tools employed now in its manufacture. We have for some time been acquainted with the design of the "Universal" engine, and our closer inspection of its construction strengthened the former high opinion we had as to the practical ingenuity in its design and the care which has been expended upon its many novel details. Space does not now permit of our entering fully upon all the novel elements of design; but it may be interesting to refer to one or two of the more important of these. The engine, we may remind our readers, in its most common form is a vertical tandem compound type, with inverted cylinders and enclosed crank case; it is designed to run at high speeds, varying from 500 revolutions in the 28 I.H.P. size to 212 revolutions in the 500 I.H.P. size, and with piston speeds varying from about 420ft. per minute up to about 600ft. per minute. Each of the tandem pistons is single-acting; but as the high-pressure piston acts only on the up stroke, while the low-pressure piston acts on the down stroke, the engine in its entirety is practically double-acting. To obviate knocking on the crank-pin brasses and at the cross-head, a special form of connecting rod has been devised, which possesses the additional merit of exceptionally small weight. The rod is in two parts—an external frame composed of two steel ties of fixed length, being secured to the lower crank pin brass seat and the upper cross-head brass holder; while a steel strut situated between the two ties, and adjustable in length, carries the top crank pin brass and the bottom cross-head brass. Thus the upward thrust during the ascending stroke is taken by the ties, while the downward thrust on the descending stroke is taken by the strut, and the adjustability of this latter prevents the development of a knock by slackness at the brasses. In the 45 H.P. engine placed on trial on Wednesday, when running at 450 revolutions, both full and light loads were taken without the least knock, and the engine ran throughout perfectly silently and without vibration. Another interesting element of design is in the piston rings. Like snakes in Iceland, these are absent from the high-pressure piston, while the low-pressure piston is provided with only one single ventilated ring. Steam is freely admitted at the back of this ring, which provides a tight fit on the working stroke, and during the idle stroke the relaxation of the outward pressure of the ring diminishes the piston friction. At starting there is a clear passage past the piston, through the ring groove, which enables any water in the cylinder to be drained into the exhaust. We should add that the absence of a piston ring from the high-pressure piston is deemed safe practice, owing to there being no apertures or ports in the high-pressure liner. Equal expansion of the liner will take place, and, the engine being vertical, equal wear will also occur, so that the liner preserves its circular form.

Arrangements were made to take the steam consumption of a 45 I.H.P. engine at full and about half load, when working non-condensing. For this purpose the engine was direct-connected to a dynamo the circuit of which included an adjustable water resistance; and the exhaust steam from the engine was condensed in a surface condenser, but without vacuum. The discharge from the condenser was collected in weighing tanks and weighed at regular intervals. The engine had a stroke of 6in., and the diameters of the cylinders were $9\frac{13}{16}$in. and $14\frac{1}{2}$in. respectively. Each cylinder was fitted with a Crosby indicator, provided with an 80lb. spring, and the speed was measured on a tachometer. During the entire period of testing, the engine was supplied with steam having a pressure of 140lb. at the engine stop valve; and the speed of the engine was maintained constantly at 450 revolutions throughout. Measurements were made first with the engine on a nearly steady load of 43 H.P., somewhat under the rated load; and afterwards on a load of about 34 H.P. The indicator cards were taken at intervals of about a minute, and the condensed steam was weighed at the same frequency for the principal part of the trials. The following is a summary of the results which were obtained:—

| I.H.P. | Total steam condensed per hour. | Steam condensed per I.H.P. per hour. |
|---|---|---|
| 43·0 | 852 | 19·8 |
| 42·3 | 840 | 19·8 |
| 44·8 | 888 | 19·8 |
| 33·5 | 675 | 20·1 |

## THE BLACKPOOL PLANT.

The following are some extracts from the Report upon the condition of the electrical plant at Blackpool, prepared by Mr. R. C. Quin, Borough Electrical Engineer, at the instance of the Electric Lighting and Tramways Committee:—

GENTLEMEN: Acting under your instructions, I have carefully examined the state of the machinery and mains, and considered the present conditions of the supply both electrically and commercially. I would first remind you that I am not a partisan of either continuous or alternating systems of supply, believing that each case must be judged entirely on its own merits, and the system adopted which is most applicable to the particular town. Taking all the circumstances into consideration, it seems to me that the Committee were well advised in adopting the high-pressure alternating supply. But I am not satisfied that the plant and machinery were the best that could have been used, nor that the class of mains, their method of laying, and the system of mains generally, were the best calculated to give a reliable and economical supply. In saying this I need hardly point out that I am not concerned as to the personality of the party or parties responsible for the blunders which have been made, but am dealing simply with the existing facts.

*Buildings.*—The Committee are already aware of the state of the engine-room walls carrying the travelling crane, and of the necessity of a considerable expenditure to repair these and supply new girders for the traveller rails. The drainage also is in a very bad condition. . . .

*Boilers.*—The five boilers are of the Lancashire type, and apparently in good condition. I have, as you know, removed the mechanical stokers with advantage, their use under the exceptional local conditions of electric lighting not being beneficial.

*Steam Pipe.*—The main steam pipe is 300ft. long, and in the form of a ring. Under present conditions it is impossible to shut off (with safety) any portion of this, or to shut off boilers Nos. 2 and 3, so that we are compelled to put up with enormous steam losses. This 300ft. of 10in. steam pipe amounts to nothing less than a "condenser" on the wrong side of the engines, which will be clearly seen when we consider that every square foot of *covered* steam pipe means a loss of 300lbs. of coal per year, or in the aggregate for the whole of the steam pipe of about 120 tons per year. This condition of affairs will, however, be remedied by the alterations now being made, but which, unfortunately, cannot be completed until the end of the season.

*Plant.*—With regard to the engines and dynamos, none of these can be termed "highly efficient," the best set giving under 75 per cent. at full load; while the day set (No. 3) on half-load (its usual output) gives only 35 per cent. efficiency. Then, as to "governing"—only two of the engines (Nos. 7 and 8) can govern passably, the governors on the remaining engines being absolutely useless. When we consider the very large floor space occupied by this class of plant and the consequent large outlay needed for buildings, &c., together with their inefficient working, I am afraid the Committee will regret their choice. I would not, however, recommend the replacing of this plant, seeing the very large amount of idle capital it would entail, but would suggest the provision of a new day set (a Parsons' turbine), giving us something more than 35 per cent. efficiency, and the adoption of electrical governors for the remaining plant (excepting Nos. 7 and 8). The new 300-kilowatt Ferranti set now being installed has a guaranteed efficiency of 84 per cent.

*Mains.*—As I have previously said, the system of mains is not the best that could have been devised. There are five separate high-tension alternating circuits, the connections to the houses being either by transformers placed in boxes under the pavement, or by transformers placed in the basements of houses. Very little distributing cable is employed. The disadvantages which this entails are many. . . .

Then as to the condition of the cables—upon the good working of each individual one of which so much depends—I find that the general rule in force here seems to have been to ram and jamb as many cables into one iron pipe as could be got by sheer force. At least, that is the impression one gets from the results. In one 4in. pipe there are five high-pressure circuits (four of 2,000-volt alternating, and one of 3,000-volt continuous) —that is to say, ten single-rubber insulated cables—how they were drawn in is a mystery to me. This gives an average of something over 6 cables per pipe. I have examined their condition, where they are visible at the draw boxes, and find the rubber in a great many places has perished. As sure as fate, if one cable breaks down the whole lot will follow suit. This is only one instance, but it is a fair sample of the state of affairs over the whole town. The high-tension rubber cables have perished on all sides, and must be replaced by more lasting ones, and different methods adopted of laying them.

The arc-lighting cables are similarly situated—that is to say, for practically their whole length they are drawn in the same pipes as high-pressure alternating cables. The condition of these arc cables is very bad—in fact, I do not think there is 100 yards out of the $11\frac{1}{4}$ miles laid which is worth more than its price as scrap copper. The repeated street-lighting failures are evidence of this deterioration. Of course, the breakdown of one cable in nine cases out of ten means the burning asunder of the other cables contained in the same pipe. Clearly, therefore, such a state of things cannot be allowed to exist. I attribute these failures to the action of the salt water; the pipes containing these cables being practically cisterns filled with muddy sea water. The inter-chemical action between sea water and iron pipes, and sea water and rubber, and sulphates and chlorides, &c., of iron (formed by the action of the sea water) upon the rubber, readily account for its rapid deterioration. In my opinion neither rubber-covered cables nor iron pipes should have been used under such circumstances,

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and I recommend their entire replacement by lead-covered cables laid in asphalte about a foot beneath the surface of the pavement.* This is, in my opinion, the only method by which a sound and lasting main is to be obtained under the existing conditions.

It is possible that the present alternating mains could be worked for, say, another six months, or, at the outside, twelve months; but this would place us in the very unsatisfactory position of continually expecting breakdowns and consequent stoppages of supply until the repairs were made. And, not only would this result in a considerable loss of revenue, but public confidence in the reliability of our supply would be further shaken, and the replacement of electric light by gas would be brought about in numerous instances.

*Estimated Cost.*—The estimated cost of treating the arc circuits in this manner is about £3,460, and the high-tension alternating circuits £8,400. Against this, however, we shall have a credit of about £1,000, which will be realised by the sale of the old copper.

*Mains (continued).*—Possibly the accidents at Bournemouth and London, whereby horses were killed and persons received severe shocks, may still be fresh in the minds of the Committee. It may be news to the Committee that the pipes laid in Blackpool are not (with very few exceptions) "connected across all street boxes," nor "efficiently connected to earth," and that the immunity from accidents, similar to those which happened at Bournemouth and the City, is not due to good design but sheer luck. As, however, I propose, when relaying the high-tension cables, to do away with this class of box entirely, there will be no need of spending money to rectify them now.

*Transformer Chambers.*—With regard to the position of the transformers and the current losses entailed by their indiscriminate use, I propose to build, under refuges or pavements, in different parts of the town, transformer chambers, each containing a number of transformers; the positions of these to be hereafter arranged with the Borough Surveyor. Each transformer chamber would be connected by a high-tension feeder direct from the works and by interconnecting cables to its neighbouring chambers. The supply to the houses would be by a network of low-tension cables completely connecting the transformer chambers. By this arrangement we get an absolutely reliable supply, since it is independent of the good working of any one high-tension cable, or of any transformer chamber. . .

*Plans and Estimates.*—Plans showing the proposed re-arrangements of the mains and positions of transformer chambers have been made, and are open to your inspection. I estimate the additional cost of modifying the high-tension mains to be £1,200, of low-tension mains £3,000, and of transformer chambers £1,300, a total of £5,500.

*Financial Position.*—Mr. Quin here goes at some length into the financial aspect of the question. It would appear from his figures that up to July 23rd last the total capital expenditure was approximately £55,599, that the total borrowing powers sanctioned amount to £80,000, and that there has been a net loss since the opening of the station of about £1,023.

The Report then refers to the very trying and peculiar conditions which obtain at Blackpool, and recommends the adoption of the Wright tariff system.

*200-Volt Distribution.*—It was not until recently that the Board of Trade, recognising the many advantages both from the consumers' and suppliers' point of view, and at the practically unanimous request of the electrical profession, consented to allow an alternating supply of electricity to be delivered to consumers at a pressure of 250 volts. . . The present condition in which we find ourselves, unfortunate though it is from many points of view, has at least one side a little less gloomy than the rest. I refer to the absence of any large sum of capital sunk in distribution at 100 volts, and the consequently comparatively small outlay now needed to adopt a higher pressure of supply, and thus reap the above-mentioned advantages. After carefully weighing the pros and cons, I recommend that the pressure of supply be raised from 100 volts to 200 volts, and distributed on the two-wire system. This change of pressure will necessitate the replacing of the 100-volt lamps by lamps made for 200 volts, and I estimate that this will cost about £650. I would point out that the estimates for low-tension net-work, transformer chambers, demand indicators, &c., are based upon the assumption that the 200-volt distribution will be adopted. Should, however, it still be decided to distribute at 100 volts, and which I should very much regret, the above-mentioned estimates must be increased by 30 per cent. to 40 per cent. . . .

*Supply to Tramways.*—That there should be two entirely separate and distinct electricity generating stations within a town, owned and worked by the same body, one for power supply and the other for lighting, seems to be rather an anomaly. Moreover, it is by no means economical, entailing as it does the employment of two separate staffs for the one purpose. Further, as regards the lighting works, for the greater portion of the day the plant is practically idle, whereas it could be profitably utilised for working the trams. I have, as instructed by you, taken measurements of the electrical output from the present tramway generating plant, and the meter readings which have been taken of the current supplied on Saturday, the 1st inst., and Monday (Bank Holiday), the 3rd inst., show that 704 units were consumed on the Saturday and 835 on the Bank Holiday; the car miles for these days being respectively 764 and 668, that is, an average of 1 unit per car mile for the first and 1¼ units per car mile for the second day. Allowing for the light running in winter, I think it would be fair to assume that on an average two-thirds of a unit are required for each car mile run. If, then, we take two-thirds of the car miles (192,262) for last year, this gives a consumption of electricity equal to 128,174 units at a cost of £1,523 approximately, which works out at about 2·9d. per unit. Taking the average of the three years' working we have a cost per unit of 2·96d., or say, 3d. per unit. What I therefore suggest for the Committee's consideration and sanction is the transference of the two Crompton dynamos from the tram shed and their erection here, coupled direct to a high-speed engine of approved type. The estimated cost of this, inclusive of foundations, fixing, &c., is £500. Further in view of the extensions of the tramways now about to be carried out, I should deem it advisable to instal an additional 100-unit Parsons' turbine combined with a continuous-current generator, so arranged that it could supply either at 250 volts or 500 volts. The estimated cost of the latter is £1,100, and it would increase the electrical output of the tramways plant to more than double its present capacity. In addition to this there would be required a main connecting the electricity works to the tram shed and a further extension of the switchboard. These would cost about £200 and £250 respectively. No extensions of the present electric lighting buildings would, however, be necessary. Altogether, therefore, the further capital expenditure incurred by the suggested transference of the generating plant from the tram shed to the electricity works would be about £2,050. The borrowing powers sanctioned for tramway purposes covers an amount larger than this, so that no application to the Local Government Board in this respect need be made. I have very carefully gone into the question of the cost of supplying current under such conditions from these works, and I have no hesitation whatever in saying that we can guarantee the maintenance of the necessary supply of current to the tramways department at 2½d. per unit, and at the same time leave us a satisfactory profit. Calculating the probable units to be sold to the tramways department at £130,000 per annum, this would effect a saving in their revenue account to the extent of £270 upon the year's working, and leave us a profit of about £500. In other words, the saving to the Corporation annually would be at least £700 if taken on the basis of the present cost of generation. In this connection it will be remembered that the estimated output last year was 128,174 units, so that with the extensions before named it is quite probable that the demand will be considerably over 130,000 units per annum, in which event the saving will increase *pro rata*.

*Conclusions.*— . . . . In conclusion, I cannot too strongly impress upon the Committee my sense of the hopelessness of the future prosperity of these works unless some immediate steps are taken to remedy the defects I have already indicated. It is not a question of saddling, or attempting to saddle, the responsibility of past errors upon the shoulders of any individual or individuals. It is emphatically rather a question of repairing the errors before they become irreparable. Towards the accomplishment of this object I have given much careful and anxious thought; and the proposals, suggestions, and recommendations I have embodied in the foregoing Report will, I firmly believe, if carried out in their entirety, bring the electrical portion of the works up to a high level of excellence, and place the financial future of the undertaking beyond the possibility of failure. The main points of my Report to which I beg to draw my Committee's most especial attention are:—(1) The replacement of faulty mains; (2) the increase of the pressure of supply; (3) the adoption of demand indicators; and (4) the transference of the tramways supply to the Electricity Works from the present tram shed. By these means there will be brought about, in my opinion, the absolute reliability of the supply, the economical working of the plant, the minimising of the financial risk, and, generally, a great saving to the Corporation by the fuller utilisation of the resources of the Electricity Works. I feel I should have failed in my duty had I not most fully put the case before the Committee, and, without blinking any facts, gone to the root of the trouble, and shown exactly what it is and how it can be remedied. It is now for the Committee to say whether this Report is worthy of their acceptance, and whether the Electricity Works are ultimately to become a success or a failure.

* Since writing the above I have been informed by Mr. William Chew, the assistant gas manager and formerly your electrical engineer, that in the year 1879 or 1880 a similar breakdown was experienced. This was in the days of the first arc lighting of the Promenade from the tall masts. Originally the cables, which consisted partly of lapped rubber and partly of vulcanised rubber, were drawn in iron pipes. Within about twelve months of their being laid they had to be withdrawn from the pipes and suspended from posts, and when the new cables having gutta-percha insulation were laid in wooden troughs, filled with asphalte, the trouble was overcome. It seems strange to me that, having had such an experience in 1880, the Electric Lighting Committee, or their advisers, should have committed the same error in 1893.

**Men and Women of the Century.**—Messrs. George Bell and Sons, conjointly with the Swan Electric Engraving Company, are bringing out a handsome work with the above title. It consists of a collection of portraits and sketches, by Mr. Rudolf Lehmann, edited with introduction and short biographical notices by Mr. H. C. Marillier. Mr. Lehmann's collection comprises a long series of portraits of notabilities who have sat to him between the years 1847 and 1895. The volume will contain 12 fine photogravures from paintings, and about 70 facsimile reproductions of the drawings in half-tone, some of them printed in colours, all executed by the Swan Electric Engraving Company. The letterpress will be printed in the well-known manner of the Chiswick Press. A glance at the list shows that amongst those included in the collection are Alexander von Humboldt, Sir David Brewster, Sir Richard Owen, Prof. Huxley, Prof. Virchow, Louis Pasteur, Sir William Siemens, Prof. Du Bois Raymond, and Prof. Burdon Sanderson.



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# TESTS OF A COMBINED ELECTRIC LIGHT AND ELECTRIC RAILWAY CENTRAL STATION.*

BY DUGALD C. JACKSON AND ARTHUR W. RICHTER.

The central station of the Four Lakes Light and Power Company supplies the power for the electric lighting of Madison (Wis.) and also supplies power for the Madison City Railway. The station is situated on the bank of Lake Monona, in a fairly central location (Fig. 1).

The boiler-room contains two return tubular boilers, rated at 110 H.P. each, and one Stirling boiler of 200 H.P. capacity. The engine-room is equipped with three Russell compound engines, two Davidson jet condensers, and two Davidson feed-pumps.

Engine No. 1, 380 H.P. capacity, is belted to the main shaft, from which are run four Thomson-Houston arc-light machines, each of which has a capacity of 50 1,200 c.p. lamps, and one Westinghouse alternator of 750 lights capacity. Two other alternators, a Slattery and a Thomson-Houston, are also installed, but are to be removed.

Engine No. 2, 190 H.P. capacity, is used for running the railway generators. These are two 90-kilowatt general electric machines of 500 volts, 180 amperes, speed 650, and are belted tandem fashion from the flywheel of the engine. A third tandem belt from the same flywheel runs over a clutch pulley on the main shaft, and

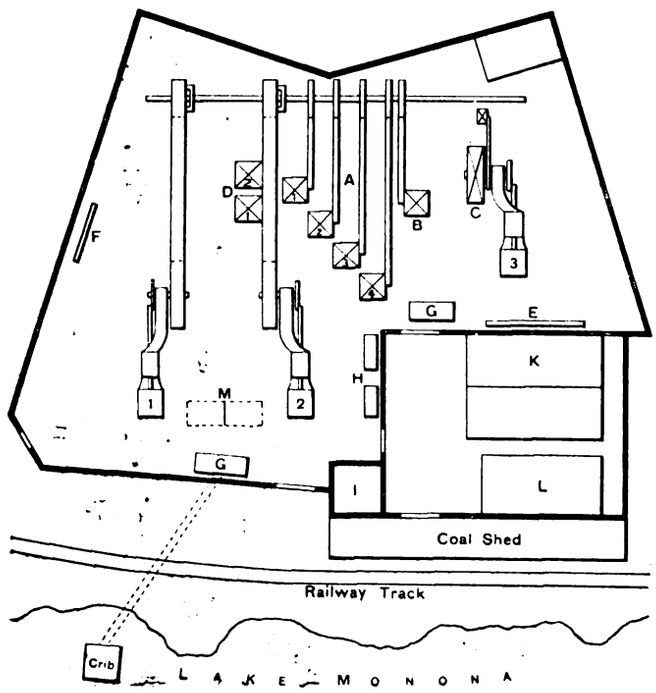


FIG. 1.—Plan of Madison Power House.

A, arc-light dynamos; B, Westinghouse alternator; C, monocyclic alternator; D, railway generators; E, electric-light switchboard; F, electric-railway switchboard; GG, condensers and pumps; H, feed pumps; I, oil-room; K, return tubular boilers; L, Stirling boiler; M, hot wells; 1, 2, 3, Russell engines.

the shaft can therefore be driven from this engine when desired. The two generators are connected to the same 'bus-bars, and supply power for the operation of the Madison-street Railway, and for a number of stationary motors which are connected to a special power circuit run out from the 'bus bars. Both of the above engines are connected to one of the Davidson condensers.

Engine No. 3, 400 H.P. capacity, is directly connected to a 300-kilowatt "monocyclic" alternator, and condenses into another Davidson condenser and air-pump. The alternating current output of the station is used exclusively for incandescent lighting.

*Engine Dimensions.*

Nos. 1 and 3:
- Stroke, 24in.
- Diameter of high-pressure cylinder, 15in.
- Diameter of low-pressure cylinder, 24in.
- Diameter of high-pressure piston-rod, crank end, 3in.
- Diameter of high-pressure piston-rod, head end, 2⅜in.
- Speed, engine No. 1, 134 revolutions per minute.
- Speed, engine No. 3, 152 revolutions per minute.

No. 2 railway engine:
- Stroke, 20in.
- Diameter of high-pressure cylinder, 13in.
- Diameter of low-pressure cylinder, 20in.
- Diameter of high-pressure piston-rod, crank end, 2⅜in.
- Diameter of high-pressure piston-rod, head end, 2¼in.
- Speed, 133 revolutions per minute.

* Paper read at the Detroit meeting (June, 1895) of the American Society of Mechanical Engineers.

The station is operated by one engineer and one fireman from midnight until noon, and by one fireman, one head engineer, and one assistant from noon until midnight, and one oiler from 6 p.m. until 12 p.m., making a total of six station employés for the 24 hours' run. Each 24 hours during the week current is furnished to the electric railway and power circuits for 17·5 hours, and to the alternating-current circuits for 23·5 hours, except on Sunday, when the alternators are shut down for an additional 12 hours. Current for arc lighting is supplied principally between the hours of dusk and midnight, though certain arc-light circuits are operated all night.

This station is one of that type, so well known to electrical engineers, which has grown to considerable proportions from a small and poorly-conceived beginning, and which therefore may be said to suffer through its own growth. During the past two or three years it has been quite thoroughly overhauled, and its physical condition has been greatly improved, but only at the expense of a considerable addition to the capital account. The results of the test which are given may be taken to represent results fully equal to those obtained by the average electric station in our cities of the smaller size. (Madison has 15,000 inhabitants.) This statement will doubtless be viewed with surprise by the numerous members of this Society who are experts in steam engineering, and who carry continually before their eyes the remarkable economy obtained in pumping plants; but that the statement is fully borne out by the facts will be affirmed by every electrical engineer of experience.

The object of the test recorded in this Paper was to determine the efficiencies of the boilers, engines, and generators under actual operating conditions, nothing having been done either before or during the test to change the conditions from those occurring in the regular daily run. All the data required was obtained and recorded entirely independently of the regular employés, who were required to attend to the operation of the station, exactly as is done day after day and week after week. A trial test of four hours' duration was made beforehand, in order to familiarise the observers with their work and to ascertain whether all the arrangements were well conceived. All reasonable precautions were used to make the data obtained reliable, and all instruments were supplied from the laboratories of the University of Wisconsin, and were compared with the laboratory standards. All electrical instruments used were calibrated by means of a Kelvin standard balance. The steam-pressure gauges and indicator springs were standardised by comparison, while hot, with a mercury column. The scales, thermometers, &c., were tested for accuracy by comparison with proper standards.

The test began at 6 a.m. Monday, when the engines started up for the day, lasting until 5:30 a.m. Tuesday, when the engines stopped for their half-hour breathing spell, and may be considered successful, as nothing more serious than the occasional breaking of an indicator cord occurred to interfere with the results. Four of the observers, one having general supervision of the test, another overseeing the weighing of the coal, another the weighing of the water, and a fourth having charge of the calorimeter tests, were on duty through the entire run. These four men, Messrs. Burgess, Frankenfield, Mead and Crane, were members of the senior class in electrical engineering in the University of Wisconsin, and handled their work excellently. They were assisted by a certain number of experienced student observers, about 20 in all, who were required to read the various ampere-meters and voltmeters, take indicator cards, &c. The test was generally supervised by two of the assistant professors of the University. During the whole of the test the station presented no confusion, but was operated with the usual systematic regularity.

*Tests.*

The coal was weighed as it was brought into the boiler-room. The water-level and steam gauges were kept as nearly constant as practicable, and at the close of the test the water in the Stirling boiler was at the original level, while in one of the return tubular boilers it was 1·in. above the string, and in the other a little over an inch below it, so they were considered as practically at the same level. The Stirling boiler was in use during the entire run, and at 4:45 p.m. and at 5:45 p.m. the two tubular boilers were successively cut in and were shut off again and the fires banked at 12:35 a.m. The coal used in getting these boilers up to pressure (nearly 500lb.) was not counted as part of the coal consumption in the computed results.

Calorimeter tests of the steam were made every hour at the boilers, and as frequently as possible at the engines, while in service. Throttling calorimeters were used, except at the railway engine, during the daytime, where there was so much water present that the throttling calorimeter could not be used, and a separating calorimeter was resorted to. The poor quality of the steam at the engines was due to the arrangement and condition of the steam mains. Engine No. 2 received the drain of the greater portion of the system. The steam-pipe was connected to the under side of the main and was uncovered at the time of

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the test. The pipe leading to engine No. 3 was also uncovered, and as the pipe is of considerable length the condensation is considerable, while the valve provided to cut the steam from that pipe during the period when the engine is idle was not made use of. The pipe leading to engine No. 1 was covered, but no provision was made to cut the steam from that pipe when the engine was not running.

The water was measured by means of two tanks placed on scales. Both feed pumps were put into use, one as an auxiliary, to pump the water from the hot well into the tanks, and the other to feed the boilers. The latter pump communicated with the tanks by two branches of piping connected by a three-way cock, and a hose was attached to the other pump, so that one of the tanks was filled while the other was being emptied. The exhaust pipe of the regular feed pump was connected to the vacuum of the condenser, and the steam consumption was figured from cards taken at frequent intervals, the number of strokes being recorded on a continuous recorder. The steam consumption of the auxiliary pump was ascertained by running the exhaust into a small surface condenser furnished from the university laboratory, by which means the condensed water was collected and allowance made therefor.

The railway engine No. 2 was started at 6 a.m. and continued running until 11:10 p.m. During the day, from 6 a.m. until 6:30 p m., this engine, besides driving the two railway generators, drove the main shaft, to which a Westinghouse alternator was belted, supplying the day demand on the incandescent circuit. This engine was indicated every five minutes, indicators made by Dreyer, Rosenkranz, and Droop, of Hanover, Germany, being used on the low-pressure cylinder, and Tabor indicators on the high-pressure cylinder. These indicators were supplied with electro-magnetic devices for taking the four cards simultaneously on closing a switch, the current being supplied from storage cells. Friction cards were taken upon starting up with the generator fields excited and again with the field circuit broken. The speed was obtained by means of a continuous revolution counter. Two ampere meters, through which the current supplying the railway feeders passed, one ampere-meter on the power circuit, and a voltmeter giving the dynamo pressures, were read every half-minute. The condenser pumps were indicated at half-hour intervals and the speeds were taken.

At 6:10 p.m. the arc-light engine No. 1 was started and continued running until 5:30 a.m. At the same time the direct connected engine No. 3 was set running, and the supply for the incandescent circuit was changed from the Westinghouse machine to the "monocyclic" alternator. The railway engine No. 2 now no longer drove the main shaft; but the belt ran over a loose pulley on the shaft. The arc-light engine No. 1 was indicated every 15min., and the direct-connected No. 3 every 10min., and the speed obtained from continuous revolution counters. Friction cards were taken both before and after the run. The current of the arc machines was measured by a Weston ampere meter, and the voltage was obtained by a Weston voltmeter in series with a high resistance, the apparatus being placed as far from the machines as possible to avoid any disturbance which might be caused by stray magnetism. Ampere-meter and voltmeter readings for the Westinghouse alternator were taken every 15min., and the "monocyclic" output was taken by 5min. readings. The power factor of the load on each of the machines was ascertained by means of a station wattmeter, loaned by the General Electric Company.

There can be no question in regard to the reliability of the results averaged from readings taken as often as was done in this test, except in the case of the railway machinery. It is still an open question as to the best method of determining the average power developed by an electric railway engine; but the results of considerable experience with electric railways on the part of one of the authors makes us feel certain that results are obtainable by the arrangements which were used in this test, which are as accurate as those obtainable by any method yet set forth.

### Results of Test.

*Boiler Efficiency.*

Quality of steam:
- Stirling, 6 a.m. to 6 p.m., 99·2 per cent.
- Stirling, 6 p.m. to 5:30 a.m., 99·7 per cent.
- Return tubular boiler No. 1, 4:45 p.m. to 12:30 a.m., 97·3 per cent.
- Return tubular boiler No. 2, 5:45 p.m. to 12:30 a.m., 93·5 per cent.

Total average, 98·8 per cent.
Average pressures:
- Steam, 85·5.
- Barometer, 29in.

Draught (inches of water), 3.
Average temperatures:
- External air, 46·2 F.
- Boiler-room, 58·9 F.
- Escaping gases, 422 F.
- Temperature of hot well, 82·24 F.
- Temperature of feed-water, 123·5 F.

Factor of evaporation, 1·119.
Water pumped into boilers, 102,349lb.

*Boiler Efficiency.*—Continued.

Equivalent evaporation from and at 212deg., 114,508lb.
Total amount of coal burned, 17,103lb.
Total ash, 1,871lb.
Total combustible, 15,232lb.
Per cent. ash, 10·9 per cent.
Water evaporated per pound of coal, 5·98lb.
Water evaporated per pound of combustible, 6·72lb.
Equivalent evaporation from and at 212deg., per pound of coal, 6·69lb.
Equivalent evaporation from and at 212deg., per pound of combustible, 7·52lb.
Steam used in throttling calorimeters, 395·7lb.
Steam used in separating calorimeter, 35 07lb.
Total, 420·8lb.
Steam used by feed-pumps, as figured from indicator cards, from 6 a.m. to 6 p.m., 538·5lb. From 6 p.m. to 5:30 a.m., 472·3lb.
Total, 1,010·8lb.
Steam used by auxiliary pump, 449lb.
Steam to be charged to engines, 100,469lb.

*Engine Efficiency.*

No. 2 railway engine. 6 a m. to 6 p.m.:
Average I.H.P., 117·5.
H.P. hours, 1,410.
Average watts output, 69,200, equals 92·8 E.H P.
Watt hours, 830,387.
Average E.H.P. divided by average I.H.P. equals 78·9 per cent.
Coal consumed in 12 hours, 7,550lb.
Per cent. ash, 9·9 per cent., equals 750lb.
Combustible, 6,800lb.
Water pumped into boilers, 43,172lb.
Steam consumed by pumps and calorimeters, 891lb.
Water charged to engine, 42,281lb.
Water per I.H.P. per hour, 30lb.
Coal per I.H.P. per hour, 5·35lb.
Combustible per I.H.P. per hour, 4·82lb.
Quality of steam, 95·7 per cent.
Moisture in steam, 4·3 per cent.
Dry steam used by engine, 40,460lb.
Dry steam per I.H.P. per hour, 28·7lb.
Watt hours per pound of coal, 109·9.
Watt hour, per pound of combustible, 122·1.

*Station Efficiency.*

6 a.m. to 5:30 a.m., 23·5 hours.
Average I.H.P., for 23·5 hours, 160·5.
Maximum E.H.P., 350·4.
Average E.H.P., 117·9.
Average watts for 23·5 hours, 87,946, which is 2,066,729 watt hours.
Average E.H.P. divided by average I.H.P., 73·4 per cent.
Load factor for 24 hours, 32·4 per cent.
Coal consumed, 17,103lb.
Combustible, 15,232lb.
Water pumped into boilers, 102,349lb.
Steam evaporated and charged to engines after subtracting that used by calorimeters and feed-pumps, 100,470lb.
Water pumped into boilers per engine I.H.P. hour, 27·1lb.
Coal per engine I H.P. hour, 4 5lb.
Combustible per engine I.H.P. hour, 4lb.
Watt-hours per pound of coal, 121.
Watt hours per pound of water, 20·8.
Average quality of steam, railway engine, 96·2 per cent.
Average quality of steam, arc-light engine, 97·1 per cent.
Average quality of steam, monocyclic engine, 97·8 per cent.
Average, 96·8 per cent.
Dry steam used by engines, 97,214lb.
Dry steam per engine I.H.P. hour, 25·81lb.
Average I.H.P. of condenser pump No. 1, 2·62.
Average I.H.P. of condenser pump No. 2, 1·96.
Horse-power hours of condenser pump, No. 1, 61·6.
Horse-power hours, pump No. 2, 9·8.
Friction load of engine No. 1, 22·4 with shaft.
Friction load of engine, No. 2, 12·2 without shaft.
Friction load of engine No. 3, 22·5.
Total friction load, 57·1 I.H.P. = 11·8 per cent. of maximum I.H.P.

*Conclusions.*

During the past three years several Papers have been read before this Society dealing with the operation of electric railway stations, but no authoritative records appear which cover the operationof the average small station, which combines in one the requisite plant for electric lighting and electric railway service. The individual action of engines, dynamos, and auxiliary apparatus, under the conditions here met with, is so well known that it is thought best by the authors not to burden this Paper by indicator cards of well-known forms, or by long tabular records. We wish, rather, to call attention to certain points which bear with somewhat startling force upon the expense of operating these combined stations. It has usually been considered that combination stations may be operated at much less total expense than is required for the operation of two small stations when the lighting and railway plants are separate. This question may be considered under four heads. First, station labour; second, fuel economy; third, superintendence; fourth, fixed charges.

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1. In regard to station labour, the plant under consideration (which we will call the Four Lakes Plant) probably could not be improved, and if the lighting and railway divisions were separated, not less than seven men would be required where five men are now employed, and the labour account would be proportionally larger for two stations than for one.

2. The fuel economy of the Four Lakes Plant is fully equal to that of the average medium-sized plant, but it is probably no better than would be given by similar engines and other machinery in separate plants. The coal used during the test was a mixture of Indiana block, costing $3·35 per ton, and Illinois coal, costing $2 72 per ton. The evaporation shown by the boilers was, on the whole, excellent, considering the kind of coal used and the fact that the boilers *were in regular service condition*. The fuel economy of the Four Lakes Plant could be improved by several minor changes; this is especially true in regard to the arrangements of the dynamos, which now require the countershaft to be unnecessarily run all day, and in regard to the piping, which might be readily changed to deliver better steam. (Some of these changes have already been made since the test.) But these changes would not give the combined plant any advantage over the separate plants. Better fuel economy would also be obtained by closer attention to the details of operation than is given in this plant, but the watt hours developed per pound of coal and per pound of water compare favourably with the reports of the National Electric Light Association for similar stations.

3. The question of superintendence requires consideration from two sides; first, where the railway and light companies are independent, and the latter sells power to the former; and, second, where one company controls both industries. In the first case, no saving is made in office force or superintendence by combining the stations; but, in the second case, a saving is doubtless effected by the combined plant.

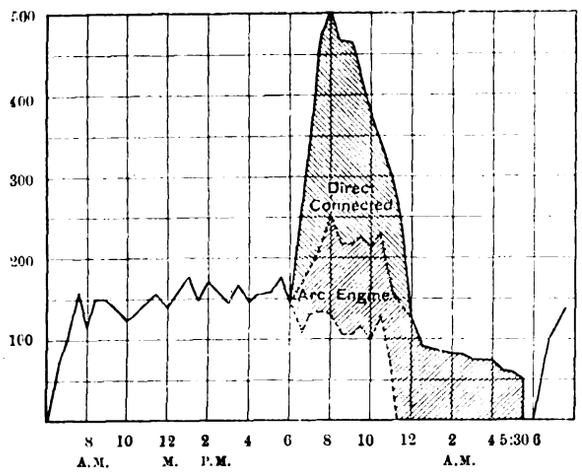


FIG. 2.—Load Curve of Madison Power House. Full line shows the total I.H.P. developed during test.

Total I.H.P. Curve.—Average I.H.P. = 160·5; Maximum I.H.P. = 505; Total Load Factor = 32·4 per cent.; Average I.H.P. for 24 hours = 157·1. Railway Engine.—Maximum I.H.P. = 248·1; Average I.H.P. = 131·2; Load Factor = 38·2 per cent

4. The preceding divisions give little clue to the best solution for the electric plants of the smaller cities, and we must find the solution in this division. The fixed charges which may be rightfully considered as belonging to the station account depend upon the cost of real estate, buildings, and the machinery in place. The first two items are undoubtedly increased to some degree in the separate plants, but not so largely as might be imagined, since the running machinery for the two classes of service must be entirely independent. It is practically impossible for any engine to drive the extremely variable load of an electric railway and regulate with sufficient accuracy to give satisfaction when driving dynamos for electric lighting; and, since the underwriters have taken the matter in their hands, it is not permissible in most places to operate stationary motors from railway circuits, on account of the fire risk involved in introducing grounded circuits into buildings. On account of this separation of the two classes of machinery the real estate and buildings required for combined railway and lighting plants must be larger than would be necessary for either a simple lighting plant or a simple railway plant of a capacity equal to the combined plant.

The comparison of the load factors of separate and combined plants throws no particular light on this question. Thus, in the Four Lakes station the 24 hours' engine load factor for the railway machinery, plus the day alternator, is 38·2 per cent. For the arc-light machinery alone it is 25·6 per cent.; for the direct-connected alternating machine it is 14·56 per cent. The total load factor of the station is 32·4 per cent. The term "engine load factor" is used here in its usual signification, of the ratio between the actual indicated horse-power hours' output of the station and the output which would be produced were the station run continuously at its maximum indicated load. Now, upon separating the lighting and railway outputs, we still have the railway load factor about 38·2 per cent. and the lighting load factor becomes about 23 per cent. Practically the same amount of boiler power is required in the combined stations as in the separate stations, and exactly the same plant in engines and dynamos are required in the two cases. The boilers, engines, and dynamos are each run at about equal average loads in the two cases, and the efficiencies are not materially different (*see* Fig. 2).

We therefore make the following gains by combining the electric lighting and railway plants of small cities into one station. First, a fair amount in the labour account; second, a small amount in the real estate and building account. The gains are not nearly so great as are sometimes asserted, nor are they comparable in magnitude to those which result from the combination of two small electric light stations in one, or two small electric railway stations in one, since, in the latter cases, one economical plant of machinery may be used to do the work of two smaller and less economical plants. When a railway and a lighting station are combined, we are forced by the conditions to use separate machinery (excepting boilers) for the two classes of service.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August 21, 1896.*

**A New Insulation.**—A new insulating material is being introduced to the electrical trade. It consists of powdered silex in its pure state, which is packed in wrought-iron pipes in which is centralised the electrical conductor. The lengths of pipe are joined by very tight sleeve couplings, and the outlets are hermetically sealed with a mica cap and shellac, through which the conductors project. The silex has some properties which render it of special value for electrical work. It is a remarkable non-conductor of heat, and an excellent electrical insulator; and it is stated by the projectors of this new enterprise that they have, on a test, succeeded in fusing a wire insulated by this method; but since the insulation surrounding the wire was incombustible, there was really no place for the fused metal to run, and after the current was withdrawn the metal re-solidified, and the metallic and electrical continuity of the wire was restored to its original condition. Silex in this form is said to be remarkably non-hydroscopic; therefore there is no danger of the insulation being impaired by moisture.

**Trolley Accidents.**—The daily newspapers fairly teem with records of trolley accidents in this section of the country. Whether they are due to the effects of the extreme heat that we have just had, or not, there is one thing certain, that in almost all the cases the accidents were preventable. Not a day passes without mishaps of this nature more or less serious and disastrous being recorded in our local papers, especially those in Brooklyn. On August 10th a very serious accident occurred on the Columbia and Donegal Electric Railway at Columbia, (Pa.). A car crowded with people from a park concert ran away down a heavy grade near Columbia, with the result that the car jumped the track at a curve and was thrown across the road, a distance of 100 yards, crashing into a railroad train, and then tumbled into a ditch 20ft. deep. Six persons were killed and 62 injured. The exact cause of this accident will probably never be known, as the motorman was one of those killed. It is stated, however, that the motorman allowed the car to attain a great velocity down hill before he attempted to bring it under control. The brake refused to work, and it is supposed that the brake rigging broke in the attempt to bring the car within reasonable speed limits. Another accident, and one of a kind that has long been looked for, occurred at Homestead Station, in New Jersey, near this city, on August 8th. A trolley car, while crossing the track of the New York, Susquehanna and Western Railroad, became unmanageable by reason of the trolley jumping the wire. Just at that time it happened that a train was approaching, and before it could be stopped it ran into the trolley car. Fortunately, however, no fatal results

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ensued. Two passengers received serious injuries, and the engineer of the train was quite badly hurt and thrown from his cab. The forward part of the locomotive received considerable damage. The above are two examples of the character of the accidents that are daily reported, and timid people are naturally becoming aroused over the uncertainty and dangers of riding in trolley cars.

**Marine Electrical Effects at Halifax.**—At the recent carnival just closed at Halifax, Nova Scotia, some very handsome and effective electrical illuminations were made on the warships and on other steamboats in the harbour. The flagship "Crescent" was decorated from the water line to the trucks with incandescent lamps, outlining the shape of the hull, as well as the masts, yards and funnels. Other English and French warships made wonderful displays of electrical illumination, and their searchlights were used with very good effect. An illuminated procession formed a part of the programme of the carnival, and was very pleasing and brilliant.

## CORRESPONDENCE.

### NEW MEN AND OLD PLANT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with much interest your leading article on the above subject in your issue of August 28th, and especially the latter portion thereof, which undoubtedly refers to myself. But I would ask your indulgence to correct certain misstatements you have made.

Your reference to the replacing of many miles of cable by cable of another make is true as far as it goes; but your remark that "we believe that the faulty cable is limited to one circuit" is distinctly untrue.

Then, with regard to the adoption of a different type of arc lamp, surely I am at liberty and justified in recommending the adoption of that which I consider best for a specific purpose! It is as well that the profession should know the true state of this case, and form their own opinion as to the right of your anonymous leader writer to make such assertions. The lamps at present in use here are of the Brockie-Pell type, against which I have nothing to say. But, as things now stand, electric-street lighting ceases at midnight, and, therefore, in order to induce "the powers that be" to consent to all night lighting, I suggested the lapping of the circuits, one of which was to be formed of arc lamps capable of burning at ten or six amperes. One circuit to be switched off at midnight, the other being reduced at that time from ten to six amperes. Tenders were asked for lamps to meet these requirements, and, on the results of the tests, the tender of Messrs. Crompton for "Crompton-Pochin" lamps was accepted.

Further, no lamps are to be "discarded," as your writer opines, the new ones being additional; nor have any Crompton lamps ever been used here before on the circuits (although I believe some were tried in the test room); and, as to the relative merits of both makes of lamps in practice, I think I am in a position to judge, having had a considerable number of both under my immediate care at Brighton, where the atmospheric conditions are practically identical.

You speak of new engineers indicting their predecessor's entire handiwork. Would it greatly surprise you to know that my report agrees with the recommendations of my predecessor, except on one point only, and that a comparatively small one? I refer to distribution from street-box transformers as suggested by Mr. Hesketh, and from chambers as proposed by myself.

There are further recommendations contained in the report, but they in no way clash with any made by my predecessor.

The question as to the propriety, or otherwise, of anonymous leaders when on general topics I do not wish to discuss; but it seems to me that such a thinly-veiled personal attack as is contained in your leader under notice should have been supported by the writer's signature. Personally, I am not in doubt as to his identity, the anonymity having been annulled by certain references in the article to matters outside the report and gas journal comments; the signature, however, would have supplied a negative quantity of considerable magnitude.

On the main point of the article—the advisability, or otherwise, of the course which I have chosen to adopt—I would again dispute the judgment of the aforesaid writer. Does not the question of improvement resolve itself into the following formula:—

$$\frac{\left.\begin{matrix}\text{Saving in}\\ \text{working expenses}\end{matrix}\right\} + \left\{\begin{matrix}\text{Unknown value of}\\ \text{general improvement}\end{matrix}\right.}{\begin{matrix}\text{Interest and sinking fund}\\ \text{upon capital cost of improvement}\end{matrix}} = X,$$

where *necessity of improvement* does not come in? And who is to judge of the relative value of the various factors? Surely the "Man on the Spot." And, in the interests of electric lighting generally, is it better to "make the best of a bad job," and attempt to "work wonders with discouraging material," or, having thoroughly considered the various factors of the problem, to at once put the house in order and "make the best of a *good* job"? In fact, does not the tacit approval by an engineer of conditions which he knows to be bad discount his honesty? And, if so, is straightforwardness to be condemned as un-English?—Yours, &c.,

ROBT. C. QUIN,
Borough Electrical Engineer.

Blackpool, August 31, 1896.

[Copious extracts from Mr. Quin's report will be found on p. 608 of the present issue. Mr. Quin informs us that at Tuesday's meeting of the Blackpool Town Council the Report was unanimously adopted.—ED. *E.*]

### COMBINED ALTERNATING AND CONTINUOUS-CURRENT DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with much interest the description of the combined alternating and continuous-current dynamos at Woolwich in your last issue. The plant is practically the same as that which I designed some twelve months ago, for the Bolton Corporation Electricity Works, where it is now doing daily work.

As the Woolwich set appears to have been in use for some years it is interesting to know that it gives such satisfaction. The advantages of such a combined plant are, to my mind, so obvious that it is a wonder it has not been more largely used.

When I got out the Bolton arrangement I was under the impression that it was original. That it turns out not to have been so is to the credit of Messrs. Pritchett and Low, the only regret being that they had not published particulars long ago.

Yours, &c.,

JOHN H. RIDER.

### A NON-SYNCHRONOUS TWO-PHASE ALTERNATE-CURRENT MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Table I. of my article on the above subject, published in your last issue, is not correct. I shall be obliged if you will publish the following table, which should take its place:—

This correction does not alter the conclusions drawn from these figures in the paper.—Yours, &c.,

ERNEST WILSON.

King's College, London, August 29, 1896.

**Table I.**

| | No. 1 circuit. | | | | No. 2 circuit. | | | | No. 1 and No. 2 circuits. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Observed maximum. $\frac{4\pi m_1 r_1}{10}$ | Observed maximum. $\frac{I_1}{10^6}$ | Observed maximum. $B_1$ | Characteristic curve gives $\frac{I\nu_1}{10^6}$ | Observed maximum. $\frac{4\pi m_2 r_2}{10}$ | Observed maximum. $\frac{I_2}{10^6}$ | Observed maximum. $B_2$ | Characteristic curve gives $\frac{I\nu_2}{10^6}$ | $\frac{I_1+I_2}{2}$ $10^6$ | $\frac{I\nu_1+I\nu_2}{2}$ $10^6$ |
| Motor running light | 2,610 | 0·448 | 5,790 | 0·412 | 3,000 | 0·437 | 5,640 | 0·466 | 0·442 | 0·439 |
| Motor loaded | 2,790 | 0·430 | 5,550 | 0·444 | 3,100 | 0·416 | 5,340 | 0·484 | 0·423 | 0·464 |

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# CONTINENTAL ELECTRIC

***Compiled by the Association of Representatives***

| TOWN. | Date of commencement of supply. | M. = Municipality C. = Company | System of Supply. A = Alternating — = Continuous | Charge in pence per kilowatt hour. (Most of these charges are subject to large discounts.) Light. | Sundry purposes. | Boilers. | Engines. | Dynamos. | Total capacity of dynamos in kilowatts apparently inclusive of reserve. |
|---|---|---|---|---|---|---|---|---|---|
| **Aix-la-Chapelle** | Jan. '93. | C | — | 8·4 | 2·1 | Double, 2 flues in lower and 2 in upper part | Vertical triple expansion and compound | Multipolar, shunt-wound... | 850 |
| **Altona** | Mar. '92 | C | — | 8·2–6·9 | 3·0 | Double, 2 flues in lower and 2 in upper part | Vertical triple expansion condensing | Multipolar, shunt-wound... | 1,010 |
| **Barmen** | Dec. '83 | M | — | 8·3 | 3·0 | Two-flue with Galloway tubes | Compound | Multipolar, shunt-wound... | 216 |
| **Bremen** | Oct. '93 | M | — | 8·3 | 8·3 | Multitubular | Vertical triple expansion | Interior pole, shunt-wound | 500 |
| **Breslau** | June '91 | M | — | 8·3 | 4·0 | Water-tube, Heine type | Horizontal compound | Interior pole, shunt-wound | 487·5 |
| **Cassel** | July '91 | M | A — | 9·6 | 4·8 | Tubular | Jonval turbines and portable engines | Generating station:—alternators. Sub-stations:—alt. con. current transformers | 994 |
| **Christiania** | Dec. '92 | M | — | 8·0 | 3·3 | Water-tube | Compound | Multipolar, shunt-wound... | 688·5 |
| **Chemnitz** | May '94 | C | A | 8·4 | 2·1 | Water-tube | Vertical triple expansion condensing | Three-phase alternators ... | 540 |
| **Cologne** | Oct. '91 | M | A | 8·4 | 3·0–2·6 | Water-tube | Compound condensing ... | Multipolar, shunt-wound... | 800 |
| **Copenhagen** | Mar. '92 | M | — | 8·0 | 2·7 | Water-tube | Vertical compound condensing | Interior pole | 946 |
| **Darmstadt** | Aug. '88 | M | — | 8·8 | 8·8 | Water-tube | Vertical compound | Interior pole, shunt-wound | 350 |
| **Dessau** | Oct. '86 | C | — | 9·8 | 4·9 | — | Gas engines | Multipolar, A.E.G. type | 120 |
| **Düsseldorf** | Sept. '91 | M | — | 9·6 | 2·4–6·0 | Water-tube | Compound | — | — |
| **Dresden** | Dec. '95 | M | A | 7·2 | 3·0 | Double and Steinmüller | Tandem compound condensing | Helios alternators | 2,208 |
| „ | July '93 | M | — | — | — | Double and Steinmüller | Compound condensing ... | Siemens and Halske direct connected, int. pole type | 555 |
| **Elberfeld** | Nov. '87 | M | — | 8·1 | 3·2 | Two-flue | Vertical compound | Two-pole shunt-wound, and six-pole interior type ... | 660 |
| **Frankfort-on-Main** | Oct. '91 | C | A | 9·6 | 2·4 | Cornish, with corrugated flues and cross tubes | Compound tandem | Brown alternators | 2,088 |
| **Gera** | Jan. '92 | C | — | 9·6 | 2·4 | Water-tube | Compound condensing ... | Multipolar, A.E.G. type ... | 330 |
| **Greifenhagen** | June '92 | C | — | Per 16-c.p. hr. 0·36 | Per 16-c.p. hr. 0·30 | Two-flue | Horizontal high-pressure.. | Bi-polar, shunt-wound | 16·2 |
| **Gummersbach** | Dec. '91 | C | — | 11·2–8·1 | 9·6 | Locomotive | Portable | Interior pole, shunt-wound | 40 |
| **Hamburg** | Dec. '83 | C | — | 9·6 | 4·9–3·0 | Cornish tubular | Vertical triple expansion, condensing | Multipolar | 2·400 |
| **Hanover** | Mar. '91 | M | — | 8·4 | 2·8 | Water-tube | Vertical triple expansion, and compound | Multipolar, shunt-wound, and interior pole | 1.021 |
| **Heilbronn** | Jan. '92 | C | A | 8·0–4·8 | 3·6–2·1 | A 450 H.P. plant in course of erection | Vertical combination turbines | Three-phase alternators ... | 400 |
| **Kaiserslautern** | Sept. '94 | M | A — | 8·4 | 2·4 | Breda tubular | Vertical compound condensing | Alternators and multipolar, shunt-wound | 693 |
| **Königsberg** | Dec. '90 | M | — | — | — | Water-tube | Vertical triple expansion condensing | Interior pole | 381 |
| **Leipzig** | Sept. '95 | C | A | 8·4 | 2·4 | Cornish | Vertical triple expansion condensing | Primary: Three phase alternators. Secondary: Three-phase, cont. cur. transfmrs. | 660 |
| **Mulhouse** | Mar. '88 | C | — | 8·3 | 3·4 | Water-tube, de Naeyer type | Vertical compound condensing | Interior pole, shunt-wound | 297 |
| **Munich** | Dec. '93 | M | — | 9·6 | — | Two flue | Jonval turbines, compound engines, gas engines | Multipolar, shunt-wound... | ... |
| **Neuhaldensleben** | Oct. '92 | M | — | 7·6 | 7·6 | Two-flue | Compound condensing ... | Shunt-wound | 76 |
| **Nuremburg** | Building | M | A | 8·4 | 2·4 | Cornish with eccentric flues | Vertical compound condensing | Single-phase alternators, direct connected | 900 |
| **Stettin** | Oct. '89 | C | — | Per 16-c.p. hr. 0·48 | 4·8 | Water-tube | Vertical compound condensing | Interior pole | 520 |
| **Stockholm** | Sept. '92 | M | — | 8·0 | 4·0 | Water-tube | Vertical triple expansion condensing | Interior pole | 840 |
| **Strassburg** | May '95 | C | A | 9·6 | 2·4 | Water-tube | Vertical compound | Three-phase alternators, multipolar dynamos | 1.133 |
| **Trarbach** | Jan. '90 | C | — | 9·8 | 9·8 | Water-tube, Willmann type | Horizontal single cylinder | Shunt-wound dynamos | 50 |
| **Vienna** | Nov. '90 | C | A | 10·8 | 6·0 | Water-tube | Compound condensing ... | Alternators | 4.640 |
| **Zwickau** | Dec. '93 | C | — | 8·4 | 2·4 | Galloway | Compound | Dynamos, drum armatures, motor-generators | 288 |

* Abstracted, revised, and recast from a Table recently published in the *Elektrotechnische Zeitschrift*. Our readers must understand that

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# SUPPLY STATION DATA.

***of German Electric Supply Undertakings.****

| Accumulators. | | Lamps connected. | | Fuel. | Consumption of coal per kilowatt-hour *sold* (lbs.). | Units *generated* during the last business year (kilowatt-hours). | Costs per kilowatt-hour *sold*, inclusive of Station consumption (pence). | | | | | TOWN. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type. | Capacity in kilowatt-hours. | Glow-lamps 8-c.p. | Arc-lamps. | | | | Interest. | Salaries and Wages. | Coal. | Oil. | Total. | |
| | | | | | | | d. | d. | d. | d. | d. | |
| Tudor.. | 386 | 19,270 | 301 | Pit-coal ..... | 7·2 | 507,341 | — | 1·02 | 0·39 | 0·07 | — | **Aix-la-Chapelle.** |
| Tudor.. | 643 | 15,014 | 234 | Pit-coal ..... | 6·3 | 976,109 | — | 0·60 | 0·26 | 0·01 | 0·88 | **Altona.** |
| Tudor.. | 453 | 14,046 | 293 | Pit-coal ..... | 10·1 | 159,675 | 3·43 | 1·75 | 0·54 | 0·02 | 5·76 | **Barmen.** |
| Tudor.. | 616 | 42,480 | 456 | Westphalian pit-coal ... | 6·8 | 608,300 | 2·58 | 1·17 | 0·58 | 0·05 | 4·40 | **Bremen.** |
| Tudor.. | 835 | 19,830 | 733 | Pit-coal ..... | 9·0 | 630,505 | 1·29 | 0·94 | 0·50 | 0·04 | 2·79 | **Breslau.** |
| Tudor.. | 338 | 9,624 | 256 | Pit-coal ..... | — | 205,559 | 3·04 | 1·63 | 0·13 | 0·05 | 4·89 | **Cassel.** |
| Tudor.. | 475 | 13,942 | 858 | Pit-coal and coke ..... | 6·3 | 563,729 | 1·42 | 0·88 | 0·70 | 0·08 | 3·09 | **Christiania.** |
| — | — | 13,034 | 183 | Pit-coal ..... | — | 398,410 | — | — | — | — | — | **Chemnitz.** |
| — | — | 41,108 | 386 | Pit-coal . mixed with coke | 9·0 | — | 1·40 | 0·80 | 0·51 | 0·14 | 2·86 | **Cologne.** |
| Tudor.. | 1,431 | — | — | Coke and coke-dust ... | 8·3 | 805,649 | 2·02 | 0·96 | 0·54 | 0·02 | 3·55 | **Copenhagen.** |
| Tudor.. | 228 | 18,592 | 217 | Rhenish and Westphalian pit-coal | 10·1 | 270,197 | 1·93 | 1·20 | 0·76 | 0·10 | 4·02 | **Darmstadt.** |
| Tudor.. | 200 | 8,028 | 68 | — | 50·2 cub. ft. of gas | 69,700 | — | 2·10 | 1·88 (gas) | — | 4·08 | **Dessau.** |
| Tudor.. | 1,168 | 29,986 | 795 | Westphalian pit-coal ... | 7·0 | 565,839 | 2·48 | 1·00 | 0·40 | 0·03 | 3·96 | **Düsseldorf.** |
| — | — | — | — | — | — | — | — | — | — | — | — | **Dresden.** |
| — | — | — | — | Bohemian brown coal... | — | — | — | — | — | — | — | **"** |
| — | — | 7,688 | 2,540 | Pit-coal ..... ... | 10·7 | 329,000 | 1·26 | 1·26 | 0·67 | 0·13 | 3·32 | **Elberfeld.** |
| — | — | — | — | Pit-coal ..... | — | — | — | — | — | — | — | **Frankfort-on-Main.** |
| Tudor.. | 234 | — | — | Meuselwitz brown coal | 22·4 | — | — | — | — | — | — | **Gera.** |
| Tudor.. | 475 | — | 2 | Silesian pit-coal ..... .. | 15·4 | 23,034 | — | 0·62 | 1·28 | 0·18 | — | **Greifenhagen.** |
| Tudor.. | 186 | 2,174 | 42 | Pit-coal ... .... ..... | 14·3 | 77,950 | — | 1·48 | 1·12 | 0·18 | — | **Gummersbach.** |
| Tudor.. | 1,745 | 56,036 | 1,105 | Pit-coal and coke ..... | 4·4 | 3,553,121 | — | 0·48 | 0·57 | 0·07 | 1·12 | **Hamburg.** |
| Tudor.. | 580 | 30,702 | 681 | Rhenish and Westphalian pit-coal | 5·0 | 690,950 | 1·32 | 0·79 | 0·43 | 0·04 | 2·59 | **Hanover.** |
| — | — | 11,533 | 42 | — | ... | — | — | — | — | — | — | **Heilbronn.** |
| — | — | 11,608 | 191 | Pit-coal ..... | 20·6 | — | 0·78 | 0·68 | 1·32 | 0·24 | 3·00 | **Kaiserslautern.** |
| Tudor.. | 369 | 17,042 | 438 | Scottish and English inferior pit-coal | 14·0 | 283,923 | 2·46 | 1·32 | 0·75 | 0·07 | 4·63 | **Königsberg.** |
| Tudor.. | 1,338 | — | — | — | — | — | — | — | — | — | — | **Leipzig.** |
| Tudor.. | 99 | 23,552 | 135 | Belgian and Rhenish pit-coal | 8·1 | 395,345 | — | — | — | — | — | **Mulhouse.** |
| Tudor.. | — | — | — | Bavarian pit coal and coke | 6·8 | 654,256 | — | — | — | — | — | **Munich.** |
| Tudor.. | 101 | 5,800 | 36 | Brunswick coal ..... | 35·2 | 76,344 | 1·57 | 0·92 | 1·24 | 0·26 | 4·00 | **Neuhaldensleben** |
| — | — | — | ... | — | — | — | — | — | — | — | — | **Nuremburg.** |
| Tudor.. | 333 | 20,342 | 512 | Anthracite ..... | 7·2 | 571,628 | — | 0·85 | 0·76 | 0·09 | — | **Stettin.** |
| Tudor.. | 1,463 | 29,114 | 212 | Coke ..... ..... | 6·3 | 435,396 | 2·31 | 0·84 | 0·58 | 0·06 | 3·80 | **Stockholm.** |
| — | — | — | — | — | — | — | — | — | — | — | — | **Strassburg.** |
| Tudor.. | 65 | 3,128 | 12 | Pit-coal ..... ..... | 11·0 | 52,305 | 1·59 | 1·24 | 1·05 | 0·02 | 3·93 | **Trarbach.** |
| — | — | 103,768 | 7,775 | Ortrau pit-coal .. ..... | 9·4 | 6,233,400 | 1·20 | 0·33 | 0·78 | 0·09 | 2·41 | **Vienna.** |
| Tudor.. | 168 | 4,386 | 182 | Local pit-coal ..... | 9·4 | 422,830 | — | — | — | — | — | **Zwickau.** |

this Table does not include only German Stations, or all the Stations in Germany, but merely those belonging to the above Association.

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# TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Edinburgh Town Council invites tenders for supplying and erecting at the electricity supply station, Torphichen-street, (1) coil hoist, gantry and capstan, (2) coal hoppers, measuring gear, and shoots, and (3) hauling gear in coal store. Tenders to the Town Clerk, City Chambers, Edinburgh, by 22nd inst.

——— The Blackpool Corporation requires tenders for the supply, laying and maintenance of high-tension and low-tension lead-covered cables and the supply of all necessary jointing materials. Tenders to the Chairman of the Electric Lighting and Tramways Committee, Blackpool, by 8th inst.

——— The Cork City Council invites proposals from persons willing to carry out the terms of Cork Provisional Order (1896). Offers to Town Clerk, Municipal Buildings, Cork, by 11th inst.

TENDERS ACCEPTED.—The Radcliffe District Council received 27 tenders for the supply and erection of a gas engine and for wiring and fitting up the Technical School for the electric light. We give below a complete list of the tenders sent in :—

| | |
|---|---|
| S. H. Heywood, Ducie-street, Manchester (*accepted*) | £492 10 |
| W. J. Furse and Co., Nottingham | 729 0 |
| George Hill and Co., Manchester | 675 0 |
| Brush Company, Birmingham branch | 675 0 |
| Hewes, Geary and Co., Swadlincote | 670 16 |
| Manchester Edison-Swan Company | 618 18 |
| Drake and Gorham, Manchester branch | 614 0 |
| Liverpool Gas and Electric Fittings Company | 600 0 |
| J. H. Holmes and Co., Newcastle-on-Tyne | 600 0 |
| Sharp and Kent, Westminster | 586 0 |
| Baxendale and Co., Manchester | 580 0 |
| H. Lightfoot, Manchester | 577 0 |
| Maunsell Mercier and Co., Manchester | 550 0 |
| Manchester Electric Company | 550 0 |
| J. H. Pickup and Co., Bury | 545 0 |
| J. Lomax Kendal and Co., Manchester | 531 10 |
| Corlett Electrical Engineering Company, Wigan | 525 0 |
| John A. Edmondson, Leeds | 523 0 |
| William Banks and Co. (Limited), Bolton | 492 0 |
| L. Alwyn, London | 490 0 |
| Fletcher, Hirst and Co., Burnley | 484 15 / 531 15 |
| Inrig and Chester, London | 469 15 |
| A. J. Harris and Co., Bradford | 459 10 |
| Stanley, Davies and Pollard, Hyde | 430 10 / 560 0 |
| Graham, Chapman and Co., Morley | 409 10 |

——— The Islington Vestry received four tenders, varying from £7,540 to £8,015, for the enlargement of the electricity station, Eden-grove, N. It has been decided to accept the lowest, that of Mr. G. Sharpe, of Stratford, £7,540.

——— The Gas Committee of the Dundee Town Council recommends the acceptance of the tender of the Silvertown Company for the supply of the electric light cable for the Overgate, Wellgate, and Whitehall-street extensions.

TENDERS RECEIVED.—The following have tendered for the erection of a factory for Messrs. Muirhead and Co., at Elmer's End, Kent :—

| | | | |
|---|---|---|---|
| Symes and Duncan | £4,568 | T. W. Jones | £3,920 |
| L. H. and R. Roberts | 4,397 | T. Graham and Co. | 3,390 |
| Simmons Bros. | 4,383 | | |

WORKS FOR SALE.—Particulars are given in our advertisement columns of engineering works and foundry (with engines, boilers, machinery, &c.), which are for disposal. The premises are suitable for carrying on a general engineering business, are situated at Mains Loan, Dundee, and are within four minutes of a railway station. Applications to Messrs. Shield and Kyd, Dundee.

APPOINTMENTS VACANT.—The Blackburn Town Council invites applications for the appointment of assistant engineer at the electricity works. Salary £125 per annum. Applications to the Town Clerk, Blackburn, by 18th inst.

——— A Science Demonstrator is required by the Liverpool School Board. Salary £100 per annum, rising to £120. Applications to Clerk to the Board by 8th inst.

APPOINTMENTS.—At Wednesday's meeting of the Council the Tramways Committee of the Leeds Corporation recommended the appointment of Mr. John Burbidge as clerk of works in respect of the projected electric tramway from Roundhay Park to Kirkstall, at a salary of £3. 3s. per week. Mr. Burbidge was manager for the British Thomson-Houston Company of the late electric tramway on Roundhay-road. There were 35 applications for the position, but this number was reduced to 5, viz., Messrs. Burbidge, F. B. Lea (London), Ernest K. Scott (Wolverhampton), C. F. F. Smith (Blackpool), and H. G. Sprague (Dublin). The salaries asked for varied from £2. 5s. to £5. 15s. per week. In selecting Mr. Burbidge the Committee was influenced to a considerable extent by his experience on the old Roundhay electric tramway. The appointment was confirmed by the Council on Wednesday. The Highways Committee is desirous of pushing on with the new tramway as rapidly as possible, and the appointment of a clerk of works to superintend the electric equipment will now enable them to proceed with some expedition.

APPOINTMENTS.—Mr. W. Williams, B.Sc., late Senior Demonstrator in the Physical Department of the Royal College of Science, has been appointed Lecturer in Physics at the Technical School, Swansea. Messrs. Allan Gibb and T. Gilbert Jones, B.Sc., Wh.Sc., have been appointed Lecturers in Metallurgy, and Applied Mechanics and Steam respectively.

REMOVAL.—The offices of the Brockie-Pell Arc Lamp (Limited) have been removed to 97, Queen Victoria-street, E.C., where all communications should in future be addressed.

DIVIDEND.—A first dividend of 2s. in the £ is payable at Monument House, Monument-square, E.C., in the failure of Sydney Cheeld, electrical engineer, Chesham, Bucks.

LIQUIDATIONS.—It has been decided to wind up Dietz, Davis and Co. (Limited), electrolier, lustre, &c., manufacturers, 44, Upper East Smithfield, E.; and Mr. A. G. Clark, 39, Beecholme-road, Upper Clapton, N.E., has been appointed liquidator.

——— Creditors of the Birmingham Central Tramways Company (Limited) must send particulars of their claims to the liquidator (Mr. Howard S. Smith), 14, Waterloo-street, Birmingham, by the 30th inst.

BANKRUPTCY.—The first meeting of creditors in the failure of Paterson and Cooper, electrical engineers, Prince's-mansions, Victoria-street, S.W., European Works, Pownall-road, Dalston, N.E., London, and also at Glasgow, took place at the Bankruptcy Court, Carey-street, W.C., on Tuesday. The receiving order was made on the 20th ult., and a special manager was appointed, with a view to the completion of certain contracts. The statutory accounts were not filed; but the Official Receiver said that, from the figures furnished to him by the debtors, and which must be accepted with reserve, it appeared that the unsecured indebtedness was estimated at about £11,000, and the assets at £18,000, exclusive of interests in certain patents. The debtors had a half-share in the Hermite patents for the electrical treatment of sewage, and they had endeavoured to float a company to acquire the same with a capital of £300,000. No proposal was made by the debtors, and a resolution for bankruptcy was passed. Mr. Edward Moore, accountant, was appointed trustee of the estate, together with a committee of inspection. The debtors signed their consent to an adjudication. The amount of the bond to be given by the trustee was fixed at £6,000.

NEW WORKS.—Mr. Fernand Espir, of 3, East India-avenue, London, informs us that his principals, Messrs. Lazare Weiller and Co., have started extensive works at Havre for the manufacture of copper, bronze, steel, and iron wires, &c., and are open to take contracts for delivery after October 1st next. The new works are situated close to the quay, and are thus on the spot for export orders. The works are equipped with power equal to 3,000 H.P., entirely distributed by electricity, no less than 120 dynamos being at work in the various shops. It is claimed for the special machinery which has been put down that many drawbacks and imperfections of manufacture are now avoidable. The capacity of the Havre works is put down at 400 tons per day.

ENGINEERING AND MATHEMATICAL INSTRUMENTS, &c.—Messrs. John Davis and Son, of Derby, forward a copy of their Section "A" 1896 Catalogue, which is just issued, containing particulars and prices of the firm's manufactures in mining, surveying and engineering instruments. The catalogue is very fully illustrated, and as the illustrations are chiefly from photographs, a more accurate idea can be gathered of their appearance than when the artist is allowed a free hand to embellish his subject. It is noticeable that a full use has been made of aluminium in the construction of the surveying instruments, as the experiments made by the firm have confirmed their view—that this metal combines strength, lightness, and non-liability to corrosion. The catalogue is clearly arranged, and, although not dealing with the electrical branch of the firm's business, contains a quantity of matter of interest to our readers. There is a lack of clearness in some of the illustrations, which is, however, due to the fact that they are from photographs. To mining engineers the catalogue will be found especially useful. The principal instruments have attached to them in the catalogue a code word for the convenience of foreign buyers.

THE "ENGINEERING MAGAZINE."—The contents of the September issue of this excellent magazine are of the usual varied and interesting character. The number contains articles on "Free Silver

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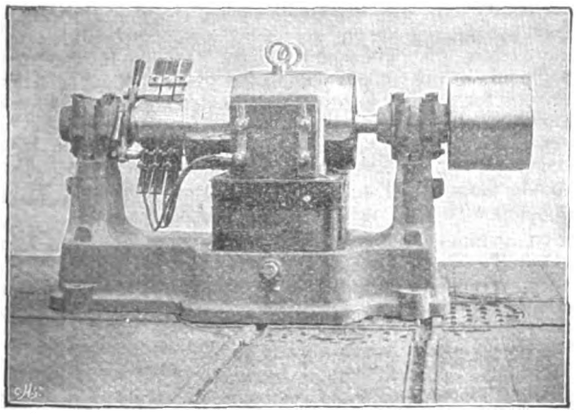
Poison the Cause of Industrial Paralysis," by J. Selwin Tait; "Gas *versus* Electricity direct from Coal," by D. M. Dunning; "The Underground Topography of a City," by William Barclay Parsons; "The Less-known Gold Fields of Colorado," by Thomas Tonge; "The Economy of the Modern Engine Room," by Charles E. Emery: "Railway Pooling and the Reduction of Freight Rates," by H. T. Newcomb; "Shifting Lines of Industrial Interest in Electricity," by G. H. Stockbridge; "The Harmony of Architecture and Landscape Work," by Downing Vaux; "Modern Machine Shops' Economics," by Horace L. Arnold; and "The Manufacture and Use of Brick for Paving," by H. K. Landis. The issue also contains the usual exhaustive review of the World's Press. This number, as well as all the back numbers, may be obtained at the offices of the European Edition, 1, 2 and 3, Salisbury-court, Fleet-street, London, E.C.

"CASSIER'S MAGAZINE."—The September issue of this magazine contains articles on: "On the Insurance of Electrical Plants," by R. H. Pierce; "Electric High-Pressure Concentric Cables and their Accessories," by J. Hetherington; "Local Developments of an Electric Central Station," by W. S. Barstow; "Steam Turbines, their Advantages and Disadvantages," by Prof. J. H. Barr; "Condensers for Steam Engines," "Filtering Feed Water for Steam Boilers," "A Mechanical Coke Drawer," and "The Milling Machine for General Shop Use in America." The number also contains a biographical sketch, accompanied by portraits, of Sir Henry Bessemer.

DYNAMOS UP-TO-DATE. — Messrs. Laurence, Scott and Co. (Limited) have recently erected new works on a commodious site adjoining the Great Eastern Railway at Norwich. These works and the new tools with which they are equipped have been specially designed for the manufacture of the high-class dynamos and motors which are this firm's speciality. One of their latest machines for belt-driving is illustrated herewith. The bearings consist of solid



gun-metal bushes, which are self-aligning and self-oiling. These bearings have proved so satisfactory that Messrs. Laurence, Scott and Co. have, we learn, discontinued the manufacture of other types of bearings. Overheating, it is stated, has been practically unknown even during the overload test of the new machines.

PERSONAL.—Mr. H. Faraday Proctor was on Friday last presented by the Chairman of the Electric Lighting Committee of the Bristol Corporation with a silver tea and coffee service which had been subscribed by the members of the Committee as a mark of their appreciation of Mr. Proctor's services since he was appointed electrical engineer to the Corporation. The occasion for the presentation was the approaching marriage of Mr. Proctor with the daughter of the late senior partner of the well-known firm of Pickett and Sons, engine builders, of Bristol. Mr. Proctor has also received a presentation from the pupils and assistants at the electricity station. The marriage took place yesterday.

——— With reference to the letter dated the 24th ult., sent out by Messrs. John Freeman, Dyson and Co., accountants, of Leeds, Mr. Frederick J. Borland, engineer and electrician, of Benson-street, Leeds, informs us that he has decided to cut out the unprofitable part of his business, and to continue as heretofore.

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ABERDEEN.—The work in connection with the extensions at the electricity station is progressing rapidly. The premises are being enlarged to more than twice their former size. A plot of ground adjoining the existing buildings, and measuring 58ft. by 36ft. has been taken in, and on this space a new engine and dynamo room, boiler house, offices and stores are being erected. In the new building there will be accommodation for machinery of a capacity of 3,000 H.P.; the offices, stores and testing room will be situate on the first floor. The new chimney shaft will be 150ft. high, 13ft. in diameter at the base, and 7ft. 6in. at the top. Messrs. Crompton and Co. recently received an order for a new 300 H.P. unit of plant at £2,660, and Messrs. M'Kinnon and Co. were commissioned to supply two 600 H.P. boilers, with feed-water heater, pumps, &c., costing £3,000. There is a brisk demand for electric current, and at present an equivalent of about 25,000 8 c.p. lamps is fed from the city mains.

BATH.—As soon as the Corporation take over the electric lighting works, energetic steps will be made by the Electric Light Committee to create a greater demand for electric current. The Committee has already formulated a scheme of extensions, and has decided to recommend that mains be laid through Walcot to Grosvenor, up Camden-place to Sion Hill, through Claverton-street and Widcombe-parade to Widcombe-crescent, up the Wells-road to Bloomfield-avenue and round Oldfield Park, and along the Upper Bristol-road to the end of the city boundary.——In anticipation of the early introduction of the electric light the Combe Down Parish Council has decided only to enter into a six months contract for repairing street lamps. The general question of lighting is being considered by a committee.

BELFAST.—The Electric Light Committee has decided to recommend the Council to grant special terms for the supply of electric current to Messrs. W. and G. Baird, printers, who have decided to employ electric motors for working the printing machinery at their establishment. The Committee recommend the Council to authorise a special scale for all similar cases of large consumption of current in the daytime, and to reduce the charge to 2¾d. per unit for all current over 4,000 units.——The Committee propose to put down an additional direct-driven engine and dynamo at the electricity station.

BOLTON.—The Gas and Electricity Committee has decided to make experiments in street lighting by means of incandescent electric lamps. The electrical engineer (Mr. A. Ellis) has been instructed to provide for a supply of electric current to the extensive establishment known as the Park Saw Mills.

DUNDEE.—Mr. W. H. Tittensor, electrical engineer to the Dundee Corporation, was on Tuesday threatened with death by an engine driver who was dismissed from the service of the Corporation through drunkeness. The man's name is Robert Wilson, and in addition to threatening Mr. Tittensor the accused assaulted a switch attendant named Samuel Jones. It appeared that Mr. Tittensor had previously notified the accused that he would be dismissed unless he mended his ways, and this warning having proved of no avail, on the next occasion he was dismissed. He took exception to this, and demanded his wages, and while these negotiations were going on the threat against Mr. Tittensor was perpetrated. At the Police Court Mr. Tittensor pleaded for a light sentence, and the accused was severely admonished and fined 20s., with the alternative of 14 days' imprisonment.

ELECTRICITY IN MINING.—The general manager of Henderson's Nigel Company (a South African mining undertaking) has prepared a scheme for the development of the property under his control. The scheme provides for the employment of electric hoists for winding purposes; the rock-breaker will also be driven electrically, and it is proposed to employ electricity wherever possible. The treatment of the tailings will be that commonly adopted on the Rand, except that the precipitation will be done by electricity.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from August 26th to September 1st, with the ports of destination:—

*Argentina*—Buenos Ayres, £1,233 (including £1,089 telegraph wire). *Australasia*—Adelaide, £73 (telegraph material); Fremantle, £16; Melbourne, £943 (including £843 telegraph material); Rockhampton, £56; Sydney, £494; Townsville, £5; Wellington, £41. *Belgium*—Antwerp, £70. *British Guiana*—Demerara, £27. *Ceylon*—Colombo, £52. *China*—Shanghai, £6,825 (telegraph cable). *Holland*—Amsterdam, £275; Flushing, £31; Rotterdam, £44. *Hong Kong*—£30. *India*—Bombay, £242; Calcutta, £1,416 (including £73 telephones); Madras, £77 (telegraph material). *Japan*—Yokohama, £78. *South Africa*—Cape Town, £308 (including £93 telegraph apparatus); Durban, £45; East London, £41; Port Elizabeth, £581. *Spain*—Pasages, £11; Santander, £20. *Straits Settlements*—Singapore, £164. *United States*—New York, £111 (telegraph material). Total, £13,359.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows:—

*Belgium*—Ghent, £70 (lamps).

EPSOM.—The Council has decided to engage Mr. W. C. C. Hawtayne, at a fee of 25 guineas, to prepare a report on the advisability of applying for a Provisional Order.

GAS AND ELECTRIC LIGHTING COMPANIES' STATISTICS.—We have received from Messrs. Hazell, Watson and Viney a copy of the 1896 edition of this Directory, which is considerably enlarged, and has been revised up to July. The information which is given in the book is more complete than in any previous issue, and a general index of officials, engineers, and managers has been added in the

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gas and water sections. This is the twentieth edition of this useful publication, and, so far as we have been able to judge, it is very complete in the gas and water divisions. In its statistical matter it is considerably ahead of the returns made to the Board of Trade. In the lists of associations we find included under the heading "Associations of Electrical Engineers," the Civil Engineers, and the Leeds Association of Engineers. Also Mr. Henry Edmunds is given as the President of the Northern Society, which is erroneous. There are a number of institutions which should be included in the list that are not here to be found, notably the Société Internationale des Electriciens, the Association Suisse des Electriens, and many others; but this is doubtless accounted for by the fact that the book is mainly intended to cover gas and water matters, which it certainly does effectively. Only a very small space (pages 291 to 302) is devoted to electric lighting undertakings. The book is well got up, and is published at 10s.

India-Rubber.—A Report from Mr. C. B. Rhind, of the Foreign Office, on the Industries and Economic Products of Para and the States of Amazonas, deals with the great importance of the rubber industry. Notwithstanding the remarkable abundance of all native productions the ease with which rubber is obtained and disposed of secures for it an almost exclusive interest and attention. The exports from 1836 to 1852 averaged 76,870 kilos., compared with 39,180 kilos. per annum from 1853 to 1862. India-rubber now represents two-thirds of the total value of the exported productions of the State. During 1894-95 the exports represented 8,209,385 kilos., equal in value to £1,560,300. Owing to the want of methodical arrangement it is difficult to ascertain what part of these shipments is absolutely of Para origin, and how much comes from the Amazonas; and therefore Mr. Rhind makes a more reliable computation of the combined exports by amalgamating the returns of the entire rubber district, which show for 1895 exports amounting to 20,769,581 kilos., of which 9,518,171 kilos was shipped to Europe and 11,251,410 kilos. to the United States.

Government Office Lighting.—Advantage is being taken of the absence of Mr. Balfour to extend the system of electric lighting at the official residence of the First Lord of the Treasury in Downing-street.

Halifax.—Sometime ago the Town Council decided to construct a system of tramways at a cost of £100,000, and plans of the first section of this scheme were submitted at the last meeting of the Council. The Council intends to promote a Bill in the next Session of Parliament for power to construct the lines specified in the plans, and to adopt a system of mechanical traction. The plans were approved.

Hospital Lighting.—The Town Council of Crewe has decided to introduce the electric light at the Isolation Hospital. The Health Committee, which had the matter under consideration, reported in favour of the scheme, and stated that the 28 beds in the hospital were apportioned in the various wards on the basis of 2,000 cubic ft. to each patient, assuming that gas was used; but with electric lighting this accommodation could be increased to 45 beds, thus obviating the necessity of future extensions for many years.

Leith.—At Tuesday's meeting of the Town Council Bailie Manclark submitted a motion in favour of applying for a Provisional Order. He said that it would have been better for them had they "gone in for" the electric light a year or two before, as some of their probable customers had recently put down independent plants, and in addition they would have been spared the humiliation of Edinburgh offering as a reason for amalgamation that they would have the electric light. He estimated the initial cost of an installation at about £25,000, and they could so construct the station that additions could be easily made as occasion arose. The annual expenditure entailed by such an installation would amount to £2,780, and the probable revenue to £6,850. The Council should also endeavour to make arrangements for improving the tramway service, and for introducing electric traction on the line. The motion was, after some discussion, agreed to.

Lincoln.—A special meeting of the Town Council was held on Monday for the purpose of passing a formal resolution in favour of applying for a Provisional Order. The resolution was, after a brief discussion, agreed to.

Liverpool.—The City Council has now sanctioned the new tariff scale for electric current for lighting and power purposes set out in our issue of the 31st ult. The modified scale comes into force on October 1st.

Llanelly.—The electric lighting scheme recently submitted to the Town Council by Messrs. J. C. Howell (Limited) gave rise to a lengthy debate at the last meeting of the Council. The Estates Committee reported in favour of the scheme; but it was eventually decided to refer the matter back for further consideration.

Northwich.—The District Council has sealed the agreement with the Northwich Electric Supply Company for the establishment of electricity supply works in the town. The Company has applied for a Provisional Order for supplying electric current in the rural and urban districts, and under the agreement the Council has the option of purchasing the undertaking at the end of 14 years on repayment of expenditure incurred in buildings and plant, and the payment of a sum sufficient to pay a dividend of 7½ per cent. for any year when a less dividend has been declared.

Nottingham.—An important report by the Parliamentary Committee on the question of improving and extending the present tramway system will be considered at a special meeting of the Town Council on Monday. The report recommends the introduction of a Bill in the next Session of Parliament authorising the Council to take over the tramways and to make considerable extensions thereto. The Committee favours the adoption of mechanical traction, but as investigations are being made as to the most suitable system to be employed no recommendation on this point is made.

Obituary.—The death is announced of Mr. Peregrine Birch, C.E., engineer in charge of the engineering works of the British Aluminium Company, at Foyers, Inverness. Mr. Birch was in his 51st year.

Portsmouth.—On the recommendation of the Electric Light Committee, the Town Council has decided to let out on hire electric motors and electric cooking apparatus at 15 per cent. on the cost price.

Rangoon.—Towards the end of 1895 the Municipal Commissioners invited proposals for the electric lighting of Rangoon, and in response 26 tenders, varying from 1½ to 8 lakhs of rupees, were received. Mr. Stirrat, the municipal engineer, to whom these tenders were remitted for analysis, now reports in favour of the lowest tender, which was submitted by a Calcutta firm. The initial cost of the selected scheme is put at Rs,1,89,750, and the annual cost of maintenance, including repayment of interest and loan, at Rs.93,250. Mr. Stirrat, however, recommends the Council to start by putting down an installation capable of supplying electric current for public and private lighting in the principal thoroughfares in the central part of the town. Should the demand for current for private lighting justify it, extensions will then be made to the outlying districts. Circulars are being sent to the ratepayers in order to ascertain the amount of support likely to be accorded to the scheme; and should there be evidence of a reasonable demand for current, the Commissioners intend to proceed at once with the erection of a generating station.

South Shields.—The electricity supply works were formally opened on Tuesday evening. The station is situated at Black's Old Foundry, West Holborn, and has a good river frontage. The contracts for the supply of the plant were let as follows:—Boilers (marine type), Black, Hawthorn and Co., Gateshead; steam engines (triple expansion, converted cylinder, marine type), J. and H. McLaren, Leeds; pumping plant, boiler feed-pumps, tanks, &c., Henry Watson and Sons, Newcastle-on-Tyne; electrical plant (alternators, switchboards, rectifiers, transformers, arc lamps and posts), S. Z. de Ferranti (Limited), London; buildings, Brown and Co., South Shields. The total cost of the machinery and plant amounts to about £20,000. It has been decided to adopt the Brighton method of charging for current. The whole of the work has been carried out under the superintendence of the Borough Electrical Engineer (Mr. J. A. Jeckell).

Sunderland.—At the last meeting of the Town Council the discussion was resumed on Mr. Alderman Bruce's motion that the Special Tramways Committee be instructed to consider the advisability of purchasing the tramlines of the local tramway company, with a view to the introduction of an improved system of mechanical traction. After a lengthy debate the motion was agreed to.

Telephone Trunk Wires.—A long list of trunk wires which will be taken over by the Post Office on the 19th inst., at 4 p.m. is issued. The list contains the names of 52 centres where junction circuits will be provided between the Post Office and the National Company's exchanges.

Torquay.—The Local Government Board has sanctioned the application of the Town Council for power to borrow £22,000 for electric lighting purposes.

Tunbridge Wells.—The electricity supply undertaking of the Town Council is already in a satisfactory financial condition. Last week it was reported that, although the station had been only a year in operation, the receipts were sufficient to meet not only the ordinary expenditure, but also to pay interest and sinking fund. It was further stated that there was a great demand for current by all classes of ratepayers.

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**WEST AFRICAN TELEGRAPH COMPANY (LIMITED).**—The half-yearly interest on this Company's £300,000 Five per Cent. Mortgage Debentures, due 1st inst., will be paid by the National Bank of Scotland, 37, Nicholas-lane, London, E.C. Coupons should be left three clear days for examination.

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## NEW COMPANIES, STATUTORY RETURNS, &c.

**MAGNOLIA ANTI-FRICTION METAL COMPANY OF GREAT BRITAIN (LIMITED).**—This Company has been registered with a capital of £1,000, in £1 shares, to carry on the business of manufacturers of and dealers in magnolia anti-friction metal and alloys, metals, &c.

**SUNDERLAND FORGE AND ENGINEERING COMPANY (LIMITED).**—This Company has been registered, with a capital of £25,000, in £50 shares, to acquire the business carried on by the Sunderland Forge Company at Sunderland, and to carry on the business of electrical and mechanical engineers, forgemen, &c.

**CHILI TELEPHONE COMPANY (LIMITED).**—The annual return of this Company to August 21st has been filed. The nominal capital is £250,000 in £5 shares, and 44,000 of these have been taken up. The full amount has been called and paid.

**EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).**—The annual return of this Company to August 14th has been filed. The nominal capital is £1,000,000, in 150,000 "A" shares of £5 each, and 50,000 "B" shares of similar value; 106,400 of the former and 23,564 of the latter have been taken up, and 17,139 "A" and all the "B" have been issued as fully paid, while the remaining 89,261 "A" shares have been issued with £3 considered as paid. A call of 10s. per share has also been made on the latter, and £44,630. 10s. has been paid.

**ELECTRICAL POWER STORAGE COMPANY (LIMITED).**—The annual return of this Company to July 30th has been filed. The nominal capital is £100 500 in 100 Founders' and 20,000 Ordinary shares of £5 each, and 66 of the former and 18,257 of the latter have been taken up. 15,120 Ordinary have been issued as fully paid. The full amount has been called on the Founders' and £3 per share on 3,137 Ordinary. A sum of £400 has been received in connection with the forfeiture of 4 Founders' and 400 Ordinary shares.

**GLOBE TELEGRAPH AND TRUST (LIMITED).**—The annual return of this Company to August 11th has been filed. The capital is £5,000,000, divided into 250,000 Ordinary and a like number of Preference shares of £10 each; 180,227 Ordinary and 180,042 Preference have been taken up, and the full amount has been called and paid.

**LONDON AND PROVINCIAL TRACTION COMPANY (LIMITED).**—The statutory return of this Company to April 8th has just been filed. The nominal capital is £100,100, in 10,000 shares of £10 each and 100 shares of £1 each; 366 of the former and four of the latter have been taken up, and the full amount has been called on the £10, and 1s. per share on the others.

**UNITED RIVER PLATE TELEPHONE COMPANY (LIMITED).**—The annual return of this Company to July 28th has been filed. The capital is £500,000, in £5 shares, and 58,000 have been taken up, of which 16,000 have been issued as fully paid. The full amount has been called and paid on the remaining 42,000 shares.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30⅝d. per oz. (Sept. 3rd). Consols (2¾ per cent.) 112—112⅛ for money, 112$\frac{5}{16}$—112$\frac{7}{16}$ for account; 2½ per cent. 107¼—107⅜ (Sept. 3rd). Stock Exchange Settling Days: Consols, Oct. 1st; Stocks and Shares Continuation Day, Sept. 14th; Ticket Day, Sept. 15th; Pay Day, Sept. 16th; Mining Share Carry-over Day, Sept. 12th.

**BABCOCK AND WILCOX (LIMITED).**—The Directors of this Company have decided to recommend the payment of dividends of 6 per cent. on the Preference and 20 per cent. on the Ordinary shares for the six months ended June 30th.

**CITY AND SOUTH LONDON RAILWAY.**—The traffic returns of this Company for the week ended August 30, 1896, were £835, against £786 in the corresponding week of last year, an increase of £49. The total receipts for the half-year amount to £8,333, against £7,669 for the corresponding period of 1895, an increase of £664.

**COMMERCIAL CABLE COMPANY.**—The Directors of this Company have declared the usual quarterly dividend of 1½ per cent., payable on October 1st. The transfer books will be closed from the 19th inst. to October 2nd inclusive.

**DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).**—The Company's estimated traffic receipts for the month of August, 1896, are £2,038.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 30th ult. amounted to £1,300. The amount for the corresponding week last year was £1,272. Increase, £28.

**STETTIN ELECTRIC SUPPLY COMPANY.**—The Directors of this Company have declared a dividend of 7 per cent., against 6 per cent. for 1894-95.

**SUSSMANN ELECTRIC MINERS' LAMP COMPANY (LIMITED).**—The statutory meeting of the shareholders of this Company was held at the Cannon-street Hotel, E.C., on Monday; the Earl of Westmorland presiding. The Chairman said the Directors were in negotiation for the sale of the Belgian, French and South African patents. There was an extensive field for the lamp, they were shipping samples to India, and many inquiries had been received from collieries both in England and Wales. He claimed that the lamp was absolutely the best lamp yet invented for underground work; it was so clean, gave such a bright light and was so handy, while its safety was unquestionable. A vote of thanks to the Chairman terminated the proceedings.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended August 28th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,791.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half-month ended Aug. 31st were £1,660, against £1,617 in the corresponding period of 1895.

**WOODHOUSE AND RAWSON UNITED (LIMITED) (IN LIQUIDATION).**—In our issue of May 22nd last, pages 128-129, particulars are given of a proposal which was then alleged to have been placed before "a meeting of some of the principal shareholders of Woodhouse and Rawson United (Limited)" held in the previous April. Lieut.-Col. N. Willoughby Wallace was stated to have put before the meeting particulars of a contract that had been entered into by Mr. F. L. Rawson with Mr. Leslie (the Receiver appointed by the Court) to purchase certain assets and goodwill of the old Company, including the "financial patents," which (the report stated) had been handed over to a concern called the Industrial Inventions Development Company (Limited). That meeting carried a resolution "that a company should be formed, with £50,000 capital, to take over the Manchester works and the supply business of Woodhouse and Rawson United, and that the shareholders and creditors of Woodhouse and Rawson United should have the right of applying *pro rata* for the first issue of £10,000 of such capital, with a minimum of £10." It was only to be supposed that a gentleman of Mr. F. L. Rawson's energy and business capacity would find in such a scheme a large field for the exercise of his particular talents, and we now have to acknowledge the receipt of a printed report of the proceedings of what is described as "the First Annual General Meeting of the Industrial Inventions Development Company, Limited, held at the offices of the Company, 33, Cornhill, London, E.C," on the 21st ult., under the chairmanship of Mr. F. L. Rawson. We do not remember to have received an invitation for our representative to be present at this meeting (this was possibly an oversight), and therefore it must be understood that any extracts culled from the report forwarded to us are given with all due reserve. A profit and loss account and balance sheet accompany the printed particulars received, which go to show that £3,340 has been subscribed towards the £50,000 capital, that there is a liability of £9,500 in connection with a special contract not yet completed, and that a net profit of £1,228 0s. 4d. has been realised up to the 30th June. Those interested in the figures which go to make up this profit and loss account and balance sheet must refer to the document itself. The Chairman at the meeting pointed out that the result of the first year of the Company's operations was thoroughly satisfactory, and doubtless those present were much impressed with the statement which followed, showing how this satisfactory state of affairs had been brought about. Looking to the future, the prospects of the Company were described as being "considerably better." The advantages of a patent taken out by the Chairman and his brother for the hardening of incandescent gas mantles was described, and the possibilities of large sums being realised by the sale of this patent duly dilated upon. "A valuable concession for the sole trading rights over a well-known part of Northern Africa" was next referred to, and this was followed by an account of a process for making briquettes or "lumps of coal," and, "if the inventor's statements prove to be correct, there is no doubt a fortune in the process both for him and ourselves" (the Industrial Inventions Development Company, Limited). Another process which the Company has taken in hand is "a method of treating aluminium at an extra cost of only about one penny per pound, which not only greatly increases the strength, making it strong enough for all practical purposes, but enables it without any annealing to be readily drawn into rigid tubes or rolled into plates thoroughly satisfactory in every respect." It will be seen that all the material for a new Elmore group is present in this valuable discovery. In fact, "a syndicate is being formed at the present moment to bring out a public company at the latter end of September." This closes the list of new matters which the Company has in process of development, unless we may mention the fact that the inventions of Mr. Pirrie, the managing director of the Company, who "has himself made one or two important inventions," and "subject to 10 per cent. of any profits made, the benefit of these inventions go to the Company." A passing tribute is paid to the value of Mr. Pirrie's services to the Company, and this tribute is handsomely reciprocated later on by Mr. Pirrie in the Chairman's behalf, Mr. Pirrie referring to the exceptional position of Mr. Rawson in having a thorough knowledge both of engineering matters and financial matters. "In fact," said Mr. Pirrie, "I know of no one else in the City in the same position." A considerable portion of the business of the meeting consisted in the rearrangement of the shares of the Company, and those who contemplate subscribing to the capital will of course carefully weigh the proposal to give to the holders of Deferred shares the same voting power as that possessed by the holders of the Ordinary shares. Of the latter description there are 49,000 and of the former 1,000 shares. We have only space for a brief extract of the somewhat lengthy proceedings at the meeting, and must conclude by saying that applications are now invited for an issue of 10,000 ordinary shares "entitled to a preferential cumulative dividend at the rate of 7 per cent. per annum and to one-fourth of the remaining divisible profits." These shares are now offered at par exclusively to the shareholders and creditors of Woodhouse and Rawson United, and will be allotted strictly *pro rata*. The circular which accompanies the voluminous printed matter notifies that "it is practically impossible to set out all the contracts entered into by the Company, and applicants will be deemed to have waived any further compliance with Section 38 of the Companies' Act (1867)." In order to be in time for an allotment of these shares, applications must reach the Secretary before Monday next, the 7th inst.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Divi-dend. | Name. | Previous Week's Price August 26. | Price Wednesday, September 2. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending August 29. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | £ s. d. | | Highest | Lowest |
| | | | **TELEGRAPHS.** | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 52 54 | 52 54 | 4 12 7 | Jan., Apr., July, Oct. | 52½ | 52½ |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 97½ 98½ | 97½ 98½ | 5 1 6 | " " | 98½ | 97½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 9 9½ | .. .. | .. .. | .. | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 6 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ 9½ | 8½ 9½ | .. .. | .. .. | .. | .. |
| 180,000 | £10 | 3/0 | Brazilian Submarine | 15½ 15¾ | 15½ 15¾ | 4 8 11 | Mar., June, Oct., Dec. | 15 5/16 | 15¾ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 3 0 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine xd | 12½ 13½ | 12½ 13½ | 6 0 9 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. xd | 20½ 21½ | 20½ 21½ | 4 15 3 | " " | 2 ½ | — |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ 4 | 3½ 4½ | 4 8 11 | April and October | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% 110% | 107% 110% | 4 2 5 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10½ | 9½ 10½ | 4 3 0 | Jan., Apr., July, Oct. | .. | .. |
| 400,000 | 10 | 5/6 | Eastern | 18 18½ | 18 18½ | 3 10 3 | " " | 18⅜ | 18½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 1 6 | " " | .. | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 3 0 3 | May and November | — | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 104 107 | 4 14 4 | February & August | 132½ | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 18½ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅜ | .. |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 3 | February & August | 133½ | 133 |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 4 17 1 | January and July | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 100 104 | 101 105 | 4 16 2 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 109 | 106 109 | 3 13 7 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% 114% | 111% 114% | 3 10 11 | May and November | .. | .. |
| 180,227 | 10 | 3 9 | Globe Telegraph and Trust | 11½ 11¾ | 11½ 11¾ | 3 15 7 | Jan., Apr., July, Oct. | 11⅝ | 11⅝ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 18 18½ | 18 18½ | 3 5 9 | " " | 18½ | 18½ |
| 150,000 | 10 | 5/0 | Great Northern | 24 25 | 24 25 | 4 0 0 | Jan., April, and July | 24⅜ | 24⅛ |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue xd | 105 108 | 104 107 | 4 13 6 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 53 56 | 53 56 | 4 9 3 | May and November | 54½ | 54½ |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures xd | 111 114 | 109 112 | 5 7 2 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 7 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | .. | .. |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 140 145 | 140 145 | 4 2 9 | " " | 141½ | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 6 | 5 6 | 5 0 0 | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) xd | 104 107 | 102 105 | 4 15 3 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. .. | January and July | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 99 101 | 99 101 | 7 15 9 | June and December | — | — |
| 88,321 | 10 | 0/6 | West India and Panama | 1½ 1⅝ | 1½ 1⅝ | .. .. | " " | — | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 12 | 5 0 0 | May and November | 1½ | .. |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | 11 15/16 | 11⅝ |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 10 11 | June and December | .. | — |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8¾ 9½ | 8¾ 9½ | 4 17 4 | May and November | .. | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 7 7½ | 7 7½ | 5 0 0 | — | 7⅜ | 7¼ |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 2¾ | 2½ 2¾ | .. .. | — | — | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 107 | 103 107 | 5 12 8 | February & August | — | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 107 | 103 107 | 5 12 8 | " " | — | .. |
| $1,177,000 | $1,000 | 7% | Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 4 2 | May and November | — | .. |
| £164,300 | £100 | 6% | Do. 6 per Cent. Sterling Bonds (red.) xd | 104 107 | 100 105 | 5 14 3 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chill Telephone (fully paid) | 3½ 4½ | 3½ 4 | 5 0 0 | — | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/16 3/16 | 1/16 3/16 | .. .. | May and November | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅜ ⅝ | ⅜ ⅝ | 5 14 3 | Yearly | .. | .. |
| 484,597 | 5 | 2/6 | National | 7½ 7¾ | 7½ 7¾ | 3 11 0 | June and December | 7⅞ | 7⅞ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | " " | .. | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 18 | 17 19 | 3 8 7 | " " | .. | — |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6¾ 7 | 6¾ 7 | 3 11 5 | — | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 3 11 | January and July | 108½ | 1 8 |
| 58,000 | 5 | 4/0 | United River Plate | 3¾ 4½ | 3¾ 4½ | 4 14 2 | July | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 104 107 | 101 103 | 4 15 3 | January and July | 104 | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| .. | 5 | .. | Birmingham Electric Supply (fully paid) | 8 | 8 | .. | .. | .. | .. |
| .. | 5 | .. | Do. | 4¾ | 4¾ | .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 16 17 | 16 17 | 2 18 10 | February & August | 16¼ | 16 |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17½ 18½ | 17½ 18½ | 3 4 10 | January and July | 18⅜ | 18 |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 132 136 | 132 136 | 3 14 1 | June and December | 135½ | 135 |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | — | .. | — | — |
| £30,000 | £5 | 2 6 | Charing Cross & Strand Electricity Supply Corp. | 9¼ 9¾ | 9¼ 9¾ | 2 16 5 | — | 9 7/16 | 9⅜ |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | — | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. | — | .. | .. |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 13¾ 14½ | 13¾ 14½ | 4 4 3 | — | 14 3/16 | 13 15/16 |
| 8,322 | £5 | .. | House-to-House Electric | .. .. | .. .. | — | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | .. .. | .. | January and July | — | — |
| 111,000 | 5 | .. | London Electric Supply | ¾ 1¼ | .. .. | .. | — | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13½ 13¾ | 13 14 | 2 17 2 | — | 13½ | 13⅜ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 123 | 120 124 | 3 14 3 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 11½ 12½ | 11½ 12¼ | .. | — | 12½ | 12⅜ |
| .. | .. | .. | Rand Electric | 1 1/16 1 3/16 | 1 1/16 1 3/16 | .. | — | .. | .. |
| 19,980 | £5 | 2 6 | St. James and Pall Mall | 12 13 | 12 13 | 2 19 8 | — | 1 ⅛ | 1 1/16 |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 6 8 | — | .. | .. |
| 59,900 | 5 | 3/0 | Westminster Electric Supply (fully paid) | 11 12 | 11 12 | 2 18 4 | — | 11 3/16 | 11⅛ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1½ 1⅝ | 1½ 1¾ | .. | — | 1 5/8 | 1½ |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅝ 1⅞ | 1¾ 2 | .. | — | 1⅞ | 1⅞ |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures xd | 112 115 | 110 113 | 3 19 8 | March & September | .. | — |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1¾ 2¼ | 1¾ 2¼ | 6 13 4 | February & August | 2 | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 6 4 | January and July | — | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | — | .. | .. | — | — | — |
| 110,000 | 2 | .. | Electric Construction xd | 1½ 1⅝ | 1⅜ 1⅝ | 3 1 6 | — | — | — |
| 12,845 | 2 | 2 9/16 | Do. 7 per Cent. Cumulative Pref. xd | 2¾ 3¼ | 2¾ 3¼ | 4 6 2 | — | 1 1/16 | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ¾ 1 | ¾ 1 | .. | September | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. | — | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 21 23 | 22 23 | 4 6 11 | February & August | 22⅜ | 22½ |
| £200,000 | 100 | .. | * Do. 4 per Cent. Debentures | 107 110 | 107 110 | 3 12 9 | March & September | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ¾ 1 | ¾ 1 | .. | — | — | — |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 39 42 | 40 43 | 4 3 10 | March and July | 41 | — |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 103 106 | 104 107 | 4 14 4 | January and July | .. | .. |
| £100,000 | 10 | 6/0 | W. T. Henley's Telegraph Works Ordinary xd | 18 19 | 18 19 | 4 10 1 | March & September | 19 | 18⅝ |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference xd | 18½ 19½ | 18½ 19½ | 3 11 10 | " " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock xd | 112 117 | 110 115 | 3 8 3 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1⅜% | City and South London Railway Con. Ordy. | 50 52 | 51 53 | 2 16 7 | January and July | 52 | 50 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15½ | 14½ 15 | 3 6 8 | " " | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 138 | 1 6 1 8 | 2 18 0 | May and November | — | — |
| 37,500 | £10 | 2½ | Liverpool Overhead Railway | 13¾ 13¾ | 13½ 13⅝ | 2 4 9 | — | .. | — |
| 10,000 | 10 | 5% | Do. 5% Preference | 16½ 17⅜ | 6¼ 1/8 | 2 17 7 | — | — | — |
| 115,000 | Stock | 4% | Do. 4% Debenture | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July | — | — |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for re lemption.

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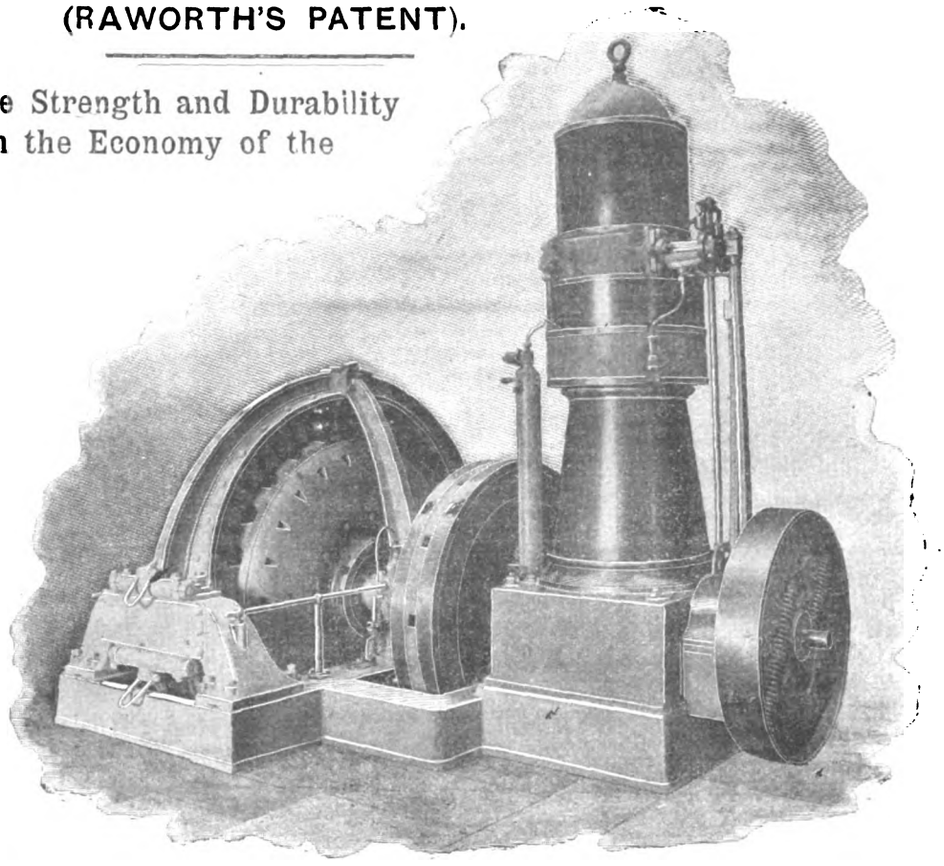

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# SUBMARINE CABLE LAYING AND REPAIRING.

**By H. D. WILKINSON, M.I.E.E.**

The Author has given a detailed technical summary of modern practice in Manufacturing, Laying, Testing and Repairing a Submarine Telegraph Cable. The testing section and details of boardship practice have been prepared with the object and hope of helping men in the cable services who are looking further into these branches. In the work of cable laying and repairing the most exact scientific processes are called into ordinary use, and the service affords great scope for the exercise of engineering and electrical skill. The enterprise has a great deal before it as regards possibilities in research, improvements in instruments, processes and methods of working, and further extension of the cable systems. The description of the equipment of cable ships and the mechanical and electrical work carried on during the laying and repairing of a submarine cable will prove also to some not directly engaged in the profession, but nevertheless interested in the enterprise, a means of informing themselves as to the work which has to be done from the moment a new cable is projected until it is successfully laid and worked.

In this original work is described the procedure on board ship when removing a fault or break in a submerged cable, and the mechanical gear used in different vessels for this purpose. Further, as regards the electrical tests in use for the detection and localisation of faults, to consider the best and most recent practice, and the various difficulties that occur to the beginner. With a total length of nearly 140,000 miles of cable submerged, and a fleet of 36 steamers employed solely in laying and repairing cables, some idea may be gained of the vastness and importance of this enterprise, and the various interests it involves. Of late years many improvements have been introduced in the tests used for locating the positions of faults in cables, and these have resulted in a considerable saving to the owners in cost of maintenance.

The book will be found of quite exceptional interest, and the illustrations assist the text in an unusual degree.

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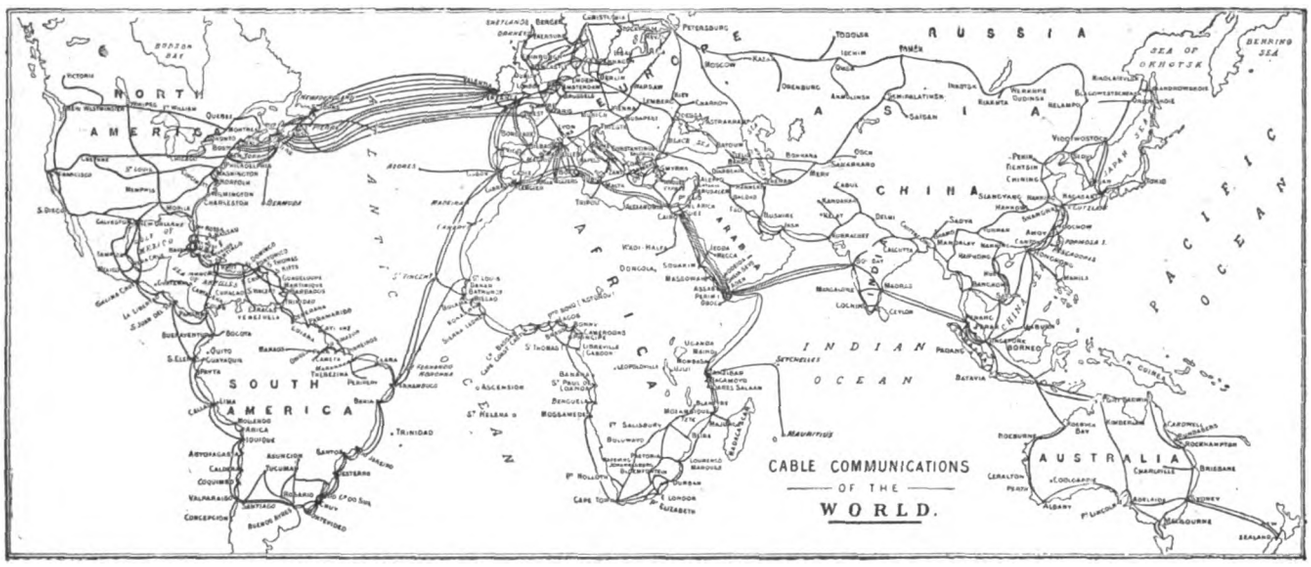
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

# EASTERN TELEGRAPH COMPANY

IN CONNECTION WITH THE (LIMITED).

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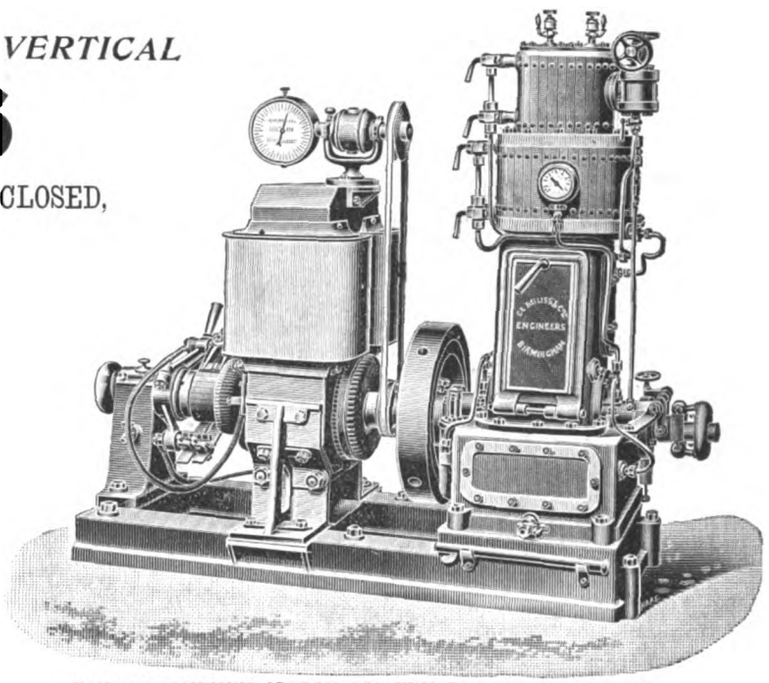

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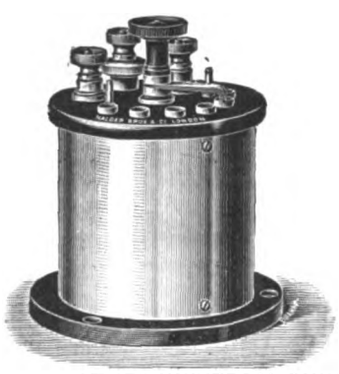

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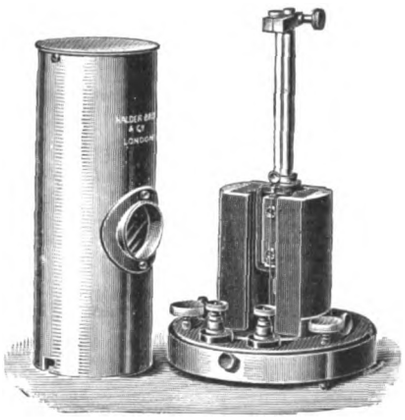

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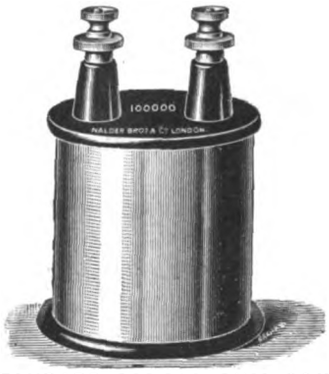


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## TENDERS INVITED.

### BOROUGH OF MORLEY.

The ELECTRIC LIGHTING COMMITTEE of the Borough of Morley are prepared to receive TENDERS for the SUPPLY and ERECTION of the following PLANT:—

(The whole bound up in One Specification, price £2. 2s., returnable on receipt of bonâ fide Tender.)

Section A.—BOILER-HOUSE PLANT—Lancashire Boilers and Fittings, Feed Pump, &c.
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Section F.—TRANSFORMERS and SWITCHBOARDS.
Section G.—ARC LAMPS, POSTS and ACCESSORIES.
Section H.—METERS.

Tenderers are at liberty to tender for either Section, but not for part of a Section.

The Ground Plans of Plant, and Specification, with Terms and Conditions of Tenders and Contract, may be obtained at the Offices of Mr. Robert Hammond, the Consulting Engineer to the Corporation, Ormond House, Great Trinity-lane, London, E.C., on and after Wednesday, September 16th, on payment of £2. 2s. for each copy, which sum will be refunded on the return of the Specification filled up with a bonâ fide Tender.

Tenders, sealed and marked "Tender for Electric Lighting," must be addressed to me, at the Town Hall, Morley, Yorks, and be delivered on or before WEDNESDAY, the 14th October.

The Committee do not bind themselves to accept the lowest or any Tender.

R. BORROUGH HOPKINS, Town Clerk.

Town Hall, Morley, September 9th, 1896.

### BOROUGH OF SWANSEA.

ELECTRIC LIGHTING OF SWANSEA MARKET.

The CORPORATION of Swansea invite TENDERS for:—

(A) The SUPPLY and FIXING of CABLES, CASINGS, SWITCH and FUSE BOARDS, and all SUNDRY FITTINGS and MATERIALS for installing Electric Light in the Swansea Market, Swansea.

(B) The SUPPLY and ERECTION of a TEMPORARY GENERATING PLANT, including Gas Engine, Generator and Main Switchboard, together with the MAINTENANCE of the same for a period of Twelve Months, for the Supply of Electrical Current to the Swansea Market, Swansea.

Specifications and Forms of Tender, and any additional information, can be obtained from the Engineers, Messrs. Kincaid, Waller and Manville, of 29, Great George-street, London, S.W., on payment of Three Guineas for each Specification, and same will be returned when a bona fide Tender is received by the Corporation. The Plan of the Market can also be seen at the Offices of the Engineers, or at the Guildhall, Swansea.

Sealed Tenders shall be sent to the undersigned, endorsed "Tender for Electric Lighting Installation, Swansea Market," or "Tender for Temporary Plant for Electric Light Installation, Swansea Market, as the case may be, at or before 4 p.m. on THURSDAY, the 24th day of September, 1896.

The Corporation do not bind themselves to accept the lowest or any Tender, nor will they pay any costs or expenses incurred by intending contractors in preparing the same.

JNO. THOMAS, Town Clerk.

The Guildhall, Swansea.

### EDINBURGH CORPORATION ELECTRIC LIGHTING.

The LORD PROVOST, MAGISTRATES, and COUNCIL are prepared to receive TENDERS for the WIRING of the Burgh Assessments Office, High-street.

Specification, Forms of Tender, and Plans of the Building can be obtained at the Office of the Resident Electrical Engineer, 5, Dewar-place, Edinburgh, on deposit of Two Guineas, which deposit will be returned on receipt of a bona fide Tender.

Tenders must be sent to me not later than TUESDAY, September 22nd.

THOMAS HUNTER, W.S., Town Clerk.

City Chambers, Edinburgh.

### PARISH OF ST. MARY MAGDALEN, BERMONDSEY.

TO ELECTRICAL ENGINEERS AND OTHERS.

The VESTRY of the above Parish invite ESTIMATES from Electrical Engineers for a REPORT upon the following points:—

1. Whether the supply of Electricity could be advantageously undertaken by the Vestry, and at what preliminary loss.
2. What would be the best system of supply for the Vestry to adopt and the best site for a generating station, and the capital required.
3. As to the advisability of combining a dust destructor with the station for the utilisation of heat.
4. Generally on the best means of putting the scheme into operation. Any information required in connection with such report can be obtained at the Town Hall, Spa-road, S.E.

Estimates endorsed "Electricity" should be received by the undersigned not later than 4 p.m. on the 23rd inst.

FREDK. RYALL, Vestry Clerk.

Bermondsey Town Hall, Spa-road, S.E.
5th September, 1896.

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## APPOINTMENTS VACANT.

### COUNTY BOROUGH OF HUDDERSFIELD.

WORKING MECHANICAL ENGINEER.

The Electric Lighting Committee are prepared to receive APPLICATIONS for the situation of WORKING MECHANICAL ENGINEER in the Electric Supply Station. The duties will be to keep the existing machinery in repair, connect up additional machinery, and to act generally under the instructions of the Borough Electrical Engineer. Preference will be given to applicants having had experience in a similar situation. Salary, £2 10s. per week. Applications, on foolscap paper, stating age, experience, and accompanied by copies of not more than three recent testimonials (which will not be returned), must be sent to me not later than Monday, the 21st September instant, endorsed "Working Mechanical Engineer."

By order,

F. C. LLOYD, Town Clerk.

Town Hall, Huddersfield, 4th September, 1896.

AN Electrical Supply Company require an ELECTRICAL ENGINEER for high-tension alternating-current system, competent to advise and carry out immediate extensions. Practical electrical training essential. Preference given to one with knowledge of continuous-current three-wire system. Commencing salary, £150 per annum.—Address, first in confidence, giving full particulars of past experience and copies of testimonials if possible, to "B. C.," *Electrician* Office, Salisbury-court, Fleet-street, E.C.

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## TECHNICAL CLASSES.

### KING'S COLLEGE, LONDON.

**ENGINEERING, ARCHITECTURE, AND APPLIED SCIENCE DIVISION OF THE FACULTY OF SCIENCE.**

**SESSION 1896—1897.**

**MICHAELMAS TERM COMMENCES THURSDAY, OCTOBER 1.**

The full Curriculum for the College Associateship in Mechanical, Civil, or Electrical Engineering, Architecture, Chemical Manufactures, and Metallurgy extends over a period of three years. A shorter course of two years qualifies for the Certificate of Engineering.

The Siemens Electrical Laboratory (founded by Lady Siemens) and the Mechanical Engineering Laboratory and Workshops, the Metallurgical Laboratory, and others, are fitted with all the necessary appliances for the most advanced practical and research work.

PROFESSORS.

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CIVIL ENGINEERING, Henry Robinson, M.Inst.C.E.
ELECTRICAL ENGINEERING, J. Hopkinson, D.Sc., F.R.S.
NATURAL PHILOSOPHY, W. G. Adams, M.A., D.Sc., F.R.S.
ARCHITECTURE, Banister Fletcher, F.R.I.B.A.
CHEMISTRY, J. M. Thomson, F.R.S.E., F.C.S.
MATHEMATICS, W. H. H. Hudson, M.A.
METALLURGY, A. K. Huntington.
GEOLOGY AND MINERALOGY, H. G. Seeley, F.R.S.

Non-Matriculated Students, or those who, not wishing to attend the whole course, are desirous of studying any particular subject, may attend any of the classes held on payment of the specified fees.

EVENING CLASSES

are held for Civil, Mechanical and Electrical Engineering, Workshop Practice, Architecture and Building Construction, Drawing, Metallurgy, Wood Carving, Mathematics, Physics, and all Science Subjects.

For Prospectuses and all information apply to

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King's College, Strand, W.C.

### UNIVERSITY COLLEGE, LONDON.

ENGINEERING AND ARCHITECTURAL DEPARTMENT,
Assisted by Technical Education Board of London County Council and by the Carpenters' Company.

SESSION 1896-7.

THE COURSES OF INSTRUCTION IN MECHANICAL, CIVIL, AND ELECTRICAL ENGINEERING AND ARCHITECTURE commence on OCTOBER 6th. They are arranged to cover periods of two and three years.

Particulars of the Courses, of Entrance Scholarships, of the Matriculation Examination, and of the Fees, may be obtained from the Secretary.

PROFESSORS:—

| | |
|---|---|
| Mechanical Engineering | T. Hudson Beare, M.I.C.E. |
| Electrical Engineering | J. A. Fleming, F.R.S. |
| Civil Engineering | L. F. Vernon Harcourt, M.I.C.E. |
| Architecture | T. Roger Smith, F.R.I.B.A. |
| Physics | G. Carey Foster, F.R.S. |
| Chemistry | W. Ramsay, F.R.S. |
| Applied Mathematics | K. Pearson, F.R.S. |
| Economic Geology | T. G. Bonney, F.R.S. |
| Mathematics | M. J. M. Hill, F.R.S. |

The new wing of the College, opened by H.R.H. the Duke of Connaught in May, 1893, contains spacious mechanical and electrical engineering laboratories, workshops, drawing office, museum, and lecture theatres.

The laboratories are fitted with all the best appliances for practical work, and for research work of the most advanced character.

VICTORIA UNIVERSITY.

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DEPARTMENT OF ENGINEERING.

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Complete Courses of Instruction are arranged in—
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(2) MECHANICAL ENGINEERING.
(3) ELECTRICAL ENGINEERING.

These Courses enable Students to qualify for University Degrees, and for the College Certificates in Engineering. They comprise, in addition to special Engineering Lectures and Laboratory Work, instruction in Mathematics, Physics, Electrotechnics, and Chemistry.

The Engineering Laboratories, and also the Electrotechnical Laboratories, are completely equipped with modern appliances.

The College Prospectus, and also the Special Engineering Prospectus, can be obtained on application to the REGISTRAR.

### THE YORKSHIRE COLLEGE, LEEDS,

DEPARTMENT OF CIVIL, MECHANICAL, AND ELECTRICAL ENGINEERING.

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## TECHNICAL CLASSES.

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The NEXT SESSION will commence on OCTOBER 6th.

The Diploma of Associate is given in the Faculties of I., Manufactures (Chemical); II., Engineering; III., Mining; IV., Applied Physics (for Electrical Engineers, &c.); and V., Natural Science.

Two Royal Scholarships of £50 per annum, with Free Admission to the Courses, are competed for each year by first-year Students.

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Special Courses to suit individual Students, and Research Work in all subjects.

Chemical, Physical, Botanical, Zoological, Geological and Mineralogical Laboratories open for Practical Work.

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|---|---|
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| Physics | W. F. Barrett, F.R.S.E., M.R.I.A. |
| Chemistry | W. N. Hartley, F.R.S., F.C.S., F.R.S.E. |
| Zoology | A. C. Haddon, M.A., M.R.I.A., F.Z.S. |
| Botany | T. Johnson, D.Sc., F.L.S., M.R.I.A. |
| Geology | J. A. J. Cole, M.R.I.A., F.G.S. |
| Applied Mechanics and Mechanism | W. McF. Orr, M.A. |
| Descriptive Geometry and Engineering | J. Lyon, M.A. |

Fees for Associate Students from £10 to £22 per Session according to Faculty and year.

Non-Associate Students' Fees for Lectures, £2 per Session (except Mathematics £3). Laboratory Fees from £2 upwards.

All the Courses are open to Ladies.

Directory of the College with List of Fees and all other information on application personally, or by letter.

NOTE.—Entrance Examination for Intending Associates will be held on TUESDAY, 6th OCTOBER. Subjects—Mathematics and Elementary Practical Geometry.

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| Civil Engineering. | Chemical Engineering. |
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| Architecture. | Chemistry. |

Mathematics and Physics.

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Session 1896-97 commences on MONDAY, OCTOBER 5th.

ENTRANCE EXAMINATION begins on Tuesday, September 29th.

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F. GRANT OGILVIE, M.A., B.Sc., F.R.S.E., PRINCIPAL.

DAY CLASSES—SESSION 1896-97.

The SESSION extends from TUESDAY, 6th OCTOBER, 1896, to FRIDAY, 4th JUNE, 1897.

These Classes provide Courses of Study extending over one or more years, suitable for students who have previously passed through the curriculum of a secondary school. The principal Courses are:—Physical and Chemical, Mechanical Engineering and Electrical Engineering. There are also Classes in French, German, Drawing, and Practice of Commerce.

Class Fees from £1. 1s. to £4. 4s. Session Fee, £10. 10s.

There is also a Preparatory Course of Instruction for Agricultural Students. Session Fee, £5. 5s.

An Extract from the Calendar of the College, giving particulars of the Day Classes, and of the various Appliances, Laboratories, and Workshops available for instruction, may be had on application to the Librarian, at the College, or to the Treasurer of George Heriot's Trust.

DAVID LEWIS, Treasurer.

Treasurer's Chambers, 20, York-place,
Edinburgh, 21st July, 1896.

### UNIVERSITY COLLEGE OF NORTH WALES, BANGOR.

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Professor ANDREW GRAY, LL.D., F.R.S., will begin in October next a systematic COURSE of INSTRUCTION in ELECTRICAL MEASUREMENT and PRACTICAL ELECTRICITY.

The Physical Laboratory is fully equipped with a Compound Steam Engine, Dynamos, Transformer, Secondary Battery, and the most approved modern Measuring Instruments for all branches of Electrical Engineering.

Laboratory fees at the rate of £1. 1s. per term for six hours per week.

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Applications for Calendar, Prospectus, and general information to be made to

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The NEXT SESSION begins 28th SEPTEMBER, 1896.

The Calendar (1s.) and Prospectuses on application to the SECRETARY.

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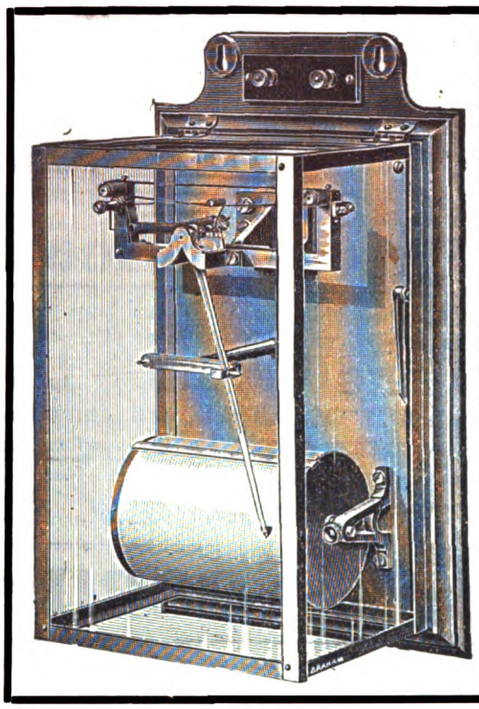

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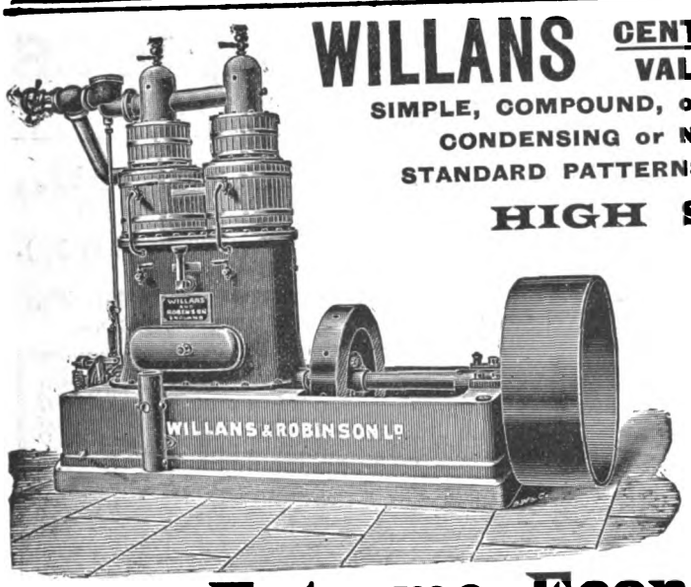


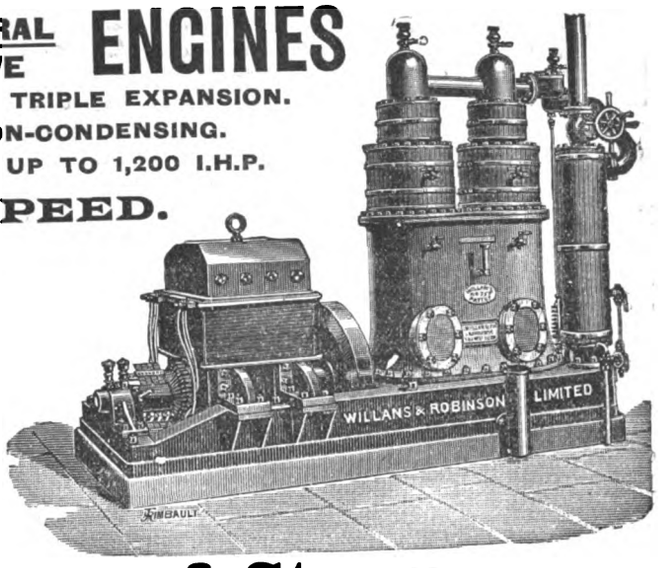


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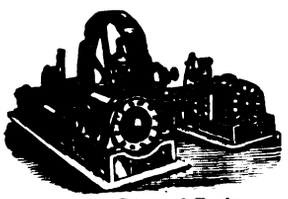

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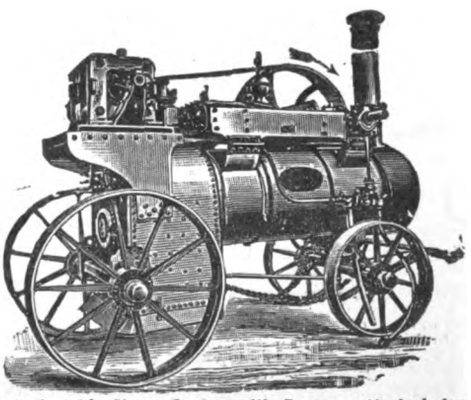

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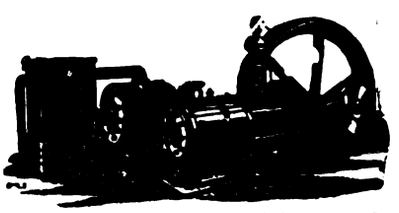

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861—1878.

No. 956. [Vol. No. 20. XXXVII.] FRIDAY, SEPTEMBER 11, 1896. PRICE SIXPENCE.


## NOTES.

THERE is alike a practical and a theoretical interest in the new type of high-speed steam engine invented by Mr. J. RAWORTH, and described in our columns this week, and in the results of the indicator and steam-consumption trials, which we also publish. The practical interest associates the engine with an ever-increasing demand for direct-coupled high-speed plant. By far the largest proportion of high-speed engines are used for driving dynamos in electric supply stations, and, to a lesser extent, in electric traction stations. Of the suitability of the high-speed direct-coupled engine for the first-named type of station there is no doubt; nor is it unlikely that in the traction power station of the future direct-coupled engines will predominate. But it does not yet appear quite certain that the suitability of high speed in the supply station argues its suitability in the traction station. The conditions of service are so utterly different in the two cases that it is not unreasonable to expect they will best be met by diverse types of engines.

Two elements of working directly and principally affect the case for traction work, viz., the distribution of steam and the action of the flywheel. A distribution of steam by constant cut-off and throttle governing is so unsuited to the needs of the traction station that a well-known engine, which it has been the custom to work on that plan, has had to be provided with an auxiliary automatic cut-off device to adapt it to this class of work. The Raworth "Universal" engine, therefore, being essentially an automatic cut off engine, is, in that respect, well adapted to the needs of an electric traction power station. As regards the action of the flywheel, however, all high-speed engines, whether controlled by cut-off or by throttle, are seriously handicapped by engines running at lower speeds. So far as controlling the irregularities of the engine goes, the high-speed flywheel is more effective, for a given weight, than one running at a lower speed. But, in the matter of controlling the irregularities of the external load, which are terribly severe in every traction station, a high-speed engine requires its flywheel to be quite as heavy as does a low-speed engine. Consequently, in stations where the principal reserve of power is vested in the running flywheels very heavy flywheels must be used, the weight of which will have to be designed quite irrespective of the speed of the engine. And where the speed is as high as in many electric light engines of to-day, it is not altogether practicable for the flywheel to be so heavy.

THE main trouble with engine flywheels is their extremely low plant efficiency. They have to carry an enormous amount of energy relatively to the energy which they give out or absorb during regulation. If one should design a flywheel which efficiently would give out about 100 per cent. of its stored energy, while not requiring the engine itself to fluctuate in speed more than usual, he would find a ready market for his invention. But the practical obstacles to the invention are very troublesome, we had almost written insuperable.

RETURNING to the Raworth engine—which, by-the-bye, has been named "Universal," because, provided, as it can be, with link motion and reversing gear, it is adapted to every purpose—we may notice one or two points of theoretical interest. Firstly, as to its cycle of operations. When Mr. RAWORTH ventures to run his new engine through the Institutions, we suspect he will be subjected to a severe cross-fire from the pure thermodynamic theorists. The practical man may wonder what matters thermodynamics when the commercial efficiency is good. But a pure theorist would rather have a correct engine and inefficiency therewith, than a money-making engine which set at naught any one dogma of thermodynamics. From his point of view he is right, and, excellent as is the economy of the "Universal" engine, theoretically the cycle undoubtedly has an element of ineconomy. The chief point of attack will probably be the use of a cold steam jacket around the high-pressure cylinder. This jacket consists of the receiver for the expanded steam from the high-pressure cylinder, and, separated as it is from the initial steam by only a thin metal partition, serious abstraction of heat, and consequent initial condensation, seem likely to take place. Were it not for the high speed we should have preferred to see a live steam jacket interposed between the cylinder and the receiver. This would also act as a re-heater for the receiver; but, at the high speed of the engine, possibly such a jacket would produce no beneficial result. The combination of automatic cut-off and throttled expansion, at low loads, will probably also be a matter for debate; but we fancy that in that particular instance, at any rate, Mr. RAWORTH will be able to justify his engine before the theorists.

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Particulars which have reached us relating to the construction and working of the telegraph line with the expeditionary force to the capital of Ashanti bring out very prominently the value of thoroughly-trained linesmen and telegraphists in the ranks of the army. Communication was maintained with Cape Coast Castle along the line of march in advance of the army for the greater part of the way by means of an aerial route affixed mainly to trees; and for the final portion by means of a ground cable which actually entered Kumassi at the same time as the invading force. From first to last more than 13,000 messages were transmitted over the wire; and besides the exigencies of military requirements there was a good deal of press work to be dealt with. Most of the linemen and telegraphists were stricken with fever, though happily no fatal case occurred among them; but their ranks were often greatly reduced, the strain upon those not on the sick list being consequently very severe. It is admitted that the proficiency of these men is due to the experience afforded them in the service of the Post Office, where, so to speak, they pass their term of apprenticeship. This co-operation between the military and the civil service is a piece of statesmanship which reflects credit on both the Departments concerned. To Major-General Webber and the late Mr. Scudamore, we believe, the credit of initiating it was primarily due.

In striking contrast to the action of certain trade societies, illustrated by the recent quarrel between fitters and boilermakers at Messrs. Thornycroft's works, are the thoughtful and humane arrangements which have been made for their employés by the Isle of Man Tramways and Electric Power Company. This Company now works no less than four of the tramway systems in the Isle of Man—viz., the Douglas-Laxey and the Snaefell Mountain electric tramways, the Douglas horse-car line, and the quite-recently-opened cable-grip line in Douglas. No lighting enterprise ever suffered so grievously from a low and fickle load factor as does this traction company; for, the few summer months of frequent and heavy service with light summer cars are followed by many months when the traffic is infrequent, and when the inclemency of the weather makes it necessary to put winter cars into service, or even to shut down the mountain line. Thus, a large rolling stock and a numerous company of motormen and conductors are required to do full duty on the lines during only a short season; and were it not for the beneficial arrangement to which we have alluded, the majority of the men would be thrown out of work for eight or nine months in the year. To prevent this the Tramway Company has selected and trained its conductors and motormen from among the coachbuilders, painters, fitters, blacksmiths and other craftsmen of the island; and in the months of infrequent traffic the men not required for working the cars are retained in the sheds, where the whole rolling stock is overhauled, repaired and repainted. Doubtless an orthodox trades unionist would hold up his hands in horror at so flagrant a violation of the sacred principle of specialised labour; but there is much to be said in favour of a system which prevents a body of workmen from being disbanded, and which provides them with regular work during the entire year.

While speaking of matters connected with the two electric tramways north of Douglas we may mention that their recent amalgamation has resulted in great engineering advantages. The rumour that these two lines are to be joined, and through cars to be run, is quite unfounded; and, since the lines are 6in. different in gauge, it is difficult to see how any such arrangement could be carried out. Certainly, it would be impracticable to reduce the gauge of the mountain line, owing to the size of the motors and the existence of the middle rail. But though traffically insulated, so to speak, the two lines have been electrically united. A feeder has been run connecting the two systems, with the result that both lines now draw power from the same three generating stations and two battery stations. These five stations are situated at nearly equal distances along the course, and a battery station is intermediate between each two adjacent generating stations. A better distribution of power could scarcely be devised, save only that the situation of one of the power houses near the summit of Snaefell is somewhat undesirable. As a consequence of the unification of the two electrical systems each station receives a much more regular load, and better economy is the result. Moreover, it is now found possible to work one of the steam stations on only one shift, instead of two, without overloading either of the other stations or the batteries; a course which has also proved conducive to economy.

**Royal College of Science for Ireland.**—The next Session commences on October 6th. Further particulars are given in our advertisement columns.

**Cable Interruptions and Repairs :—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique ..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Para—Maranham ..... | Aug. 6, 1896 ... | — |
| Zanzibar—Mombasa ..... | Aug. 23, 1896 ... | Sept. 5, 1896. |
| Bahia—Rio de Janeiro ..... | Sept. 4, 1896 ... | — |
| Penang—Medan ..... | Sept. 7, 1896 ... | — |

**Erratum.**—The following correction should be made in Mr. F. C. Raphael's article on "The Localisation of Faults in Electric Light Mains," equation 44, page 595 of our last issue, viz., *for* $\left(\frac{x-yF}{K-F}\right)$ *read* $\left(\frac{xK-yF}{K-F}\right)$.

**Battersea Polytechnic.**—We have received a copy of the first Report of the Governors of Battersea Polytechnic, and are glad to notice the prosperous condition of that educational institution. The Polytechnic has been working for two years, during which some 6,000 students have attended classes. At the present time there are 2,850 students in attendance.

**Electric Transmission to Montreal.**—According to our American contemporaries the contract for the development of 20,000 H.P. on the Richelieu River, the outlet of Lake Champlain, has been let for $550,000, the electric machinery not being included. This power is to be carried to Montreal, a distance of about 12 miles. This is the second electric water-power development furnishing current to Montreal, the first being for 12,000 H.P. at the Lachine Rapids, five miles above the city in the St. Lawrence River. The investment in both powers will be about $3,500,000, and is, it is said, all subscribed for by Montreal capitalists.

**Personal.**—The Indian Government has deputed Dr. J. C. Bose to visit Europe, in connection with the extension of the department of physical science of the Presidency College, Calcutta, and the establishment of a magnetic observatory at that institution. Dr. Bose will also read in Section A, at the forthcoming meeting of the British Association, at Liverpool,

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a Paper on "A Complete Apparatus for Studying the Properties of Electric Waves." This apparatus will be shown during the meeting. While in Europe, Dr. Bose will inspect a number of electric lighting and traction plants, preparatory to the erection of an electric tramway plant in Calcutta.

**A Modified Hatchet Planimeter.**—A modification of the hatchet planimeter has been devised by Mr. E. K. Scott. The original form of the instrument was invented by Capt. Prytz, of Denmark, and consisted simply in a tracing point and a convex hatchet-shaped edge rigidly connected in the same plane by a frame or rod. The construction and theory of the instrument were described by Mr. F. W. Hill, in the *Proc.* Physical Soc., Vol. XIII., p. 229 (*see* also *The Electrician*, Vol. XXXIII., p. 267). Mr. Scott's alterations of the original form chiefly consist in the substitution of a rolling wheel, with a sharp rim, for the hatchet edge; he has also added a guide plate, for keeping the instrument normal to the surface being planimetered. A description of the instrument in this form appeared in *Engineering*, August 14th.

**The Magnetisation of Liquids.**—Experiments on the coefficient of magnetisation of liquids have recently been made by Mr. J. S. Townsend, and communicated to the Royal Society. The experiments were made with a sensitive induction balance, the two circuits being commutated sixteen times per second. The principle of the method consisted in balancing against known small inductances the increase of the mutual induction of the primary on the secondary of a solenoid arising from the presence of a liquid in the solenoid. Chlorides and sulphates of iron were tested in solution, and the Paper is accompanied by tabular data of the results. The effect of temperature was also estimated, the results being shown by means of curves. These curves all show about the same temperature coefficient at points corresponding to the same temperature.

**The Transverse Effect in Bismuth.**—In a Paper read before the Royal Society of Edinburgh, Mr. J. C. Beattie has described some "Experiments on the Transverse Effect and on some Related Actions in Bismuth." The author states that in bismuth the transverse effect, although allied to the Hall effect, has not been proved to be proportional to the first power of the magnetisation. He is of opinion that the transverse effect in bismuth is really the sum of three separate effects. He finds that the following modifications of the effect take place:—With thick plates the transverse current does not change its direction for any strength of magnetic field, though in some cases a maximum value is reached and passed; with thinner plates the transverse current is positive for strong fields, negative for weak ones. The field strength at which vanishing takes place is the same for the same plate, so long as it is modified only in length and breadth; but if the plate be planed thinner, the field at which the current vanishes is stronger than in the original case. Similarly, if the original plate be hammered, the field required to produce vanishing of the effect is increased; a combination of hammering and planing raises the required field strength very considerably. In one sample of certainly pure bismuth the ratio of the increase of resistance to the square of the transverse effect was practically constant. Mr. Beattie's Paper is published in full, with curves and tabulated data, in the *Transactions* of the Royal Society of Edinburgh, Vol. XXXVIII.

**New Westinghouse Railway Generators.**—In the new type of Westinghouse generator, says *Engineering*, the poles are cast into a circular yoke and project radially inwards; they are made of laminated steel, in order to obtain the highest possible magnetic field. The frames are divided in a horizontal plane, the bearing stands being integral with the lower castings. The machines are self-oiling, and self-aligning ball and socket bearing are used, which enable them to run for a considerable time with little attention. All the field coils are machine-wound, and are completed before being slipped into their position on the dynamos. The series coils for these machines are made out of forged copper bars, which are insulated before being placed in position. The armatures have their cores constructed from punched discs of special sheet steel most carefully annealed before assembling. These sheets, when assembled, form the cores, and in the larger machines the ventilation is augmented by ducts perpendicular to the axis of the core. When the machine is running, air is drawn through the core and forcibly thrown from the ducts to the armature windings against the pole-pieces and field coils, keeping the entire machine at a low temperature. In all cases the armature core is slotted, and in these slots the armature coils are laid. The wire lies below the surface of the armature. The coils are of forged copper, being retained in the slots by means of wedges pressed into notches near the tops of the slots. Every coil is continuous through its length, with no joints except where it connects with the commutator. The method of winding employed is such that free circulation of air is permitted across the ends of the core through the coils. The design of the brush-holders is of special interest. Carbon brushes thickly plated with copper are used, and the brush-holders are so arranged that any one brush can be examined and taken out from the machine while it is running, without in any way affecting the working of the generators. A novel feature of the brush-holder arrangement is that the brush-holder is made in a circular form, and is supported entirely by the framework of the machine. When the field of the machine has been bored, a cutter attached to the bearing bar forms the groove in which the brush-holder rests, thus ensuring perfect centring for the brush-holder, and enabling it to have greater stability. Being n a circular form with the various brushes attached to it, one man, by means of the worm gear, can adjust all the brushes at once, and should anything go wrong with the armature and any serious sparking arise, he can adjust the brushes whilst being out of harm's way.

**Relative Cost of Iron and Copper Conductors for "Third Rail" System of Traction.**—The following table, recast from one given by Mr. J. R. Allen in *The Technic* of New York, shows the relative cost of copper in pence per pound as compared with wrought iron, Bessemer steel and cast iron in £ s. d. per ton. The comparison is made for conductors having equivalent carrying capacity. In using Bessemer steel rails for conductors it is possible to use those that are winding and imperfect. Such rails may be purchased at a greatly reduced price. Let us consider the saving that can be made by the use of Bessemer rails, assuming the rails to cost £5. 4s. 2d. per ton, as compared with copper at 5·5d. per pound. Let the current to be transmitted be 1,000 amperes at 500 volts, and the distance it is to be transmitted be three miles with 5 per cent. drop in voltage.

| | |
|---|---|
| Cost of copper conductors | £8,124 |
| Cost of Bessemer steel conductors | 7,023 |
| Difference | £1,101 |
| Deducting £83 per mile for bonding | 250 |
| Total saving | £851 |
| Saving per mile | 283 |

| Cost of copper in pence per lb. | Cost of equivalent wrought-iron conductor, in £.s.d. per ton. | Cost of equivalent Bessemer steel conductor, in £.s.d. per ton. | Cost of equivalent cast-iron conductor, in £.s.d. per ton. |
|---|---|---|---|
| 3·50 | £4 0 2 | £3 15 5 | £3 0 5 |
| 3·75 | 4 6 5 | 4 1 3 | 3 2 11 |
| 4·0 | 4 9 7 | 4 4 7 | 3 9 9 |
| 4·25 | 4 18 11 | 4 12 8 | 3 13 9 |
| 4·50 | 5 4 2 | 4 17 11 | 4 2 11 |
| 4·75 | 5 10 5 | 5 4 2 | 4 3 4 |
| 5·0 | 5 16 8 | 5 9 4 | 4 7 6 |
| 5·25 | 6 1 10 | 5 14 7 | 4 11 8 |
| 5·50 | 6 8 1 | 6 0 10 | 4 15 10 |
| 5·75 | 6 14 4 | 6 6 0 | 5 1 0 |
| 6·0 | 6 19 7 | 6 12 3 | 5 5 2 |
| 6·25 | 7 5 10 | 6 17 6 | 5 9 4 |
| 6·50 | 7 12 1 | 7 3 9 | 5 13 6 |
| 6·75 | 7 18 4 | 7 8 1 | 5 18 9 |

**Scientific Education in England and Germany.**—The following is an abstract of a letter addressed by Prof. S. P. Thompson to the *Times* of Monday last:—

"Of the accuracy of the observations of 'Chemical Manufacturer' when he deplores the frittering away of funds upon a host of inferior schools instead of devoting them to a relatively small number of the best colleges, there can be no question from his point of view. It is ridiculous to suppose that a smattering of chemistry given to 10,000 boys in 500 different centres can have any appreciable effect in the chemical industries as

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compared with that which might be effected by spending the same money on thoroughly training 100 young men in five highly-equipped modern laboratories. The absorption by Germany of our chemical industries is being effected, not by giving evening instruction to boys, not by science-teaching in courses lasting two years, but by giving men a first-rate laboratory education, lasting four, five, six, or even seven years, under the most eminent chemists of the day. These are the skilled tools whom the German manufacturer finds ready to hand and employs to develop his processes of manufacture. But, having said this, let me endorse the point made by Sir Philip Magnus—that, beside this highly specialised training, there is room for the lower and more popular kind of technical education. It cannot in the present fever for creating technical schools be too strongly insisted that in no two industries does technical education mean the same thing. Take as an example such trades as those of the carpenter, the sheet zinc-worker, and the plumber. In these industries it would be perfectly absurd to train a few men for six or seven years in highly-equipped special laboratories. Whereas in the chemical factory there are needed the few highly-trained men and a large number of untrained labourers to mix and shovel and weigh and pack and watch, the conditions in these other industries are entirely different. Such industries as mechanical engineering and electrical engineering stand in a midway position. In these, while many skilled workmen are wanted, each with a certain amount of elementary scientific training, there is also wanted the smaller number of highly-trained specialists, for whom two or three years spent in the most perfectly-equipped laboratory is not too high a training. It is here that the existence of first-class engineering and electrical laboratories in a few technical colleges comes in as the complement of the more elementary instruction of the local technical school. Lastly, let me point out the latest phase of this tendency to annex an industry by specialised technical instruction. There is no question that, in the future, electricity will enter largely into the chemical manufactures. Already the electric refining of copper has practically superseded the older metallurgical processes; and for the manufacture of bleaching liquid, of chlorate of potash, of aluminium, of caustic soda, the use of electricity is extending every day. Under these circumstances one would have supposed that every first rate technical college would have anticipated the coming time by establishing special electro-chemical laboratories and by appointing a special instructor in electro-chemistry. What are the facts? In Germany three at least of the Universities have already created professorships of electro-chemistry, and large electro-chemical laboratories have been erected at three of the Universities besides that previously existing at Frankfurt. In England, so far as I am aware, there exist only two small electro-chemical laboratories—one at the Technical College, Finsbury, one at the Municipal Technical School at Birmingham—and both of these are devoted to instruction in electro-plating and typing rather than to research in electro-chemistry. As for the rest of the science colleges in England, they are too busy with preparing pupils to pass examinations or are too poor to be able to undertake any such new departure. Comment is superfluous."

**Selective Absorption of Röntgen Rays.**—A Paper with this title was recently read before the Royal Society by Mr. J. A. McClelland, M.A., Fellow of the Royal University of Ireland. The substance the absorptive power of which was to be examined was placed over a hole in the wooden metal-lined box containing the Crookes tube, so that the rays traversed it before falling on a charged disc connected to a quadrant electrometer. Evidences of selective absorption were sought for in the following manner. The rate of leakage was accurately determined when the rays were passing through one of the substances. Sheets of tinfoil were then substituted for the glass and the number—$n$, say—taken such that the leakage from the charged disc was approximately the same as when the glass was used. The rate of leak was then measured accurately. The ratio of the rate of leak with the glass to that with $n$ sheets of tinfoil gives a measure of their relative transparency to Röntgen rays. A number of tinfoil sheets was now placed over the hole; the glass plate was placed on the top, and the rate of leak measured. The glass was removed, and the same $n$ sheets of tinfoil as were formerly used put in its place, and the leakage measured. The ratio of the rate of leak in the latter two cases is a measure of the relative transparency of the glass and the $n$ tinfoil sheets to the Röntgen rays after they have been already screened by passing through several layers of tinfoil. The two ratios thus obtained should be equal if the Röntgen rays are all of one kind; but if the glass is relatively less transparent in the second case, it can only be explained by assuming that the Röntgen rays are not homogeneous, and that some of them are more readily absorbed by the glass and others by the tinfoil. Various substances were tested against tinfoil in the manner described. With some there was no selective absorption, with others it was very marked. Glass gave none, with mica and paraffin the effect was small, with fuchsine, eosine, fluorescine, aesculin and barium sulphide the effect was very marked. With several fluorescent screens the effect was also marked. Pure water also gave a distinct though smaller effect. The table below sets forth the results obtained with these substances. Column B. gives the quotient of the rate of leak through the substance in Column A. to that through a number of tinfoil layers which gave approximately the same leak. Column C. gives the quotient of the rate of leak through the substance to that through the same tinfoil layers after the rays have already passed through four layers of tinfoil.

| A. | B. | C. | Difference. |
|---|---|---|---|
| Calcium tungstate | 1·07 | 0·85 | 0·22 |
| Calcium platinocyanide | 1·30 | 0·86 | 0·44 |
| Luminous paint | 1·0 | 0·71 | 0·29 |
| Potassium platinocyanide | 1·10 | 0·87 | 0·23 |
| Fuchsine | 1·15 | 0·77 | 0·38 |
| Eosine | 1·31 | 1·00 | 0·31 |
| Aesculin | 1·33 | 0·90 | 0·43 |
| Fluorescine | 1·32 | 1·08 | 0·24 |
| Barium sulphide | 1·30 | 0·97 | 0·33 |

The author concludes from the above results that Röntgen rays are of different kinds, and that the substances given in the table differ very much from tinfoil in their selective absorption. The above results were all obtained with one vacuum tube, which was working extremely well. It produced a very rapid leak from the charged disc, and the pressure of its residual air was very small. In fact, after working for a time it became too strong for the coil that was being used to work it. Another vacuum tube, in which the pressure of the residual air was greater and which was not so efficient in producing leakages, was then used, and several of the substances used before were again tested, but in no case was any evidence of selective absorption obtained. As far as the test was efficient, the radiation from this bulb was homogeneous. A third tube was then used, more efficient than the last in producing leakage, but not so good as the first used. With this tube experiments made in the same way as before gave evidence of selective absorption, but not so marked as with the first tube. It seems, therefore, that as a tube becomes more efficient the rays given off become less homogeneous.

**Contemporary Electrical Science.**—Röntgen rays may be used, according to C. Marangoni (*see* Wiedemann's *Beiblätter*), for discovering larvæ of insects infesting grapes and other fruits. They can be photographed inside the fruit, or, better still, observed with the cryptoscope.——Signor Stefanini reports having observed no action of an electrostatic field upon X-rays. They cannot be deflected, even by a rapidly rotating ebonite plate which they traverse. Sensitive plates contained in a box exposed to sunlight do not show any effect, unless a phosphorescent sheet is also enclosed. But it must not be concluded that this sheet intensifies the X-rays due to the sun. The latter merely produces phosphorescence by its heat, and this impresses the plate. This is demonstrated by the fact that a sheet of tinfoil placed over the box intercepts the heat, and also stops the photographic action. Also, the action may be produced by mere heating to 40°C. Calcium sulphide is the best phosphorescent substance for this experiment.——E. Villari's work, of which an account will also be found in the *Beiblätter*, proves that the walls of vacuum tubes are statically charged not only by the cathode rays, but also by the rays proceeding from the anode in all directions. The author succeeded in obtaining figures strikingly characteristic of the charges by the simple expedient of blowing a mixture of sulphur and red lead on to the tubes. Thus a pear-shaped tube was at first covered with only the sulphur over its entire surface. Then gradually the charges were distributed over alternate zones. Very highly conducting tubes showed no surface charge. This method should be further developed. It might shed some new light on the electrostatic deflection of the cathode rays, which, according to Jaumann, follow the direction of the electrostatic lines of force.——Profs. Lussana and Cinelli have communicated to the Siena *Accademia dei Fisiocritici* a "law," according to which any conductor exposed to Röntgen rays and protected against electrostatic effects assumes, whatever its initial potential, a final potential of 0·44 volt. The result is independent of the current, the distance, the medium traversed, and other circumstances. This is almost too simple to be true. It is to be hoped that the *Fisiocritici* lived up to their name.

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# THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 595.*)

*Localising during Working.*

*Induction Methods.*—These methods depend on the principle of the induction coil or transformer. Suppose a wire or cable, C (Fig. 42), and above this a triangular coil, D, of several turns of wire. The windings are parallel to the sides of the triangle, and the coil is placed so that one of the sides is parallel to the cable. Now, if the current through C be suddenly increased or decreased, a momentary E.M.F. will be induced in the coil D, and a momentary current will flow

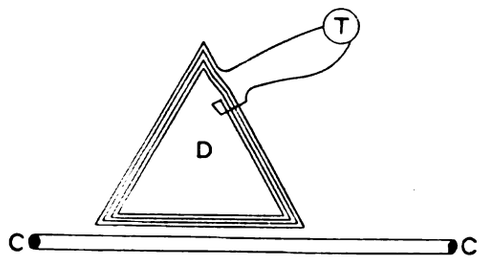


FIG. 42.

through the galvanometer or telephone, T, which is connected to it. If the current through C is alternately interrupted and restored several times in quick succession, a croaking noise is heard in the telephone; if an alternating current be flowing through C a hum is heard in the telephone. Such a coil is called a search coil.

We will consider now the case of a low-tension network which is divided into a number of sections, *a*, *b*, *c* and *d*, fed off the same 'bus bars, but otherwise independent of one another. Suppose the insulation tests in the station, by one of the methods already described, indicate a fault on the + side. A galvanometer or current detector is connected to the search coil, and one side of the latter is held against the main $+a$. The $-$'bus bar is then momentarily connected to earth. If the fault is in $+a$ the

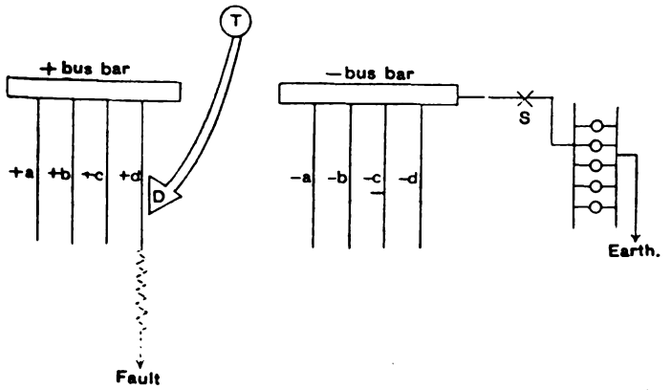


FIG. 43.

current through this main will be momentarily increased, and the needle of the search coil galvanometer will swing. If this does not take place the next main, $+b$, is tried in the same way, and so on until the faulty main is found. A small current may perhaps be induced in the coil when held against the sound mains, but the largest current will be obtained when it is held against the faulty one. Fig. 43 shows the connections diagrammatically, when there is a fault in the main $+d$. D represents the search coil, and T the galvanometer or telephone. Instead of the $-$'bus bar being earthed directly, it is shown connected to earth through a bank of lamps; this puts a resistance in series with the fault, and thus prevents too much current from flowing through the faulty main. If a telephone is connected to the coil instead of a galvanometer, the increased current will be indicated by a loud click. When a telephone is used it is preferable to have a switch of the "Paiste," or similar pattern, at S, such that the earth connection is made and interrupted rapidly by turning the switch handle continuously in one direction. It must be remembered that switching lamps in or out, on the circuit, will also induce currents in the coil and make the telephone croak; but by repeating the test two or three times the correct main can be decided upon without a doubt. Instead of making and breaking the contact at the switch, an ordinary electric bell (with the hammer bent back from the gong, until out of striking distance) may be connected in its place.

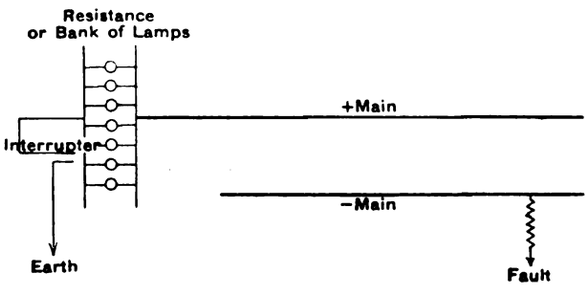


FIG. 44.

If the network is a closed or continuous one fed by a number of feeders (instead of being divided into sections each with its own pair of feeders, as just considered) the method described will also give good results at times of light load. The feeder nearest to the fault will then be the one that will induce the greatest current in the search coil; and the fault will lie between this feeder and the one which induces the second greatest current.

To obtain a nearer indication of the position of the fault without disturbing the supply, this method is often used in the streets. The sound main is put to earth at the station through an interrupter and a resistance (such as a bank of lamps). Fig. 44 shows the connections diagrammatically. On placing the search coil over any part of the cable on the station side of the fault, a sound is heard in the telephone. The tester can thus start from the station and walk along the cable with his ear to the telephone, and note where the sound

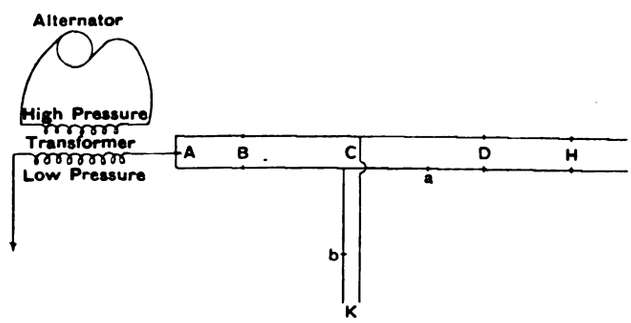


FIG. 45.

stops. This point, at which the sound ceases, will be where the fault is; but in some cases only. On bare copper strip networks, and on networks of unarmoured cables in non-metallic conduits or pipes, this is so, and very good results can be obtained. But when the cables are lead-covered or armoured, or in metal pipes, the sound in the telephone begins to decrease at the fault, but does not cease altogether until there is an interruption in the continuity of the metal covering. It is also very difficult to estimate where this decreasal begins. If the metallic covering run right through to the station without discontinuity, the sound in the telephone will be throughout very faint or altogether absent.

These methods apply as well to a three-wire network, whose middle wire is not permanently earthed, as to a two-wire one.

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

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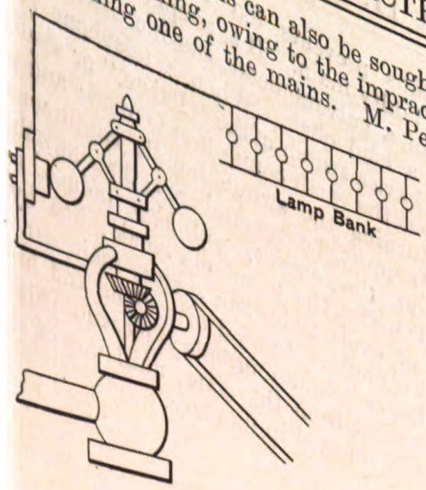


FIG. 46.

central station at Troyes, has used the method with success on his high-pressure network. His cables are lead-covered, but the continuity of the lead is broken at all the straight-

FIG. 47.

through and T or service joints. He notes at which joint the hum in the telephone ceases, and then examines the *previous* joint, where he usually finds the fault. His connections are shown in Fig. 45. The faulty cable, A H, and its fellow-conductor are disconnected from the dynamos, and are connected together at the station end, A. This end is connected to one of the low-pressure terminals of a transformer, whose other low-pressure terminal is earthed. The high-pressure winding is now connected to an alternator, and the search party starts out with its coil and telephone. The points B, C, D, H represent straight-through or T-joints, where, as already stated, the continuity of the metallic sheathing of the cable is broken. If it is found that the hum in the telephone has entirely stopped when the point D is reached, the fault will be at C, between C and D or between C and K; and the listener has to decide whether the *diminuendo* begins at C or at some point *a* in C D or *b* in C K.

On low-pressure alternating-current networks the connections are made at the transforming station, as on Fig. 44, the interrupter omitted. Arc-light machines of the Brush or Thomson-Houston type also give a current discontinuous enough for the test, without the use of an interrupter. When an interrupter is needed, an electric bell, with the hammer bent back, or the primary of a Rühmkorff coil with its contact breaker, does well, if only a small current has to be sent through the fault, as is the case when the search coil can be brought quite close to the cable. The current required also depends on the number of turns of wire on the search coil, and on the system of the network; the current necessary to induce a loud hum or croak when working on a "bare strip" network might induce none at all in the case of a sheathed system. If larger currents are required a switch turned by hand will also do, or a rotating contact-breaker can be easily rigged up. Fig. 46* shows an arrangement used as interrupter by Messrs. Latch and Waddell at the Edison station in Detroit. The figure represents the governor of a small engine which drives the mechanical stokers. An iron arm, fixed to the governor frame, carries a block of wood on which is a metal strip. The engine frame is connected to earth; the metal strip to one terminal of a bank of lamps, the other terminal of which is connected to the healthy main, as on Fig. 44. As the governor rotates, the balls make and break contact with the strip several times per second.

The triangular shape of search coil is the one mostly used, and it is very convenient to handle. The size of the coil and the number of turns on it must depend on the system of the network and on the maximum current that shall be allowed to pass through the faulty cable. An average size is, perhaps, an equilateral triangle of, say, 3ft. side, with a couple of hundred turns of No. 26 or 30 gauge wire. Fig. 47 shows the

* From the *Electrical Engineer* of New York.

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enormous coil used by M. Pernin at the Troyes station. The lower side of the triangle is nearly 12ft. long. It has only 25 turns of insulated copper wire of 0·8mm. diameter (about No. 21 S.W.G.). There is no doubt but that a coil of smaller dimensions and more turns of wire would serve the same purpose.

The author has often heard it stated that this induction method can be employed to localise a fault during supply hours without earthing the healthy main, or in any way disturbing the ordinary connections of the network. This theory is illustrated by Fig. 48 in the case of a fault in the – main. Current from all the small leakages in the + main will find its way to the – main through the fault F, as shown by the arrowheads. The value of these leakage currents will be continually changing. Accordingly, a buzz would be heard in the

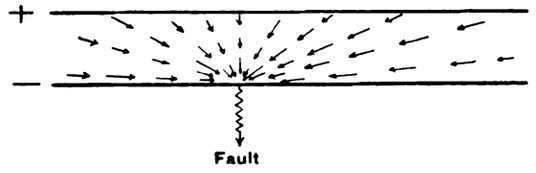


Fig. 48.

telephone when the coil is held over the fault, in addition to the clicking or croaking produced by switching lamps in and out, which is heard all over the network, and to the regular hum from an alternating-current network. The author has, however, been unable to meet an ear-witness of this pretty effect. As soon as he receives experimental proof of it on an actual network, he will willingly go more fully into the theory and consider the special cases of sheathed and concentric conductors. It is a fascinating notion that one might just wander along the streets with a telephone held to his ear and listen till the fault "rings up." It reminds one of a story told by Mark Twain, of a man who fell in love with a voice which was switched on to his telephone by mistake. The poor fellow wandered around the world for years with a telephone as sole travelling companion, and listened at every wire he came to. But he *did* discover the voice at last.

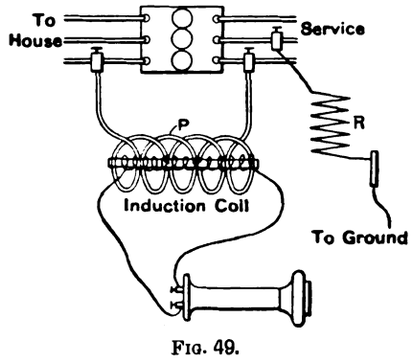


Fig. 49.

When seeking faults in mains which only carry small currents a regular induction coil or miniature transformer may be used instead of a search coil. The thick wire coil is "cut in" at the point of the circuit to be tested, so that the main current flows through it. If, on earthing the other main, the current through the faulty main is increased, a current is induced through the telephone connected to the fine wire winding. This modification is very useful on minor branches of the network and in houses. Fig. 49* shows such a search coil cut in at the foot of a house service main on a three-wire network. The thick-wire coil is connected across the cut-out on the faulty main, and the fuse wire, or strip, is removed, so that the coil is in the circuit. On earthing (or "grounding") the other main a current is induced in the telephone, if the fault is in the house. If this is the case the same test can be made at each branch fuse in the house wiring until the circuit in which the fault is is found. The earthing of the good wire may be done through a resistance and an interrupter, such as an easily working switch, as in the other cases.

* From an article by Mr. Austin S. B. Latch in the *Electrical Engineer* of New York.

Mr. George L. Thayer uses a very simple method to locate faults in house installations.* It is exactly similar to the one above described, excepting that a lamp, current detector, or galvanometer is used, instead of an induction coil and telephone. The connections are with this difference, as in Fig. 49; but now the resistance R must not be too high, and the lamps in the house which is being tested must be switched off. If there is current through the detector, or if the lamp glows when the earth connection is made through R, the fault is in the house, and one repeats the test at the branch fuses until the faulty branch is found.

The following is a fall of potential method used by Mr. Latch† to locate faults in distributing mains. After finding by the induction method which is the nearest feeder to the fault, he disconnects the feeder from the distributor at the feeding point, and tests whether the fault is in the feeder itself or not. If it is in the feeder, the feeder to the other main at this point is also disconnected, the two feeders are short-circuited, and the fault in the loop is localised from the station by Method 1, already described in the preceding chapter. If the fault is in the distributing main, connections are made as in Fig. 50. The pair of mains is disconnected

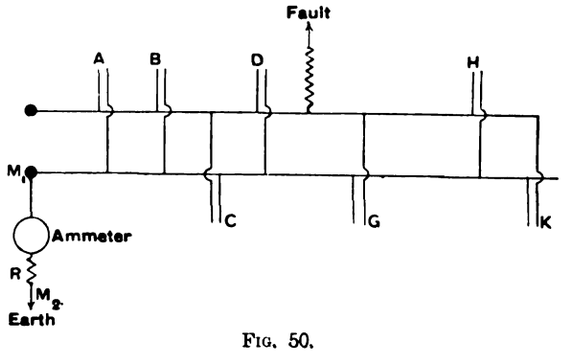


Fig. 50.

from all the feeders but one, so that it feeds from one end only. Then the good main is connected to earth at this feeding point through a resistance and ammeter. The resistance is so proportioned that the current is as strong as the smallest service wire could carry without damage, should the fault be in it. The house fuses are sufficient protection to the houses. Now the voltage is measured between $M_1$ and $M_2$, and between the service wires at A, B, C, &c. The potential difference between the ends of the service wires will drop gradually until the fault is reached, but after the fault is passed it will not drop any more, and will have the same value as between $M_1$ and $M_2$, or only slightly higher. Thus suppose the fault is in the position marked in the figure, the voltage will drop gradually from A to D, but at G, H, K, &c., the same voltage will be obtained. The only condition for this to be correct is that the test must be taken at the time of light load, so that the current sent through R is great compared with the current supplying the lamps on the distributor in question. The test, of course, only shows between which two service wires the fault lies; it does not actually localise the spot which has caused the trouble.

*(To be continued.)*

* The *Electrical Engineer* of New York, April 11, 1894.

† The *Electrical Engineer* of New York, April, 1894; or *The Electrician*, Vol. XXXIII., p. 81.

## THE DAVY ARC-CONTROLLED SWITCH.

The accompanying illustrations show the construction and circuit arrangements of the arc-controlled switch, invented by Mr. W. J. Davy, of the Davy Electrical Construction Company. The purpose of this switch is to effect an automatic change-over between an arc lamp and glow lamps, such as when it is desired to use arc light until midnight and glow light after midnight. For this purpose the switch is mounted inside the

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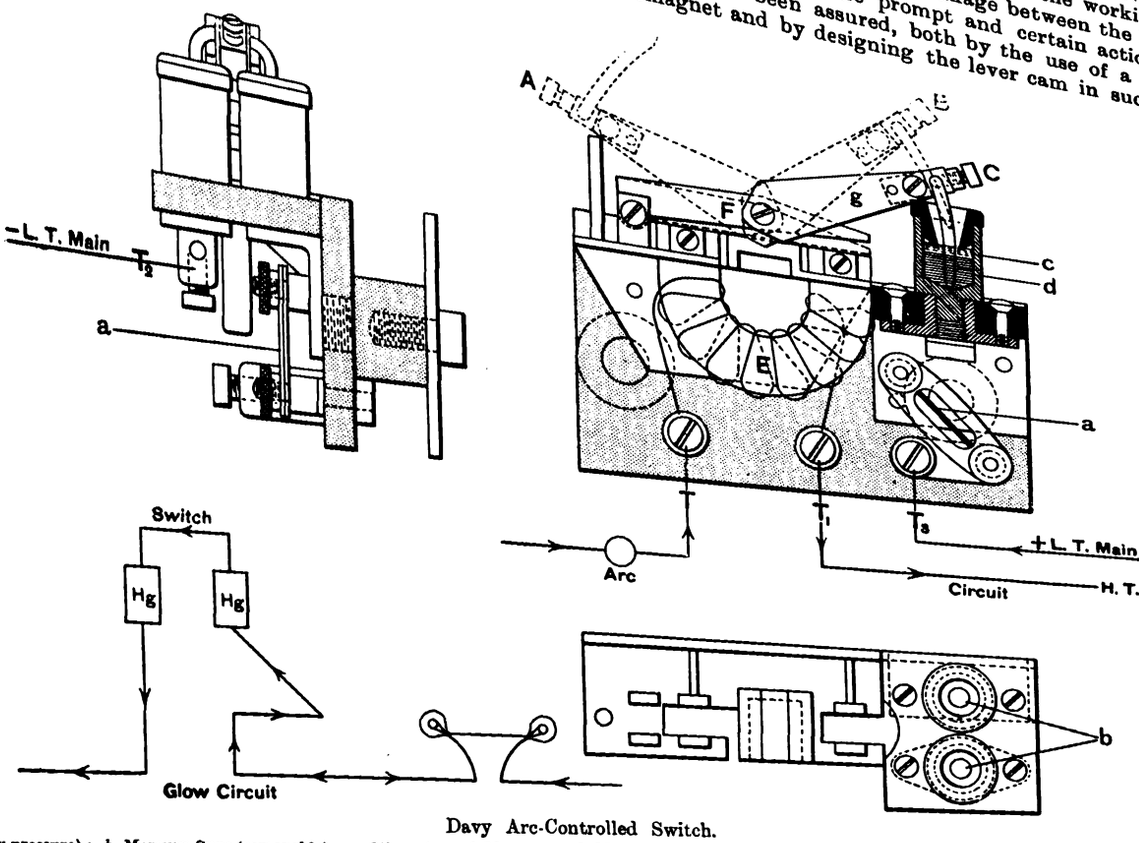
...-lamp column, and connections as shown are ...arc and general distribution circuits, the glow lamps ...ving power from the latter. Both the change-over and the re-setting actions of the switch are perfectly automatic, and are controlled from the central station, and there is no necessity to send a man to set it or to attend to its action. These several actions are as follows: In the daytime, when no light is required, the glow circuit-closing lever is in the position shown at A, and the glow-lamp circuit is open. In the evening, when the arc-lamp current is switched on, this current magnetises the electro-magnet E, and attracts the iron lever F, which, by means of a cam attached to the throw-over lever *g*, causes this last-named lever to turn forward into position B, in which position it is suspended directly over the mercury cups *b*, ready to close the glow circuit. The lever *g* will remain in this position for as long as the current is in the arc circuit; but directly this current is switched off, the lever will drop into the mercury cups, and will cause the glow lamps to light up. This condition is maintained until dawn, when it is necessary to switch off the glow lamps; and to effect this a current is passed through the arc circuit for a brief period. This current causes the magnet E to attract the iron lever F, and thereby jerks the switch lever out of the mercury cups, and throws it back into position A, where it remains until the arc lamp is again required.

In the design and construction of this ingenious device great care has been taken with the insulation of the working parts, and especially to ensure against leakage between the high and low pressure circuits. The prompt and certain action of the switch has also been assured, both by the use of a powerful electromagnet and by designing the lever cam in such a form that it must carry the switch into the desired positions. Several of these automatic change-over switches are about to be placed in the arc-and-glow columns for the street lighting at Portsmouth, where the arcs are run in series on rectified alternating current, while the glow lamps derive power from the ordinary low-pressure alternating-current network. The switch is being manufactured by the Davy Electrical Construction Company, of Westminster, and should prove useful to electric lighting concerns combining arc and glow lighting in streets and other public places.




Davy Arc-Controlled Switch.

*a*, Fuse (low pressure); *b*, Mercury Cups (removable); *c*, Oil on top of Mercury; *d*, Mercury; *g*, Switch; F, Controlling Armature; E, Controlling Coil; T $T_1$, High Pressure Main Terminals; $T_2$ $T_3$, Glow Lamp Circuit, Low Pressure Circuit.

## IMPROVED TESTING APPARATUS.

In a review of Signor Jona's admirable book on submarine cables* space prevented us from giving more than a short description of its general contents; a more detailed perusal, however, of the handy little volume has revealed several interesting novelties in the apparatus used for cable testing, two of which appear to us worthy of a detailed description. They consist of a universal testing key and a new form of high resistance, and are the joint inventions of Signori Perelli and Jona.

Fig. 1 represents the universal testing key, which not only does away with many connections and leads now in use for the same purpose, but admits of perfect insulation, and combines in one single system a battery reversing key, a discharge key, a short-circuit key, a galvanometer reverser, and a shunt-box, a condition of things obviously desirable, especially when testing apparatus has to be hurriedly fitted up in some cable hut or test room unprovided with the same.

To the binding posts 1 and 2 is permanently connected the shunt, and ordinarily the two terminals of the galvanometer, the shunt-box being furnished with two plugs, so that its multiplying power may be varied at will without breaking the circuit. The short-circuit key makes contact between K and 1, pressing against the screw V when closed, and with 2 when open, being hooked down to an ebonite block in the usual way. C and D constitute the galvanometer reverser, C being joined up to 1 and D to 2, and when in repose both rest against the screws *v* and *p* of a metallic crosspiece T, on ebonite columns. Two ebonite levers serve to clamp on either key in order to make contact with the line terminal 4. Terminal 3 is to earth.

* "Cavi Sottomarini," dal Ing. E. Jona. (Milano: Ulrico Hoepli.) *The Electrician*, December 6, 1895, p. 191.

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A and B form the battery, reversing key A being connected to 3 (earth), and B to the cross-piece T, the battery terminals being on 5 and 6. A double-action ebonite lever, shown between A and B, serves to clamp down either key as desired. If we assume that the zinc pole of the battery be joined to the binding post 5, and the copper pole to 6, the other connections having already been explained, communication is established between the line, galvanometer and shunt and the earth, and by clamping down A and C and the short-circuit key K, copper is to earth and zinc to line, through B the cross-piece T, the screw *p*, thence to D, terminal 2, galvanometer and shunt; the circuit being completed through terminal 1, thence to C and the line terminal 4.

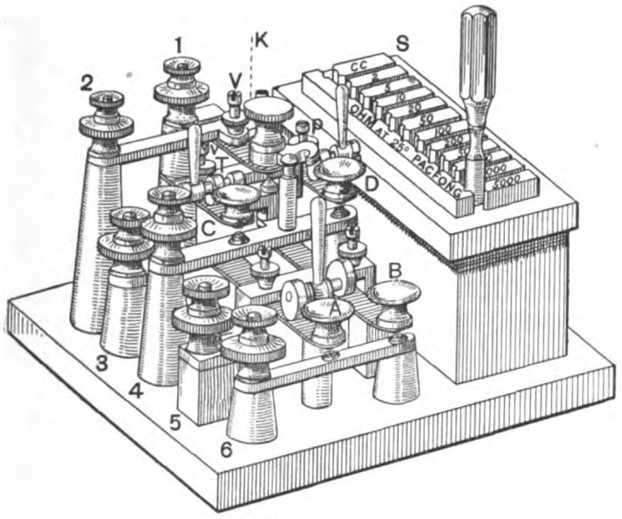


FIG. 1.

With a key arrangement of this description it is obvious that all tests of charge can readily be made by it. The line, after being charged as above can be insulated by simply releasing C and discharged at leisure through the galvanometer to earth by pressing down B and C simultaneously. Loss of charge can also be taken in the following manner: First note the charge of the cable as already given; instantaneous discharge can be compared with it by clamping down C and A and

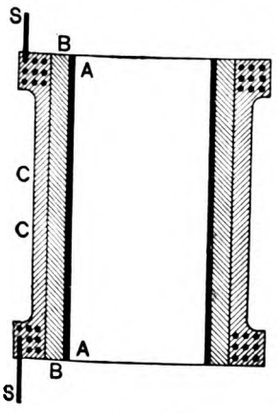


FIG. 2.

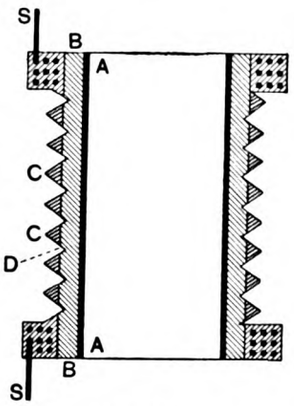


FIG. 3.

pressing B; and if the cable be again charged with A clamped down and C simply pressed and then released, the charged cable will remain insulated, and its discharge can after a given time be taken by pressing down B and C at one and the same time.

Lord Kelvin's capacity test can also be taken with this key. By carefully manipulating the front lever the key A is cut off from contact with either 5 or 6, one terminal of the galvanometer being then connected to 3, and the other direct to earth. The battery rheostat is joined up between terminals 4 and 6, the line terminal 2 and the condenser to the binding post 1. The short-circuit key is left open, and the shunt cut off. When these connections are completed the test is taken by pressing down B and D, and the two condensers become charged, and on raising B and D again their respective charges flow into each other and combine. The lever near A is then turned, so that the key makes contact with terminal 5, thus discharging both condensers simultaneously through the galvanometer.

The other instrument referred to is a novel form of high resistance, which has the merit of cheapness in construction and efficacy in action and constancy. It is made in two different shapes, as shown in Figs. 2 and 3, the first being for resistances of 1 or 2 megohms, and the other for resistances of 50 to 100 megohms. A A represents a brass tube, upon which is laid a stratum of ebonite paste, B B, of about 5-6mm. in thickness, and perfectly even. This paste is then vulcanised and smoothed in the lathe. Over this is laid a coating of a semi-conducting paste, C C, made of ebonite and smoke-black, the ebonite being now vulcanised. At the extremities of the tube are two iron springs, S S, which serve as contacts. The tube is again placed in the lathe, the second coating vulcanised, and then thinned down, as shown in Fig. 2.

Fig. 3 shows the same instrument, but for much higher resistances, this result being obtained by turning the tube, when in the lathe, in the form of a screen, the points of the semi-conductors C C being separated at intervals by the first stratum of ebonite, as at D.

## BRITISH ASSOCIATION.

The following are particulars of some of the Papers and Reports which will be read before Section A (Physics) during the forthcoming meeting of the British Association at Liverpool, together with the probable programme of Section G :—

### SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

PRESIDENT: PROF. J. J. THOMSON, F.R.S.

Reports :—

1. On Electrical Standards.
2. On Magnetic Standards.
3. On Comparison and Reduction of Magnetic Observations.
4. On the Establishment of a National Physical Laboratory.

Papers :—

1. F. BEDELL, "The Division of an Alternating Current in Parallel Circuit with Mutual Induction."
2. W. M. MORDEY, "An Instrument for Measuring Magnetic Permeability."
3. E. H. GRIFFITHS, "The Measurement of Electrical Resistance."
4. Dr. J. C. BOSE, "On a Complete Apparatus for the Study of the Properties of Electric Waves."
5. W. H. PREECE, "Disturbances in Submarine Cables."

### SECTION G.—MECHANICAL SCIENCE.

PRESIDENT: Sir DOUGLAS FOX.

*Thursday, September 17th.*

1. PRESIDENT'S Address.
2. Report of Committee on Tides.
3. G. F. LYSTER, "Dock Development of Liverpool."

*Friday, September 18th.*

4. T. W. BARRY, "Tower Bridge" (lantern illustrations).
5. J. PARRY, "Liverpool Waterworks."
6. T. MAGINNIS, "Development of Atlantic Steamships."

*Monday, September 21st.*

7. Report of Committee on "Small Screw Gauges."
8. Prof. MENGARINI (Rome), "Electric Light and Tramway Systems of Rome."
9. S. B. COTTRELL, "Liverpool Overhead Railway."
10. E. W. ANDERSON, "Notes on Electric Cranes."
11. W. H. PREECE, "Test of Glow Lamps."

*Tuesday, September 22nd.*

12. Report of Committee on Standardising of Instruments in Engineering Laboratories.
13. H. B. TANY, "Expanded Metal."
14. W. W. BEAUMONT, "Why Railway Rails Break."
15. Prof. HELE SHAW, "Engineering Laboratory Apparatus."

*Wednesday, September 23rd.*

16. A. R. SENNETT, "Horseless Carriages."

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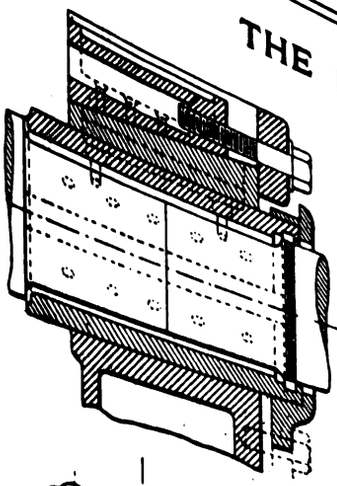
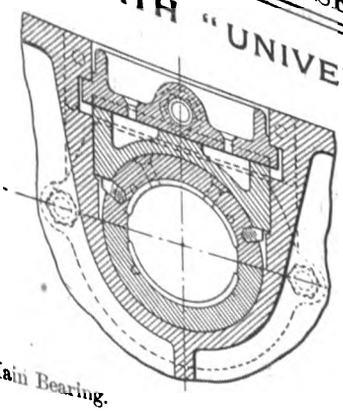
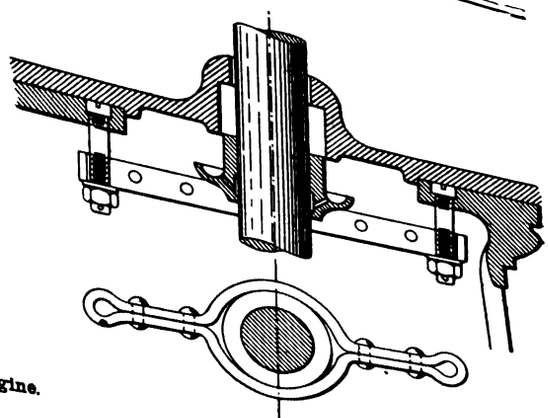
# THE RAWORTH "UNIVERSAL" STEAM ENGINE.



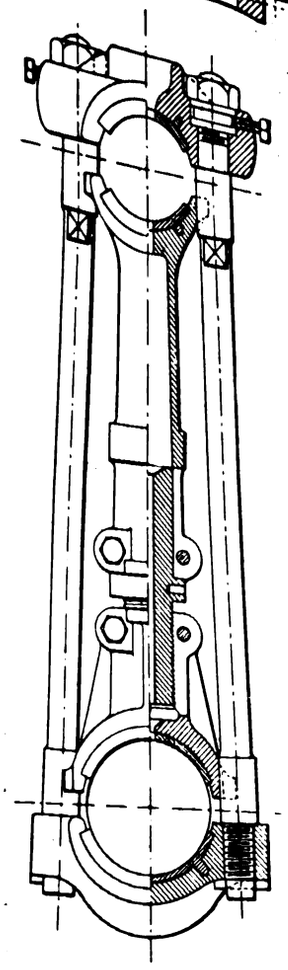


Main Bearing.

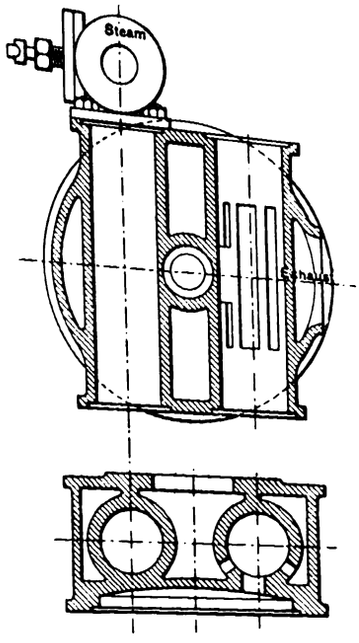


Piston-rod Gland.

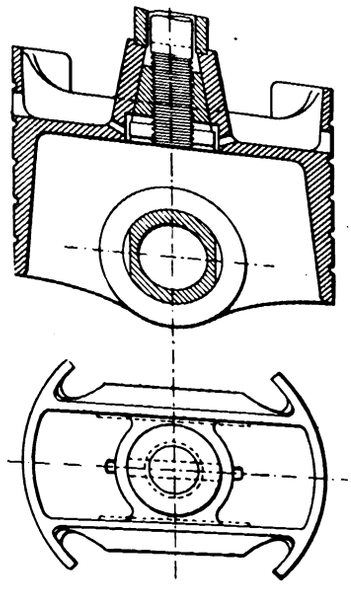
Fig. 2.—Details of Raworth "Universal" Steam Engine.



Connecting Rod.




Section through Valves.



Details of Crosshead.

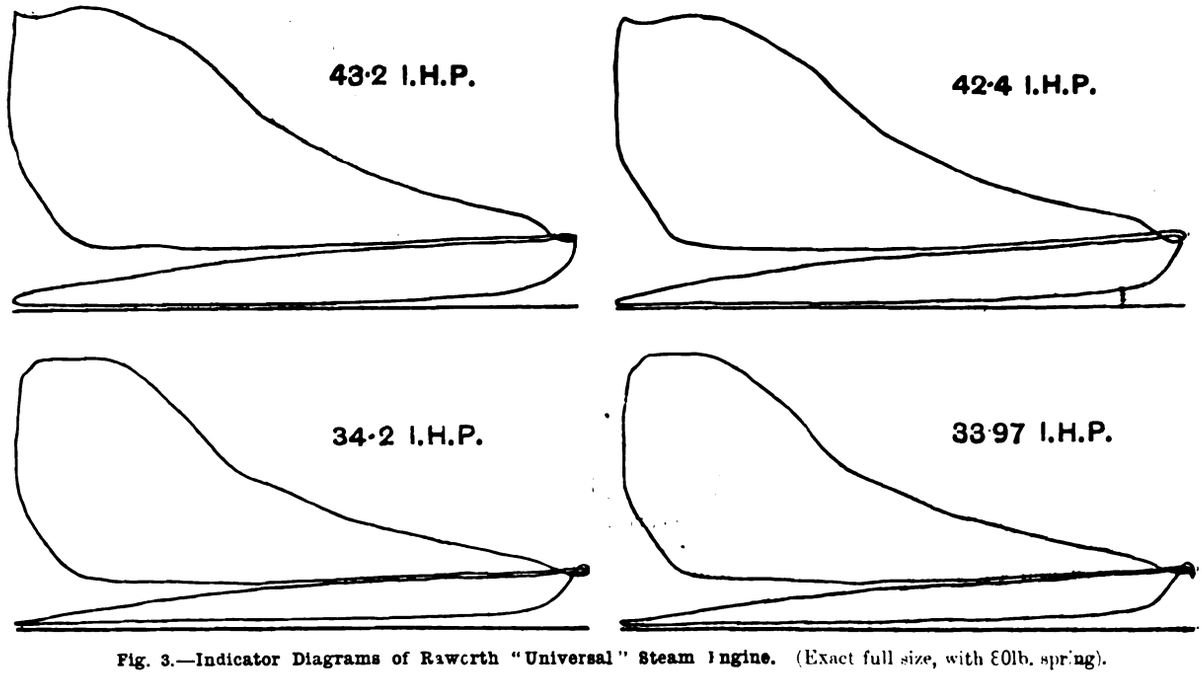



Fig. 3.—Indicator Diagrams of Raworth "Universal" Steam Engine. (Exact full size, with 80lb. spring).

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## THE RAWORTH "UNIVERSAL" STEAM ENGINE.

In our last issue we mentioned that the Raworth "Universal" steam engine, which is now being manufactured by the Brush Electrical Engineering Company, had recently been subjected to a number of trials of its efficiency by means of the testing plant at the Brush works at Loughborough. This week we are enabled to publish further particulars of these trials, together with a number of scale drawings of the details of construction of the engine, and an exterior view (Fig. 1) of the engine direct-coupled to a Mordey-Victoria alternator. Referring, firstly, to the last-named illustration, we may call attention to several prominent features of the engine. It will be seen that the crank-case is enclosed with light sheet-steel splash guards, formed conically around the main pedestal and cross-head guide blocks. At the lower part of this enclosed crank-case the crank runs in an oil bath, providing copious and efficient lubrication. To the right of the main engine column is seen the cylindrical guard placed around the eccentric and valve rods, all the working parts of the engine being thus enclosed. To the left of the main column is seen a vertical cylindrical reservoir, which is capable of holding one month's supply of cylinder lubrication. The engine

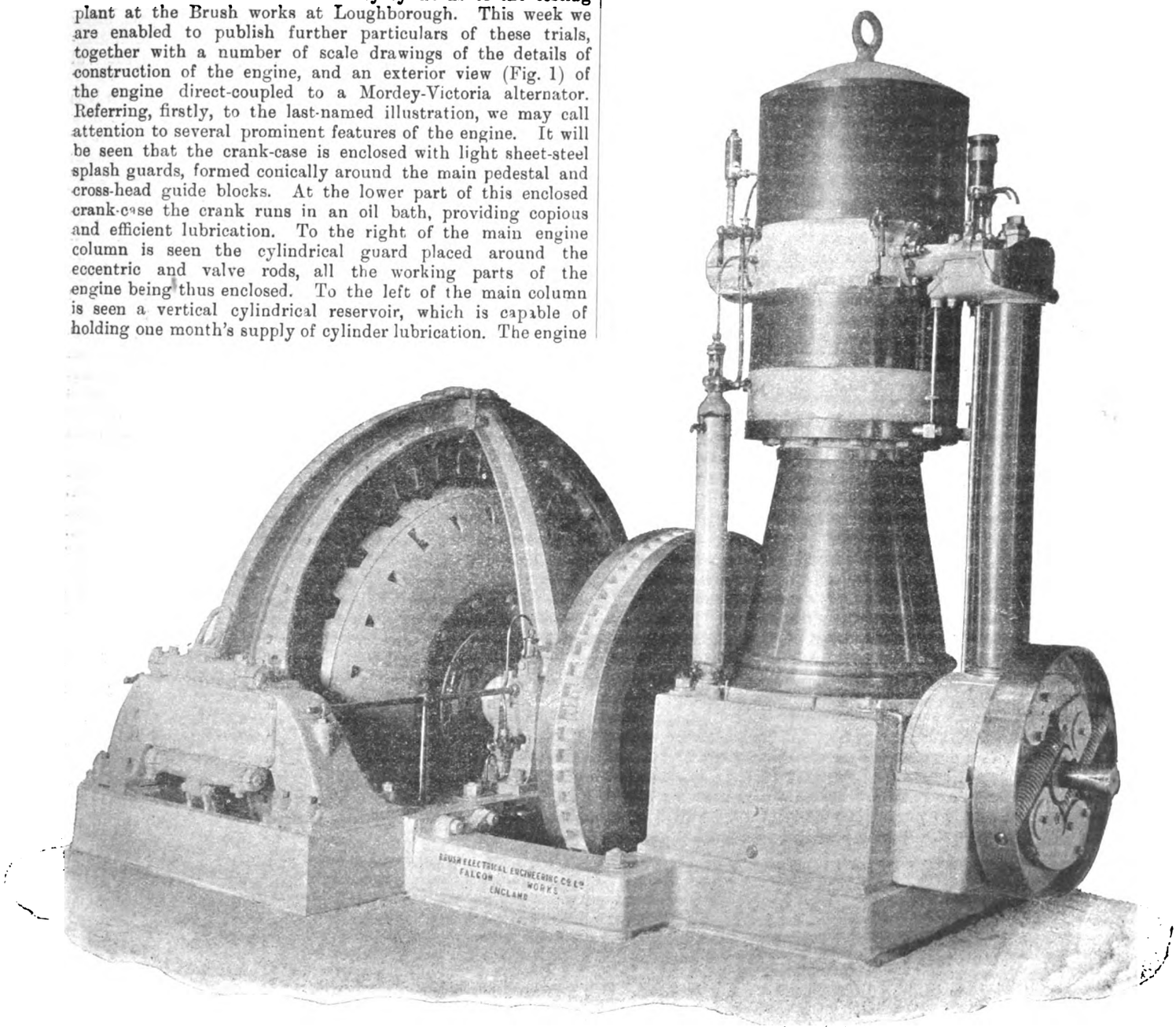


FIG. 1.—A Raworth "Universal" High-Speed Steam Engine, Direct-Coupled to a Mordey-Victoria Alternator.

cylinders are lubricated by sight-feed displacement, the regulator being placed on the condensed steam escapement, and not, as is more usual, on the oil. A more reliable and steady feed is obtained by this method. An ingenious detail of the cylinder lubricator consists in a steam-controlled oil cut-off valve, which is only opened when steam is admitted into the engine. Thus, when the engine is not working, cylinder lubrication is suspended, with economical results. Within the case surrounding the eccentrics is the chain-geared oil-pump for supplying the forced lubrication of the bearings and other brasses. This pump raises oil from the crank case to the little reservoir on the right of the upper cylinder. From this reservoir the oil descends by gravity, and is distributed to the various brasses. The overflow from the oil-pump is discharged in a cataract on the working parts in the crank case.

In Fig. 2 are shown several of the engine details to which reference was made in our article last week. The construction of the connecting rod, with its two tie rods and adjustable strut, has been fully explained. The cross-head pin (Fig. 2) is hollow, and is designed to be perfectly tight in working yet quite loose for removal. This pin is a free fit in the hole in the cross-head, but the ends are bored conical and are split. To fix the pin, the two cone plugs are drawn up tight by the bolt, and thus expand the pin in the bearing holes. A very ingenious but simple device is used for the attachment of the piston rod, enabling the rod to be freely drawn out from above. The end of the piston rod is screwed and fitted with a conical nut in halves. To get the rod out it is only necessary to unscrew the top nut of the piston rod, and let the rod down a few inches, when the divided conical nut falls off, and the piston rod can then be drawn through. The bottom gland of the piston rod (Fig. 2) is forced into position by a loose frame, which puts no cross-wind on the gland, whatever inequality there may be in the screwing up.

Turning now to the trials of the "Universal" engine, Fig. 3 gives some specimens of the indicator diagrams which were



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taken during the trial described in our last issue, p. 607. Since that trial, the lengths of steam-pipe between the boiler and the engine have been measured; the length of covered pipe was 44ft., and there was an equal length of uncovered pipe. It may be inferred, therefore, that the steam arrived rather wet at the engine stop-valve. Notwithstanding this uncomfortable condition, the engine made an excellent showing,

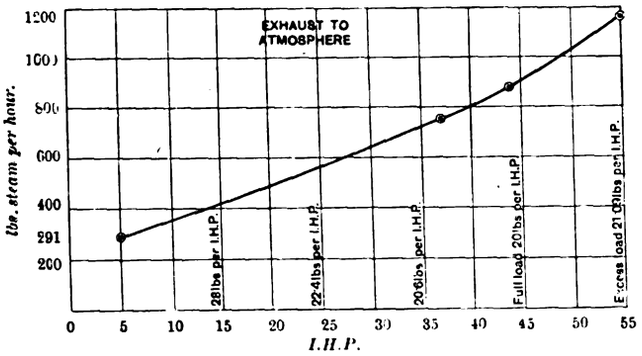
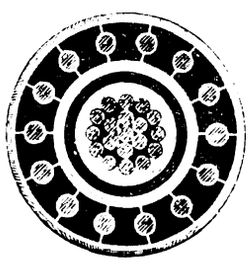



FIG 4.—Trial of Raworth "Universal" Engine. H.P. 9¾in., L.P., 14¼in.; Stroke 6in.; Revolutions 450; Steam at 140 lbs. boiler pressure.

as is evidenced by the accompanying indicator cards, and by the consumption of 19·8lb. of steam per indicated horse-power per hour, working non-condensing. A similar trial of identically the same engine was made on August 26th, the engine running at 450 revolutions, under steam at 140lb. pressure, and exhausting to the atmosphere. The results of this trial are shown in Fig. 4.

## HIGH-CONDUCTIVITY LOCK-ARMOURED ELECTRIC LIGHT CABLE.

A high-conductivity lock-armoured electric light cable, to meet the requirement of a "bare return" conductor, has been brought out by Messrs. W. T. Glover and Co., of Salford and London, and is illustrated in the accompanying figure. In



ordinary bare return cables the iron or steel armour is used as a return conductor; but, particularly in cables of large size, the weight of armour required to conduct the current is very great, viz., about seven times that of copper, and the cables are liable to be costly and unwieldy in consequence. The lock armour of Messrs. Glover and Co.'s bare cable is designed to provide a higher conductivity in the return conductor. It will be observed that the cable is completely sheathed with iron or steel segments, which carry round copper wire in semi-circular channels. The copper acts as a return conductor, while the locked iron or steel segments provide the mechanical strength and protection of the armour.

**Glasgow and West of Scotland Technical College.**—The Session for 1896-97 commences on Monday, October 5th, and the entrance examination begins on Tuesday, the 29th inst. The laboratories for practical instruction in physics, chemistry, metallurgy and electrical engineering, and the engineering workshop at the College are liberally equipped with the most approved apparatus.

## ELECTRICAL WORKS IN SWITZERLAND—THE VAL DE TRAVERS STATION.

BY J. E. PETAVEL.

At the entry of the Gorges de la Reuse, near Neuchatel, two large central stations on the constant-current system have just been erected. One of these is destined to furnish power and light to the industrial town of Chaux-de-fonds; the other will supply a number of small villages and isolated manufactories spread over the long narrow valley known as the Val de Travers.

The first-mentioned station being not yet in operation it is with the second, although the smaller of the two, that I now propose to deal. The Thury system is already well known by the power transmission at Genoa. A constant continuous current is always maintained in the distributing mains, the generators and motors being placed in series. In the case of the Val de Travers station the motive power is furnished by the Reuse, from which, even when the river is at its lowest, an available supply of 70 cubic feet per second can always be obtained. A canal 764 yards long cut in the solid rock brings the water to a reservoir 95ft. above the station, whence an iron tube 5ft. 3in. in diameter and 158 yards in length, conducts it to the distributing vanes of the turbines. These turbines are five in number, giving 250 H.P. at 325 revolutions. They are coupled to the dynamos by insulating rubber coupling. Six-pole series-wound dynamos are used, each giving 65 amperes and 2,600 volts. All these machines are first tested at 3,700 volts, and the generators all destined to work in series are placed in circuit in the following manner.

The dynamo started on short circuit gives the normal current of 65 amperes at about 12 revolutions per minute. It is then switched in series with the other generators, and the speed increased until it takes up its share of the load. When it is desired to take a generator out of circuit, the water supply is cut off from the turbine, and an automatic device short circuits the dynamo as soon as it tends to reverse its rotation, and run as a motor. A view of a generator and turbine is given in Fig. 1. One of the remarkable features of this system is the extreme simplicity of the switchboard. In the centre is placed an ammeter, the other fittings consisting merely of a short-circuiting switch and a voltmeter for each generator.

At full load four generators are placed in series, one being always kept in reserve. The total pressure may thus attain 10,400 volts. The safety devices adopted in this station offer considerable interest. All the generators are placed, as shown, on porcelain insulators, and these in turn are supported on a brickwork flooring. In the construction of this flooring a special sulphur cement is used, and it is said to form in itself a very good insulation. The floor of the station is of wood, also bearing on porcelain insulators, and the walls themselves are covered to the height of some 5ft. or 6ft. with a wooden wainscoting. Under these circumstances the men in charge can touch any part of the machinery without danger.

The line starting from the central station supplies the districts of Noiraigue, Travers, Couvet and Fleurier, the total length being 21·8 miles. This line is entirely overhead, and is supported on double porcelain insulators. It consists of bare copper wire, 0·412in. in diameter. Wherever the wire enters a village an insulated cable of 90 sq. mm. (0·139 sq. inch) in section is used. At first it was found difficult to protect the line against atmospheric discharges, but this difficulty has of late been overcome by the use of the lightning arrester shown in Fig. 2. This arrester consists of an arm A, about 2ft. in length, made in U section and pivoted at C. The upper points D are arc-light carbons. In shunt across the second air gap, E, are placed the coils of an electromagnet, M. When the main current tends to follow the lightning discharge, the magnet attracts the armature F, and the arm flying out breaks the arc, after which it automatically returns to its original position. Between the generators and the lightning arrester is placed a large self-induction, and again behind this a capacity. This device was strongly recommended at the Electrical Congress of Geneva, and in practical working seems to prove very efficient.

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In each village there is a secondary station, comprising a constant-current motor direct-coupled to a constant-pressure dynamo. The pressure maintained on the secondary mains is

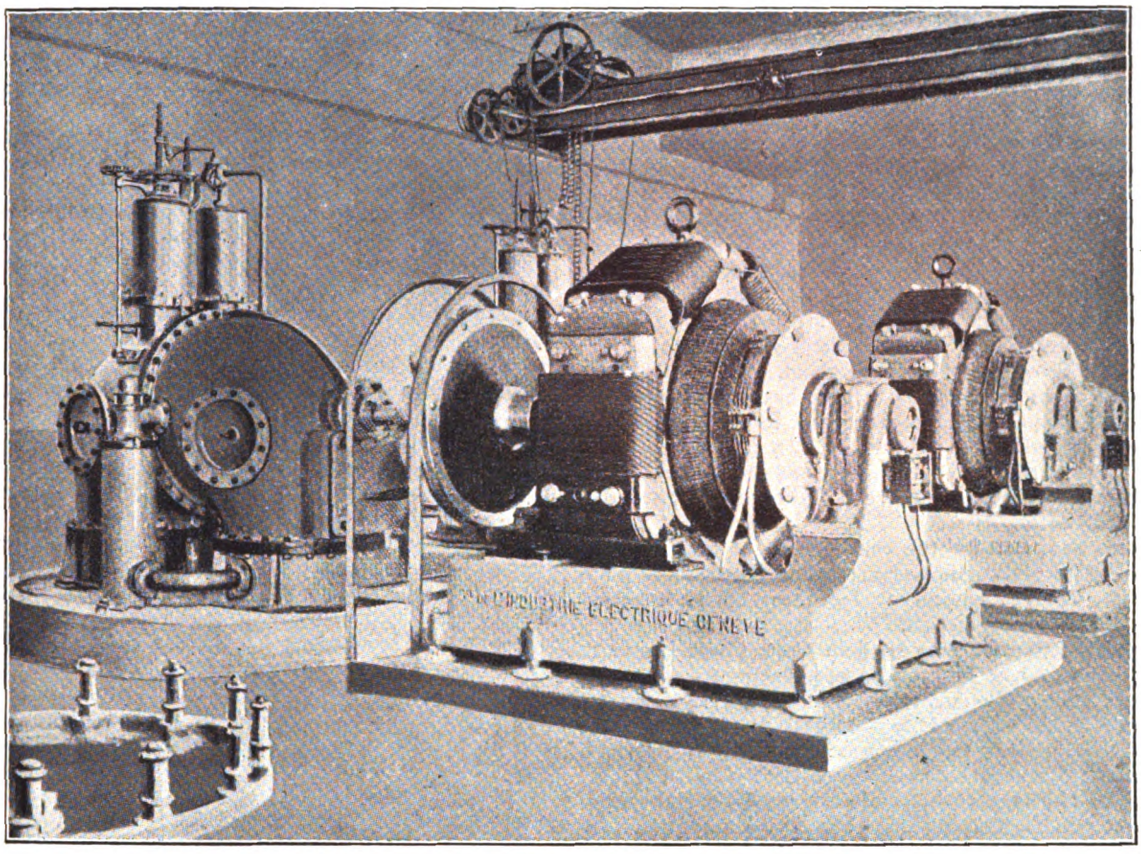


FIG. 1.—View of Generator and Turbine at the Val de Travers Central Station.

125 volts, but the electromotive force of the dynamo can be raised sufficiently to charge the battery of accumulators attached to the station. A great economy of power is obtained

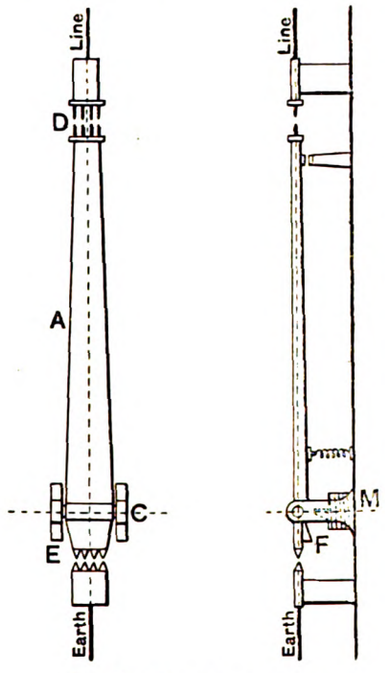


FIG. 2.—Lightning-arrester.

by the use of these accumulators. When the water is scarce they are charged at night only, thus permitting the whole power of the generating station to be available during the day for distribution to the various factories. Each motor is furnished with an automatic speed regulator, which places a shunt of variable resistance across the terminals of the field-magnet coils. This regulator, adapted to one of the motors used, will be seen in Fig. 3. In case of accident to this regulator racing is prevented by a safety device placed on the shaft of the motor. It consists of a horizontal governor, which, if the speed increases beyond a certain limit, strikes a trigger, lets fall a short-circuiting switch, and brings the motor instantly to rest. An electromagnet is placed across the terminals of the motor, which short-circuits it in case of the volts rising above a given maximum. This electromagnet, therefore, takes the place of the fuse in the constant-pressure system, and prevents overloading.

A number of factories have been fitted with constant-current motors placed in series on the high-tension line, and there, as

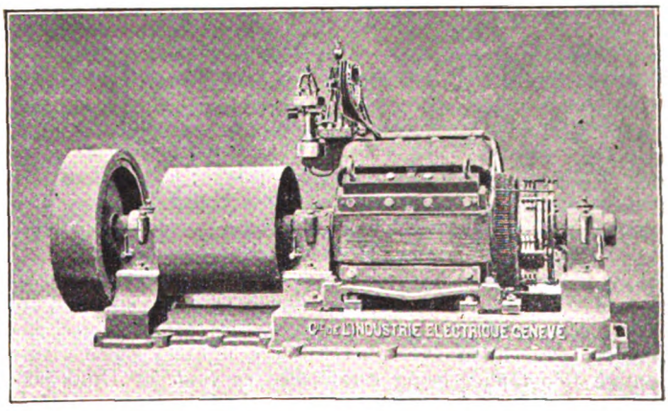


FIG. 3.—Motor fitted with Automatic Regulator.

in the secondary stations, the insulation is provided for in much the same way as at the generating station.

The cost of power varies, according to a sliding scale, from £7 to £12 per horse-power per annum.

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## THE TELEGRAPH IN THE ASHANTI EXPEDITION (1895-6).

The following particulars, culled from official sources, with regard to the construction, maintenance and method of working of the telegraph during the recent Ashanti Expedition will prove of interest.

The detachment of the Telegraph Battalion of the Royal Engineers, sent to the Gold Coast for the construction of a military telegraph line, consisted of two officers (Capt. R. S. Curtis, R.E., and Lieut. D. S. MacInnes, R.E.), and 21 non-commissioned officers and men of the 1st Division Telegraph Battalion and 11 non-commissioned officers and men of the 2nd Division, or 34 in all. The first party disembarked at Cape Coast Castle on December 13 and 14, 1895, and a second party disembarked about December 19th. The 2nd Division men were all telegraphists, with considerable experience in the General Postal Telegraph offices in England. The 1st Division men were all intended for construction, but several of them were also telegraphists, and became very useful in the latter part of the campaign, when the 2nd Division men were reduced by fever. Two of the 1st Division men had been trained in the Clearing House at Aldershot, and established a similar system at Cape Coast Castle.

The stores sent out for the construction of the line were roughly as follows:—90 miles of aerial-line material, 60 miles of cable-line material, equipment for three offices, together with tools, &c, for construction.

The original intention was to join Cape Coast Castle to Prahsu by cable in the first instance, replacing by an air-line as soon as possible. The instructions received were that communication with Prahsu was to be completed by December 27th. On arrival at Cape Coast Castle it was found that the Colonial Government had erected a line on permanent poles to Mansu, and that poles (without wire) had been placed for eight miles beyond that point. This modified the above intention considerably, and enabled the line to be extended beyond the Prah to Kumassi; and so telegraphic communication was kept up throughout, instead of to Prahsu only, as originally intended.

Arrangements were made with the Governor of the Gold Coast, by which the Colonial line from Accra (where the cable to England terminates) to Cape Coast Castle, and thence to Mansu, was to be under the Director of the Colonial Telegraphs for maintenance, &c., as usual; and the Director of (Military) Telegraphs was to send two clerks to Accra, Cape Coast Castle, Mansu, each respectively, to assist in overcoming the extra work due to military exigencies. With the exception of one European clerk at Cape Coast Castle, the Colonial offices are worked entirely by natives, who are not sufficiently skilled to meet a large amount of work. The usual arrangements as to Press censorship were made, and the list of newspaper correspondents entitled to send messages published. Code or cipher messages, except from authorised offices, were forbidden. Merchants, however, by handing in a certificate "on honour," to the effect that their messages contained no political or other public information, were permitted to wire in code.

A working party of about 150 natives was handed over on December 14th. They were at once divided into gangs of about 25, and given distinguishing badges; a special pattern, consisting of a brass label with steel chain, had been purchased privately before leaving England. These proved invaluable, a telegraph carrier or workman being recognisable at once.

On the afternoon of the 15th the construction party, consisting of 2 officers, 16 non-commissioned officers and men, and 125 natives, left Cape Coast Castle by march route, and reached Mansu on December 18th, a military office with a native telegrapher being established *en route* at Dunkwash. Meanwhile a large number of stores had been conveyed to Mansu by the carriers employed under the Director of Transport. On December 19th a cable line was started from Mansu. The mode of working was as follows:—Four natives, carrying a barrow with drum of cable, marched in front, superintended by a non-commissioned officer, and a sapper reeling out cable. In rear came a number of natives, carrying further supply of cable (half-mile of cable per man), small stores, kits, accoutrements, &c. Close to the paying-out drum was a native carrying a portable vibrator, set so that communication could be established at any time. In rear came two or three natives, with a supervising sapper, placing the cable out of harm's way. It was found that the cable could be laid as fast as the men could march. Communication by cable to Prahsu was opened in the evening of December 22nd, the date required being December 27th.

On December 20th a party commenced the construction of the air-line from Mansu. The first eight miles was merely running a copper wire on the iron poles already erected by the Colony. After that point the regular construction commenced. This work was most arduous. The road was but 8ft. wide, very tortuous, and bounded on either side by dense bush; the bush in many places met overhead. The large trees were covered with enormous creepers, which were infested with insects. The officer or non-commissioned officer in charge usually went ahead choosing the direction, eight to 10 natives, with hammer and jumper, ladder, &c, under a non-commissioned officer, followed, fixing poles or insulators as directed; the wire-barrow, being carried by natives, came next. The straining was done by natives, but it was found advisable to always use two natives at one time to strain, the pull being steadier. The rear party consisted of two or three sappers, who had to fix the wire and generally build the line. These men were the hardest worked of the detachment, being constantly up ladders exposed to the sun, having to do manual work, the natives being useless in this matter. The same trouble was found as was noted by Lieut. Jekyll in 1874 with the insects, the men being often driven down the ladder by a swarm of ants, who resented the hammering of spikes, &c., into a tree. A clearing party of natives under a sapper worked where most advantageous to free the line from contact with creepers, &c.; this was also most laborious. Spare wire, poles, &c., were carried by the remainder of the natives, who were also loaded with rations, ammunition, tents, kits, &c.

As the air-line progressed the cable was reeled up and sent on to the front. This system was continued throughout, viz., firstly, communication by cable established; secondly, the cable was replaced by air-line, the cable being moved to the front for further extension. This arrangement worked well throughout.

The natives worked better at the technical details than was expected. They soon became fairly skilled with the hammer and jumper, and some few were almost good builders. They were not trustworthy as linemen, being apt to loiter and inspect the line very superficially.

The following table shows the progress of the air-line and cable from Mansu to Kumassi:—

*Table showing Progress of Air Line and Cable from Mansu to Kumassi.*

| — | Cable. | Air line. |
|---|---|---|
| 1895. | | |
| Dec. 19 ..... | Mansu to Sutah. | |
| „ 20 ..... | To Assin Yancoomassie. | To Inyabuni. |
| „ 21 ..... | „ near Barraku. | „ near Sutah. |
| „ 22 ..... | „ Prahsu. | „ Sutah. |
| „ 23, 24... | — | „ near Fesu. |
| „ 25, 26... | — | „ Assin Yau Coomassie. |
| „ 27 ..... | — | „ Barraku. |
| „ 28, 31... | „ Tobiassi. | „ near Prahsu (detachment all [down with fever). |
| 1896. | | |
| Jan. 1 ..... | „ Essiaman Kuma. | |
| „ 2 ..... | — | „ Prahsu and over Prah. |
| „ 4 ..... | „ near Fumsu. | |
| „ 5 ..... | „ near Akusirem. | „ near Tobiassi. |
| „ 6 ..... | „ Akusirem. | |
| „ 7 ..... | „ Baafo Edru. | |
| „ 8 ..... | — | „ 1 mile north of Essiaman. |
| „ 9 ..... | „ Kwisa. | |
| „ 10 ..... | „ near Essian Kwanta. | „ Fumsu. |
| „ 11 ..... | „ Essian Kwanta. | „ near Akusirem. |
| „ 14 ..... | „ Ejinassi. | „ near Kwisa. |
| „ 15 ..... | „ Edunku. | „ Kwisa. |
| „ 16 ..... | „ Dedesmia. | |
| „ 17 ..... | „ Kumassi. | |

A moving office, with telegrapher, always accompanied the Head-quarter Staff. A portable vibrator set with condenser

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and a long lead of copper wire was employed, so that communication could be opened at any point by connecting up with the standing line. This arrangement was found invaluable. When the Head-quarter Staff reached the advanced guard the moving cable office was used. The head of the cable moved with the column *pari passu*, and entered Kumassi at the same time as the force. If it had not been for an unlucky tornado on the morning of the 17th and night of the 16th, which demolished military and Colonial lines alike for miles, the news of the entry to Kumassi would have been known in England very few hours after its occurrence.

The following table shows the faults, &c., that occurred. In it are also shown the faults occurring on the Mansu-Accra Colonial line. By this it will be seen that frequently, although the military line was working well, communication with England was interrupted by faults beyond military control. The cable to England was reported not working for three or four days about January 14th. The breakdown about January 17th was most inopportune, but was entirely due to the severe storm. Between Prahsu and Mansu the line was down in various places for two miles, which was a large matter to repair. The faults were in every instance due either to falling trees caused by storms, &c., or to natives cutting pieces out of the wire for ornaments, bracelets, &c. In one instance as much as 80 yards was taken. During the early morning and evening the line was always very "earthy" owing to the excessive moisture; this caused a good deal of delay. Thunderstorms of a very severe description were constant, and in such a case the instruments were often disconnected to prevent injury.

*Table of Faults occurring on the Telegraph Line between Accra and Kumassi.*

| Colonial line. | Military line. | Remarks. |
|---|---|---|
| Accra to C. C. C., dis. Dec. 21-24. | *Mansu to Prahsu, dis. Dec. 31, 4 p.m., to Jan. 1, 10:45 p.m. | *(*a*) Tree felled by working party (Colonial) breaking line; (*b*) 30 yards wire stolen. |
| C. C. C. to Mansu, dis. Dec. 26-27. | | |
| C. C. C. to Mansu, Jan. 4 (wire cut by natives). | | |
| Accra to C. C. C., dis. Jan. 9, 10, 12, 15. | | |
| Accra to C. C. C., Jan. 16. | Mansu to Prahsu, dis. Jan. 16, 7:30 p.m. | Heavy tornado. |
| | Cable Kwisa to Eginassi, cut in many places. | |
| " " " Jan. 17. | C. C. C. to Prahsu, Jan. 17, restored for four hours, then dis.; Kwisa to Prahsu, cut. | Trees falling. |
| " " " Jan. 18, 12 noon, right. | | |
| C. C. C. to Accra, dis. 4 p.m. | Kwisa to Prahsu, Jan. 18, right for one hour, then dis., right at 6:30 p.m. | Wires cut, and pieces stolen. |
| C. C. C. to Mansu, down. | | |
| " " " right, then dis. 6:45 p.m. | C. C. C. to Prahsu, Jan. 19, right. | Messages to Accra per H.M.S. "Magpie." |
| Accra to C. C. C., dis. Jan. 19. | Mansu to Prahsu, Jan. 24, 1:30 p.m. till 10 a.m., Jan. 25. | Stay cut and stolen. |
| Accra to C. C. C., Jan. 20, 21, 24. | Cable cut near Kumassi, Jan. 26. | |
| C. C. C. to Mansu, cut Jan. 23, maliciously. | Line cut near Fumsu, Jan. 29, but soon repaired. | |

For the maintenance of the line one non-commissioned officer or sapper, with four natives, was left about every 12 miles as lineman, with the necessary tools, &c. He patrolled either way as required. The line was well maintained on the whole. After a thunderstorm the line was, as a rule, so damaged by falling trees that it was very hard work for a man to repair it quickly. In one case, near Fumsu, the wire was on the ground for nearly a mile; to restore this alone was difficult enough for two men, but one man achieved it, and in good time. The constant work imposed on the linemen by the above repairs, and the almost daily necessity of clearing the line by cutting the fast growing creepers, had a prejudicial effect on their health, and they all suffered from severe attacks of fever.

The clerking by the trained telegraphists of the 2nd Division Telegraph Battalion and 1st Division Telegraph Battalion and the men of the 1st Telegraph Battalion was very good. The strain was very great, and the sickness in consequence considerable. Very often one clerk out of two in an office being ill with fever, the other was 14 to 16 hours at the instrument. The value of the postal training of the 2nd Division Telegraph Battalion was very evident, and the non-commissioned officers and men mobilised from that division did excellently throughout, in spite of bad accommodation and a very trying climate. The construction was carried on from dawn to sunset

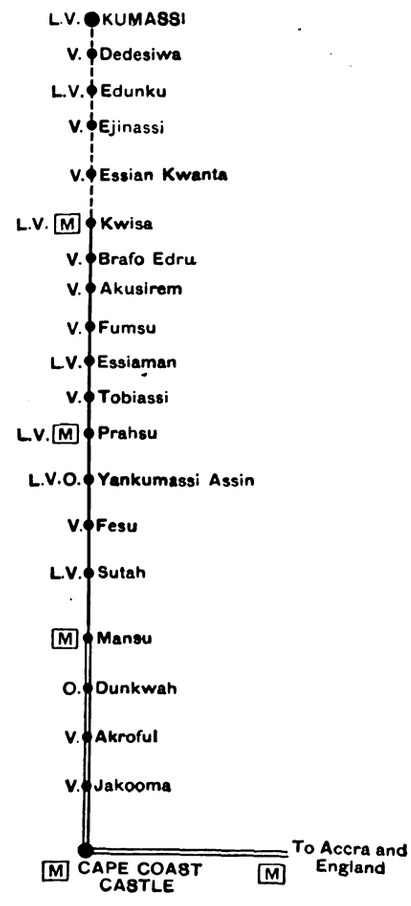


Diagram showing Telegraph Lines, Ashanti Expedition, 1895-6.

often; clerks were often at their instruments throughout the day and well into the night; linemen were out as long as they could see. In addition to the above the men had to do manual labour in a climate where manual labour is considered fatal to Europeans; and there was also the constant supervision and payment of large gangs of carriers and working parties. All these points will account for the amount of fever, but fortunately during the time the detachment was on the Gold Coast no life was lost. Out of the two officers and 32 men about two officers and 24 men have suffered from more or less severe attacks of fever.

The total number of messages of all kinds sent over the line during the expedition was 13,192.

**Electrically Annealing Armour Plates.** — Plant for the electric annealing of armour plates is about to be put down at Cherbourg for the French Government. The plant will be of the Thomson-Houston type.

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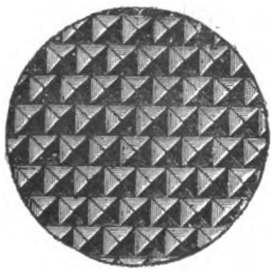

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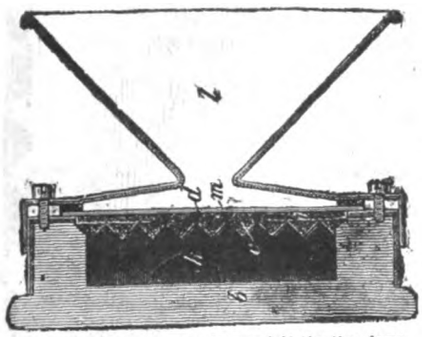

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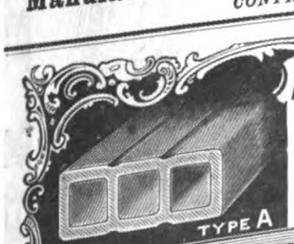


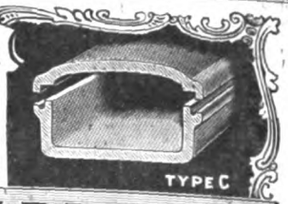


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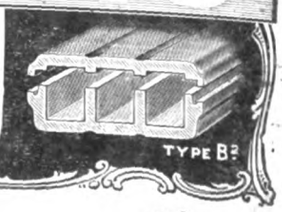





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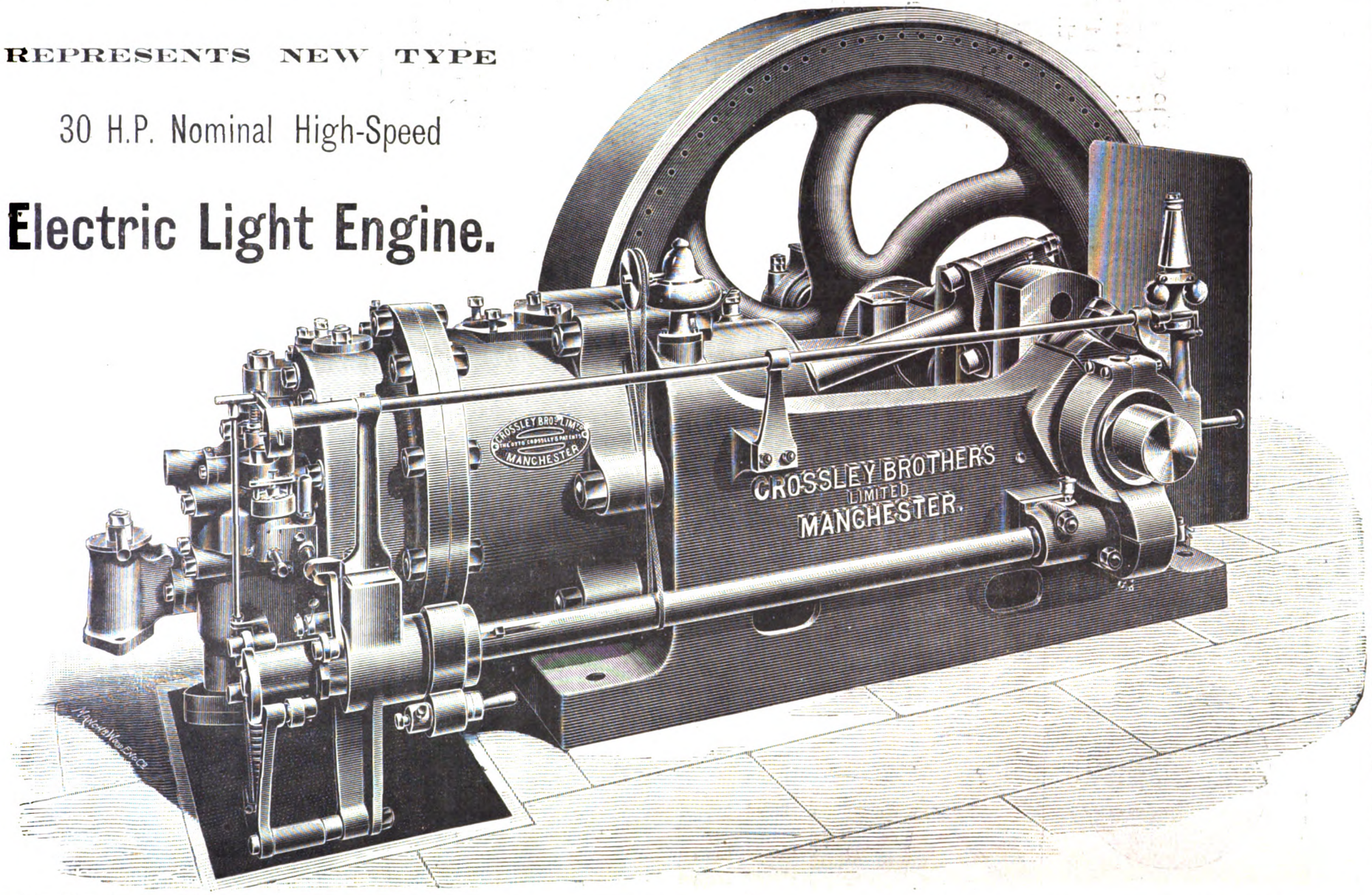


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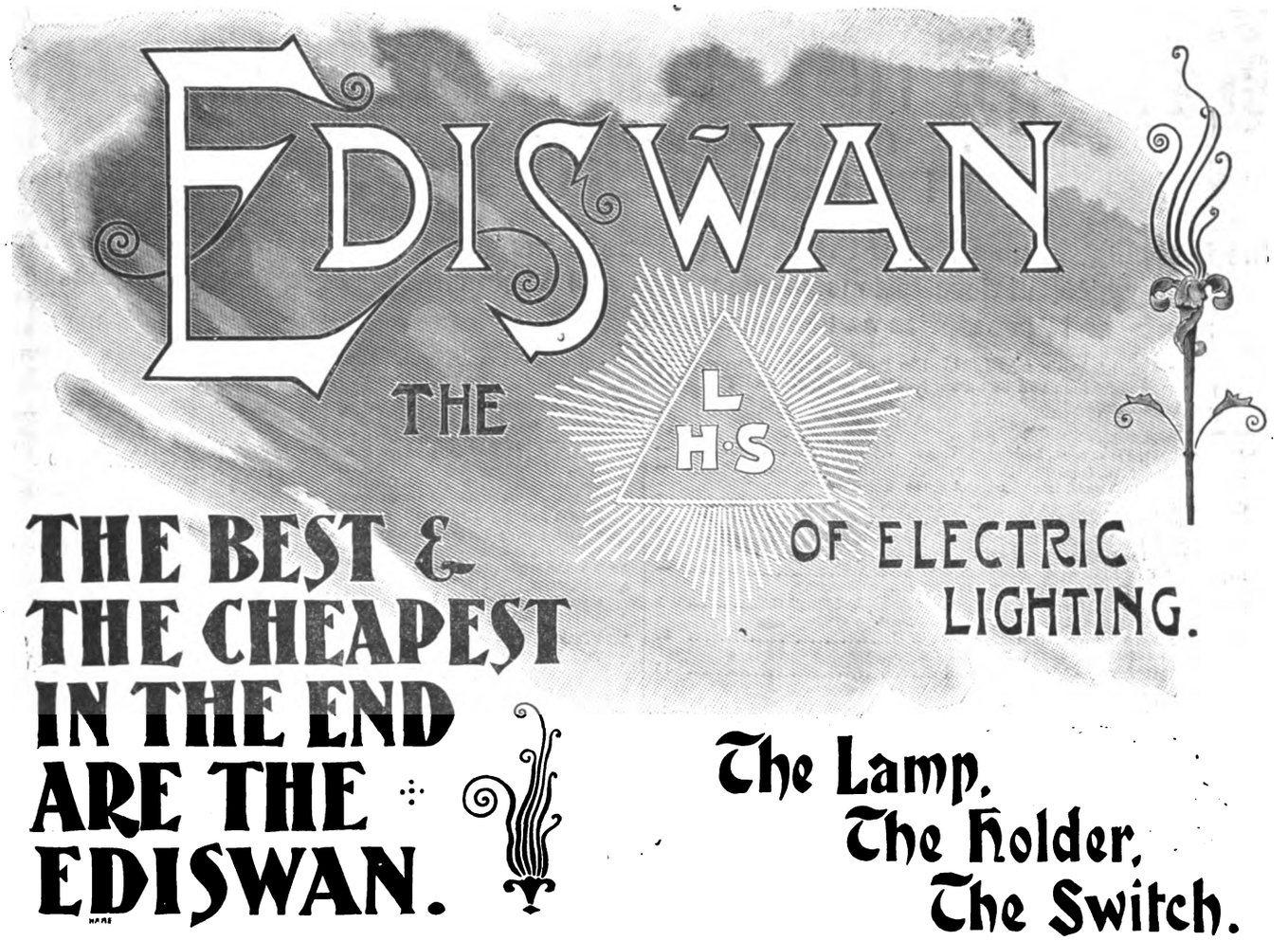


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Turner (J.) and Sons, Denton, near Manchester ..... 11

**ALTERNATORS.**

Brush Electrical Engineering Co., 49, Queen Victoria-st., London, E.C. ..... 33
Crompton & Co., Mansion House-buildings, London, E.C., and Chelmsford. 14, 24
Easton, Anderson & Goolden, 3, Whitehall-place, London, S.W. Works: Erith, Kent ..... 40
Electricitats-Actien-Gesellschaft—Conze and Simon (Sole Agents), 52, Queen Victoria-street, London, E.C. ..... —
Electric Construction Company, Wolverhampton; and Dashwood House, Old Broad-street, London, E.C. ..... 5
Johnson & Phillips, 14, Union-ct., Old Broad-st., London; & Charlton, Kent. 1, 19
Siemens Bros. & Co., 12, Queen Anne's-gate, London, S.W.; & Woolwich, Kent. 7

**AMMETERS.**

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Electric Construction Company, Wolverhampton; and Dashwood House, Old Broad-street, London, E.C. ..... 5
Elliott Brothers, 101, St. Martin's-lane, London, W.C. ..... —
Evershed and Vignoles, Woodfield Works, Harrow-road, London, W. ..... —
Johnson & Phillips, 14, Union-ct., Old Broad-st., London; & Charlton, Kent. 1, 19
Nalder Bros. and Co., 16, Red Lion-street, Clerkenwell, London, E.C. ..... 20

**AMMETERS**—*Continued.* PAGE

Paul, R. W., 44, Hatton Garden; and Saffron Hill, London, E.C. ..... 6
Pitkin, J., 56, Red Lion-street, Clerkenwell, London, E.C. ..... 22
Richard, Jules, Paris ..... 32
Salmony (H. M.) & Co., 61, Charing Cross-rd., London, W.C. ..... —
Siemens Bros & Co., 12, Queen Anne's-gate, London, S.W.; & Woolwich, Kent 7

**ANTI-FOULING COMPOSITIONS.**

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Kirkaldy, (J.) and Sons, East London Works, Garford-street, London, E. .. 35

**ARC LAMPS.** (See LAMPS)

**ASBESTOS.**

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Willcox (W. H.) and Co., 34 and 36, Southwark-street, London ..... 3

**AUCTIONEERS AND VALUERS (Mechanical).**

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**BATTERIES.**

Aylmer, R. 47, Victoria-street, London, S.W. ..... —
Chloride Electrical Storage Syndicate, 39, Victoria-street, London, S.W. ..... 6
Cologne Accumulator Works, Kalk, near Cologne ..... —
"D.P." Battery Co., 66, Victoria-st., London, S.W.; and Old Charlton, Kent .. —
Electrical Power Stor. Co., 4, Great Winchester-st., Lond., E.C.; & Millwall, E 40
Epstein Electric Accumulator Co., Victoria Mansions, 28, Victoria-street, Westminster, London, S.W. ..... 2
General Electric Co., 69 & 71, Queen Victoria-st., London, E.C.; and Salford 25
"I.E.S." Accumulator Co., 3, Delahay-street, Westminster, London, S.W. .. 10
International Electric Company, 55, Redcross-street, London, E.C. ..... 8
Johnson and Phillips, 14, Union-ct., Old Broad-st., London; & Charlton, Kent. 1, 19
Salmony (H. M.) & Co., 61, Charing Cross-rd., London, W.C. ..... —
Siemens Bros. & Co., 12, Queen Anne's-gate, London, S.W., & Woolwich, Kent. 7
Universal Electrical Fittings Co., Suffolk-road, Sheffield ..... 13

**BATTERY JARS.**

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**BEARINGS.**

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**BELTING.**

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Eastern Extension Tel. Co., Winchester House, 50, Old Broad-st., London, E.C. 34
Eastern & S. African Tel. Co., Winchester House, 50, Old Broad-st., London, E.C. 36
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the deductions allowed in arriving at the amount of profits actually rated, and in one case even the indicated horse-power of the engines is alleged to be the criterion for the rate. Whether or not there is in fact such a great diversity of practice we cannot say; but if so there does not appear to be any necessity for it, and the matter will no doubt be set right whenever a rate becomes sufficiently aggressive to provoke an appeal.

The principles involved are well known and have been applied for many years to railways, gas and water works, and tramways, and even more recently to telephones. It is true that the application of these principles to different cases in different localities has often proved a troublesome matter, and more particularly is this so in the case most common with railways, where parts of the undertaking are rated in several different parishes. The position of electric lighting undertakings seems to present hardly any novel features, and it is certainly not more difficult than that of many other enterprises which have been commonly dealt with hitherto. A municipality carrying on a manufacturing concern, and being debarred either wholly or partially from making profits, will sometimes entail a different method of arriving at the annual value of their rateable property, from that by which the same result is obtained in the case of a purely commercial undertaking; but plenty of precedents can readily be found with reference to municipal gas, water and sewage works. No doubt in practice assessments are frequently made by guess-work; and the skilfulness of the guess will be tested, in the event of an appeal, by finding out how far it accords with an assessment strictly ascertained in accordance with the principles to be presently stated.

The rating basis is in all cases the annual value of the rateable property to a hypothetical tenant. If the nature of the property is such that the actual owner is the only possible tenant, then you must take what it would be worth while for that owner to pay as rent for it, or rather what he would have to give in order to obtain an exactly similar property if his own were not available. Profits derived, not from the whole undertaking, but from the rateable part of it, are *primâ facie* the proper criterion from which to ascertain the annual value; but if, in any particular case, profits are not a true criterion, some other method must be used, since it by no means follows that because there are no profits the annual value is *nil*. You must, in such cases, estimate what rent the hypothetical tenant might be expected to pay by taking the interest on the capital expenditure required to obtain a similar property. For this purpose the capital actually expended upon the rateable part of the undertaking may, subject to certain allowances, be a fair guide for arriving at a correct result.

The rateable part of the undertaking consists of the land, with all the fixed machinery and plant upon it; it does not include chattels which are moved about in using, such as the rolling stock of a railway. On the other hand, there is an intermediate class of utensils which, though not so permanently fixed as to render them legally inseparable from the freehold, can yet only be used when fixed. Items of this nature form a borderland, and sometimes give rise to difficult questions whether they are to be included in the rateable value or not. Gas meters, however, have been held not to be included, and presumably the same rule applies to electricity meters.

The normal method of ascertaining the rateable value of electric lighting works should be, roughly speaking, as follows: Take the gross receipts for the year and make the following deductions therefrom, namely, working and management expenses, including in the latter item Directors' fees, salaries, rates, audit, legal and general establishment charges. The balance so arrived at will be the profits of the whole undertaking. Next deduct the proportion of this profit which can be treated as due to what may be called "tenant's capital," that is to say, capital expended in meters and anything else which would not belong to a hypothetical landlord assumed to be owner of all the rateable part of the undertaking. The difference will give the gross annual value of the rateable property. Finally, from this gross value there should be subtracted the statutable deductions for maintenance and renewals of mains and works, insurance and depreciation. The ultimate balance so arrived at will be the rateable value. Where the works extend into different parishes the question becomes complicated by the fact that each parish is entitled to a proportion of the rateable value, based not on the relative cost of the works in that parish compared with that of the whole undertaking, but on the receipts derived from the parish. The rateable value of the mains would then have to be ascertained separately from stations, and the rateable value of the mains in any parish would depend, amongst other things, upon the proportion which the receipts for that parish bear to the gross receipts. The sum of all these separate assessments must not, however, exceed the total rateable value of the whole undertaking.

It will be seen that the rigid application of these principles in practice must involve in many cases the preparation of accounts of a complicated nature, and afford plenty of room for dispute as to details. The result has been to foster a policy of agreeing quickly with the adversary, by some rough and ready method of compromise; so that although the main principles for ascertaining rateable value have been frequently discussed before the Courts, there are many questions of detail which have never received judicial decision. Probably electric lighting undertakers will be guided by a similar policy; and so long as the item of rates does not figure too largely in their annual accounts, they will continue to pay, and like other people to grumble at the persistently upward tendency of the collector's demands, trusting that they may live long enough to benefit some day by the long-deferred revision of our rating system.

## REVIEWS.

**The Principles of the Transformer.** By Dr. Frederick Bedell. 8vo., cloth. (New York: The Macmillan Company.)

It may be questioned whether the demand for an additional volume, dealing, in a space of some 400 pp. 8vo., largely with the hypothetical transformer of the mathematical variety, is sufficient to justify the existence of this latest addition to transformer literature. In the ten years of its short and active life the transformer has certainly suffered as much from its friends as from its enemies. At its first appearance in this vale of tears mathematical physicists of a certain type fell over head and ears in love with it. Ignorant of its real inner nature, they dressed it up in certain ready-made mathematical garments, and spun a long romance in algebraical language about its doings at home and abroad. Like other dumb animals, not being able to emit anything but an inarticulate hum, it was unable to offer a word of protest against the production of this burlesque. Manufacturers and other experimentalists, however, who had to get a day's living out of it, and were in the habit of standing no nonsense, very soon came to the conclusion that all this mathematical finery really amounted to very little. They took the matter in hand with the brutal frankness of experiment, and, with some trouble in contriving suitable means, discovered the precise manner in which its currents flow in its copper veins, and the mode in which its sturdy little iron body thrills with magnetic tremors. That being done, the next matter was to predetermine what it

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would do, or to so mould it as to make it achieve desired results. Then came the difficulty. If the exact manner in which its core induction varies with any given mode of variation of the magnetising force could be expressed in some neat and simple algebraic formula, the puzzle of its doings would be solved. But no one has yet found the equation to the hysteresis loop of induction in iron in terms of magnetising current; and so it comes to pass that transformer manufacture is a question largely of experience as to what will not succeed, and only partly of applying known principles to produce definite results. A book, therefore, on the Transformer, whether about its principles or its practice, to be of the slightest use in this year of grace, must deal very much with the results of experiment; and the literary *chef* who proposes to cater for the wants of those who are concerned with any other form of transformer than the heroine of mathematical fiction must serve up a limited course of sine-curve mathematics, and bring his results very considerably to the test of actual experiments. That mode of treatment is, however, chiefly conspicuous by its absence in the volume before us. The tone of the preface might lead the uninitiated reader to suppose that this volume opened up the subject for the first time, and that no previous ground had been broken by writers such as Kapp, Fleming, Ewing, Blakesley, and others. The first and second chapters are occupied with a short general description of the mode of using transformers, and with a formidable list of symbols set apart for subsequent use. The third chapter enters upon a discussion of the magnetic circuit. It follows closely on the lines of other well-known English text-books, and in no respect rises beyond being a *resumé* of information culled from them. The reader is not assisted to grasp the meaning of fundamental quantities by any original attempt to bring them down to the level of practice. Magnetic induction is defined as being the total number of lines of force which pass through any space. What should we think of a writer who defined electric current or current density as being the total number of lines of (electric) force passing through any space? Yet it would not be one whit more inadequate as a definition. It would almost seem as if mathematical writers conspired to bewilder the student as to the meaning of this term "induction." Some construct in masses of iron imaginary transverse crevasses, into the depths of which the student is invited to descend, carrying in his hand "a free magnetic north pole," like a policeman's bull's-eye, with which he is to make exploratory observations. Others, through not sufficiently distinguishing between numerical value and physical nature, lead him to believe that magnetic force and magnetic induction are one and the same thing—as cruel a deception as suggesting that there is no difference between electric current and electric force. Why not deal honestly with the ingenuous reader? Tell him that just as an electric current in a conducting circuit produces or may produce electrolysis, and the unit current is defined as one depositing so much silver per second, so magnetic induction in a magnetic circuit produces, when it varies, electromotive force in a conducting circuit linked with it.

The unit of magnetic induction (call it a Weber, or what you please) is one which, when added to or removed uniformly in one second from a magnetic circuit, creates an electromotive force of one volt in a conducting circuit linked once with it. Build up from this the definition of magneto-motive force by the aid of the idea of magnetic reluctance, and the student has at once practical conceptions which lead to methods of measurement. Anything else leads to confusion. Chapter IV. brings us to the simple treatment of harmonic currents and electromotive forces in circuits possessing inductance and resistance, in which chapter the author makes a judicious and careful selection from the material gathered by other writers who have preceded him in this field.

A short section on the theory of the alternator contains a polar diagram of alarming complexity but doubtful utility. In Chap. V. to Chap. XIV. inclusive we are then plunged into a discussion of the mathematical theory of transformers and condensers, with the usual limitations of constant coefficients of induction and simple harmonic variables. As an example of ingenuity in the construction of most complicated polar diagrams and elaborate equations, this section of the book is worthy of the highest praise; but we should very much doubt whether the most persevering engineering student or ambitious young draughtsman who waded through it would rise from it with anything more permanent than a headache as his reward.

A slightly more useful chapter follows on the design and construction of transformers, prefaced by a very sketchy historical account of the development of the induction coil. Ruhmkorff, as usual, is prominently associated with the induction coil, and Page's 1838 coil is figured. Callan, however, to whom we really owe the coil with two separate wires of different sizes, has his name merely mentioned; and other English inventors, Bachhoffner, Hearder and Apps, are passed over in silence. After some generalities on the subject of transformer design, we reach a single numerical example of the design of a 5-kilowatt transformer for power purposes, transforming from 1,000 to 100 volts and for 125 frequency. This transformer is designed to have a core loss of 137 watts. Almost any of our principal manufacturers would undertake to provide a transformer of this size with a core loss of 70 watts. The efficiencies are then calculated; but as no actual tests of the transformer are given to confirm them, the student has no way of discovering the actual result to which these empirical formulæ when used lead. Chapter XVI. deals with transformer curve tracing. With one exception the curves are taken from a Hedgehog transformer. As open-circuit transformers are very little used in practice, it would have been more assistance to the reader to exemplify the behaviour of the closed-circuit transformer.

No actual practical details for obtaining the curves are given. The remaining chapters deal with transformer testing and the consideration of the effects of hysteresis on the form of transformer diagrams. As regards the subject of testing, none of the actual practical refinements and precautions are adequately described, and many of the little details which make all the difference between knowing *about* the subject and knowing how to do it are omitted. The student, for instance, reading this chapter might be led to suppose that the three-voltmeter method would be a good one to use in testing transformers at a sub-station.

On the whole we cannot conclude that the book will prove of much service to those actually engaged in transformer construction or design. It is handled too much from the point of view of the mathematician, and too little from that of the practical electrical engineer, to take a place in the drawing office. The engineering student will not find in the book the elementary information cast in any sufficiently new mould to make the book a distinct advance in the treatment of the subject on other treatises in use, and he will look in vain even for the simple practical information necessary to enable him to design a choking coil to work in series with an alternating arc lamp. The references, with few exceptions, to other literature on the subject are to American publications and sources. The book is well printed, and the typography clear; and although in the particular copy we have before us pages 117 to 132 inclusive are missing, owing, no doubt, to an oversight of the binder, the book is generally well got up. J. A. F.

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**Les Applications de l'Électrolyse à la Métallurgie.** By M. U. Le Verrier, Ingénieur en Chef des Mines. (Paris: Gauthier-Villars et Fils.)

This little work of 55 pages may be useful to those who wish for a short account of the principal industrial applications of electrolysis to the refining of metals, and their recovery from their ores; as it is pleasantly written and well illustrated, though not full enough for the use of the student. The work is rather a collection of notes on the various subjects treated of, and it requires a previous knowledge on the part of the reader, or subsequent study and practical experience, to make these notes commercially useful. But there are many people nowadays who may be glad of a short work of this sort, which gives accurate information and is not overloaded with details which do not concern the general reader. The author confines his attention to those electrolytic processes which have been employed commercially, and which do not involve the electrolysis of a fused salt, and which do not come under the

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head of electroplating or electrotyping. This considerably narrows the sphere of the work; but it is a wise limitation, for the theory of electrolysis is far too complex and controversial to admit of its being satisfactorily treated in a book of this sort, while to have included the various applications of electrolysis which have not got beyond the laboratory stage would only have confused the reader.

As might be expected, copper receives the largest amount of attention; but nickel, zinc, antimony, tin, the alloys of the precious metals and the extraction of gold are also dealt with, and the economic and electrical problems involved in estimating for electrolytic plant are fairly and clearly set forth. The Elmore process, which finds favour in France, is described, as also a very recent method introduced by the "Société de Cuivres de France," by which the metal is deposited on rollers which are so arranged that, when they have received a protecting coating, they bear on one another, and consolidate and burnish the deposit. The circulation and ventilation of the electrolyte are dealt with, and the author notes the great difference which exists between the European and American practice as regards the current density employed; for while in the former the current density ranges from 20 to 40 amperes per square metre, in the latter it often rises to from 80 to 100 amperes. With reference to the acidity of the bath, the author contents himself with stating that the solution usually contains 15 to 20 per cent. of sulphate and 5 to 6 per cent. of free sulphuric acid; and that, though the presence of the latter increases the purity of the deposit, care must be taken to avoid an excess which retards the deposition and increases the amount of energy required to effect it. On this head fuller information is desirable, as by some the waste of energy has been ascribed to the formation of persulphuric acid.

The author's conclusions are that the electrolysis of aqueous solutions cannot be considered a satisfactory method for the extraction of metals from their ores; for, with the exception of the Siemens process for the treatment of gold ores, there is only one method for electrolytic separations, and that is a secret one for the treatment of Canadian copper ores containing nickel. Electrolysis is usually employed for the purification of metals which have been already fairly purified by ordinary chemical means. The refining of copper and of silver poor in gold come under this category; the former is a well-established industry, and the latter bids fair to become so.

## SOME DISTINCTIVE FEATURES OF CONTINENTAL ELECTRICAL ENGINEERING PRACTICE.*

BY KENELM EDGCUMBE AND E. J. FOX.

The object of this Paper is not so much to describe particular installations, but rather to point out in what respects Continental practice in general may be said to differ from that found in this country. An attempt has further been made to give, as far as possible, a few of the advantages and disadvantages met with in the respective systems, and the reasons which seem to have led to the adoption of the one or the other. Since it is probable that in most cases the system which appeared to be the most suitable has been adopted, we have as much as possible resisted the temptation to decide which of the two perfectly distinct methods, the British or the Continental, is the correct one. We say it has been so in *most* cases, as the Continental way of giving contracts, viz., without the intervention of the consulting engineer, has in some cases had the effect of causing that system alone to be employed of which the large contracting firms hold the patent rights.

It would seem that the majority of the most noticeable points of difference may be traced to the fact that Continental engine builders have in the past given their attention almost exclusively to the design of extremely efficient slow-speed condensing engines. Electrical engineers abroad have consequently been forced to design their dynamos to suit these engines. In England, on the contrary, the work of the late Mr. Willans and others has resulted in the production of the numerous high-speed engines which are now to be found at almost every central station in this country. Further, as at an early stage Continental engineers fully appreciated the efficiency and convenience of direct coupling, there was nothing for it but to build slow-speed dynamos, and consequently multipolar machines came into favour. In order to economise floor space, they were further induced to lay down units of considerable size; for, of course, the space occupied by a station of given output is proportionately smaller the larger the units chosen. These considerations further account for the large storage plant to be found in most Continental central stations, for it is only by running large units continuously, charging the battery during light load, and being assisted by it at times of heavy load, that any degree of efficiency can be attained. To this fact may further very probably be traced the decided leaning of Continental engineers towards continuous rather than alternating currents, since storage batteries can only be employed with alternating currents by the use of rotary transformers, which must, at the best of times, be somewhat complicated and inefficient. In this connection it may be mentioned that a large storage plant has recently been installed for the lighting of a theatre at Zürich, the cells being charged by rectified alternating current. By a slow-speed engine in England we usually mean one running at anything below 200 revolutions per minute, whereas high-speeds range from this up to, say, 400 revolutions per minute.

Without entering into the extremely controversial subject of high *versus* slow-speed engines, it may be remarked that a fast-running engine is for a given power smaller and lighter than a slow-running one, and that the greater number of impulses given per unit of time ensures for it a more even turning moment. The initial condensation in a high-speed engine is very considerably diminished owing to the shorter exposure of the cylinder surfaces to successive changes of temperature. By this means an unjacketed engine becomes practically as good as a jacketed one. It is often claimed for slow-speed engines that the wear and tear, and consequently the cost of maintenance, must be less than with high speed. This, however, overlooks the fact that the piston speed is in reality much lower in the latter case, about 525ft. per minute being the maximum in any single-acting electric light engine. The wear of piston rings and cylinders is therefore actually diminished, as also that of valves and glands. As regards governing, by reason of the small amount of steam contained within the cylinder at any one time, the high-speed engine has somewhat the advantage. The variation in speed also during each revolution is smaller in this case.

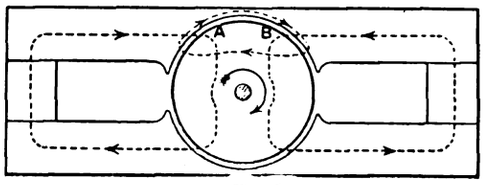


FIG. 1.

Turning now to the question of dynamos, it has been already pointed out that slow speeds were practically a necessity on the Continent. It may, therefore, be worth while to inquire very briefly how it is that the multipolar dynamo enables this to be obtained without increasing the weight or cost of the machine. Now, in order to get sparkless commutation, it is necessary that by the time the brush ceases to short-circuit an armature coil, the current in that coil shall have died out. To obtain this end, first, the self-induction must be reduced by having very few turns per section; second, he coil must be caused to cut a fringe of lines of force of such a direction as to counteract the self-induced E.M.F.—that is, a lead forward or backward, as the case may be, must be given to the brushes. Now, the armature being itself an electro-magnet, will produce a field in the air-gap, as shown in Fig. 1. At B the field in the gap will in the case of a generator be strengthened, whereas at A it will be weakened, and it is just at A that a field is necessary, as has been said, for sparkless commutation. If, therefore, the armature overpowers the field-magnets at this point, sparkless commutation will be impossible. Now, since the resistance encountered by the armature field is almost entirely in the air gap, its magneto-motive force will be proportional to ampere-turns embraced by each pole-piece; that due to the field-magnets will be proportional to the intensity of the lines in the air-gap multiplied by the length of gap. Thus there will always be a minimum length of air-gap, below which it is impossible to go. Now, if this space is required for windings and clearance, as in small machines will be the case, well and good. With large machines, however, it will be found that the necessary air-gap becomes excessive, and the efficiency of the machine is impaired. Suppose we have a generator with a double magnetic circuit, say of the Manchester or Crompton type, having N conductors round the armature, and taking $i$ amperes without sparking, the ampere-turns per pole-piece upon which the sparking depends will be proportional to $\frac{N}{2} \times \frac{i}{2}$, and will also depend, of course, upon how much of the armature is embraced by the pole-pieces.

* Paper read at Students' Meeting of the Institution of Electrical Engineers.

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Now, by cutting through the pole-pieces, as shown in Fig. 2, we shall get a four-pole machine, and with the usual parallel grouping of the armature conductors, it will give half the original volts at the same speed. Let us now re-wind the armature with double the number of turns, which can, of course, be done without increasing the length of air-gap, by slotting the armature. At the given speed the volts will now be what they were in the two-pole machine, and the amperes are $2i$, consequently the output has been doubled; commutation will still be sparkless, for the number of ampere turns per pole-piece is unchanged, for they are now proportional to $\frac{N \times 2}{4} \times \frac{i \times 2}{4} = \frac{N}{2} \times \frac{i}{2}$. Thus the output of the machine has been doubled, and yet the weight is practically the same as before, or, what is usually of more importance, the speed for a given output and weight can be reduced to half its original value. A corresponding saving in material is attained by going over to six, eight, or ten poles, but, of course, the labour would increase somewhat with the number of poles. It is probable, owing to the fact that in England the cost of labour is greater compared with that of raw material than abroad, that multipolar machines have found so little favour here.

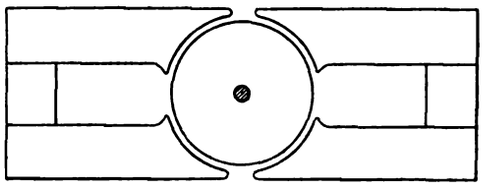

FIG. 2.

Closely connected with the question of multipolar design is that of using cast steel in place of wrought iron for the magnets. On entering the erecting shop of almost any Continental firm, the first thing that strikes one is the almost entire absence of two-pole machines of any sort, and the second (as a result of this) is the almost universal use of cast steel for the magnets. With our English system of building up the cores from separate pieces of wrought iron, each joint having to be accurately machined, it is probable that any saving in material used in a multipolar dynamo will be more than counter-balanced by the extra labour required. With cast steel, however, the cost of the finished magnet is much more nearly proportional to its weight. We are given to understand that the permeability of the cast steel used by one firm comes out from 3 to 5 per cent. higher than that of good wrought iron, and that of forged steel still higher.

Of course, there are several other considerations to be taken into account, as affecting the number of poles selected, such as the increased number of commutator segments, and the additional brushes required; for it is to be noted that the armature employed

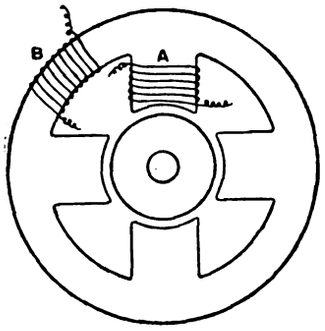


FIG. 3.

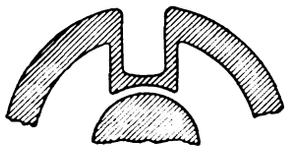

FIG. 4.

on the Continent is almost invariably a simple Gramme ring, with a separate brush to each pole. Again, the length of wire required for the magnet coils increases as the square root of the number of poles, and therefore, for a given loss, the copper required in the magnet coils is directly proportional to the number of poles. As regards the cost of the magnets themselves, we are informed by an English firm that two-pole wrought-iron magnets, when machined up, come to 20 per cent. less per hundredweight than cast steel multipolar magnets, with, say, four or eight radial poles. It would therefore seem that when a fairly high speed is possible, no great saving is to be effected by the use of steel magnets cast in one piece; but it is noticeable that many English firms are now taking to cast or pressed steel in the place of wrought iron.

On the subject of the various forms given to continuous-current generators, little need be said, as everyone is probably already familiar with them. A few points, however, may be of interest. In the majority of cases, both generators and motors have self-oiling bearings, having a loose ring which runs round with the shaft, and carries the oil with it. Excepting in small sizes, drum armatures are very rarely found. Siemens and Halske, indeed, build a large number of two-pole machines, often with drum armatures; but with this exception ring-wound armatures in multipolar fields are almost universal. In very small sizes, drums, often slotted, are much used. The field-magnets are found to take a variety of shapes, but usually some modification of the form shown in Fig. 3. The windings are generally situated at A; but sometimes they are to be found at B, as, for example, in many of Thury's machines. They are, as a rule, cast in one; but in large machines they may be made in two or more pieces and bolted together. Often, no pole pieces are employed, the former being kept in place by set screws, or if the area of the pole so obtained is not large enough, cast-iron pole-pieces may be bolted on. In some cases the pole is hollowed out (Fig. 4), thus economising metal, but taking more copper for the magnetising coils.

One type of machine, perhaps, deserves notice, as possessing several rather peculiar features. That is the so-called "Inner-pol" machine of Messrs. Siemens and Halske. This machine differs from ordinary design in two ways: first, the armature revolves outside the field-magnets, which are stationary, and second, the commutator forms one with it, and together they have the appearance of a huge ring armature, with, however, the insulation turned off the outer rim. This method gives, of course, a very large number of commutator segments, which, although involving considerable labour, reduces sparking to a minimum. Occasionally, however, an ordinary commutator is employed with these machines, especially when a high voltage is required. A further advantage is that the length of the magnetic circuit is reduced to a minimum, and the armature has a very large radiating surface. Some of the machines, even in small sizes, run at extremely slow speeds, a 15-kilowatt generator giving, for instance, 75 volts at 90 revolutions per minute. Consequently, they are much used for direct-coupled exciters, which, with flywheel alternators, have to run, for small machines, at an extremely slow speed.

TABLE I.—*Central Stations in England, Germany, and France.*

| System. | England. | | Germany. | | France. | |
|---|---|---|---|---|---|---|
| | No. | Per cent. | No. | Per cent. | No. | Per cent. |
| Continuous current ..... | 41 | 44 | 120 | 81 | 293 | 79 |
| Single-phase alternator ..... | 50 | 54 | 15 | 10 | 75 | 20 |
| Polyphase ..... | ... | ... | 8 | 5·5 | 4 | 1 |
| Mixed ..... ..... | 2 | 2 | 5 | 3·5 | ... | ... |
| Total ..... | 93 | 100 | 148 | 100 | 372 | 100 |

The following Table gives the economy of copper in transmission by the various systems. Two distinct cases arise—(1) where the maximum P.D. allowable is fixed, and (2) where the effective voltage alone enters into the question:—

TABLE II.

| System. | Weight of copper. | | Cost of cable. |
|---|---|---|---|
| | Case 1. | Case 2. | Case 1. |
| Continuous current..... | 100 | 100·0 | 100 |
| Single-phase, two wires ..... | 200 | 100·0 | 146 |
| Two-phase, four wires..... | 200 | 100·0 | 200 |
| Two-phase, three wires ..... | 291 | 72·8 | 218 |
| Three-phase, three wires ..... | 150 | 75·0 | 150 |
| *Three-phase, four wires ..... | ... | 29·2 | ... |

* In case of three-phase four-wire system the wire from neutral point is supposed to have half-cross sectional area of the other three wires.

Those who have not had an opportunity of inspecting engineering practice in Germany, and elsewhere on the Continent, are often led to believe that the alternating-current work considerably outweighs that carried out on the continuous-current system. This very general belief is probably due to the fact that the names of German and Swiss manufacturers are so intimately connected with the development of the two and three phase systems. The field for distant-power transmissions, often from plentiful sources of water power, is very great, and hence these firms have necessarily given their attention to that class of machinery which appears specially suitable for work of this description. As a matter of fact the alternating stations amount to only 16 per cent. of the total number of stations, and of these about 6 per cent. are polyphase. In France alternating plant makes up 21 per cent., with only 1 per cent. polyphase, while in England we have no less than 54 per cent. single-phase alternating stations, with, of course, no polyphase stations at all. (*See* Table I.) In Germany 50 per cent of all the stations employ storage cells, which are usually placed in sub-stations. These sub-stations are generally fitted with complete booster plant for battery charging purposes, and are situated at

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the centre of distribution. The distributing mains appear, as a rule, to be laid on the three-wire system, whilst only two wires run back from the sub-station to the generators. In many cases the plant runs for only a part of the 24 hours, the engines being shut down, and the battery left to the remaining work.

With regard to the best frequency to be adopted in alternating-current schemes, England seems to hold an intermediate position between American and Continental practice. In the former country frequencies up to 140 alternations per second are to be found, whereas on the Continent 40 to 70 seem to be the rule. The choice must depend on the purpose for which the supply is required. We will briefly consider the effect of the frequency—first, on the line; second, transformers; third, generators and motors.

With regard to the line, little need be said; the frequency makes itself felt—first, by the skin effect; second, by self-induction; third, by capacity. The increase of resistance due to the skin effect is proportional to the square of the frequency, and while in small conductors it may be negligible, it varies as the fourth power of the diameter; and therefore in large secondary cables it may amount to a considerable loss. The self-induction and capacity of the circuit oppose each other, the former being of most importance in overhead, and the latter in underground lines; they should, therefore, as far as possible, be made to neutralise each other, and the frequency be chosen accordingly. In overhead lines this will most probably be impossible, but in underground concentric cables the capacity will probably amount to as much as $\frac{1}{3}$ microfarad per mile.

The effect on the transformer is more important. Now the cross section of the transformer core must be such that with an open secondary the back E.M.F. in the primary, due to self induction, shall, as nearly as possible, equal the impressed E.M.F., *i.e.*, S is proportional to $\frac{V}{N \times B \times n}$, where S is the cross-sectional area of core V, the impressed E.M.F. $n$ the frequency, B the induction, and N the number of turns of primary winding. According to Steinmetz, the loss of power by hysteresis per unit volume is proportional to the 1·6th power of the value of magnetic induction B. Therefore, for a given loss, the product $n \times B$ increases with the frequency; hence the necessary cross-sectional area of the transformer decreases with an increase of periodicity, $S \propto \frac{1}{n}$, or, with a given area, the efficiency increases. A limit is, however, soon reached on account of the reduced radiating surface in large sizes, since the volume, and therefore the heat generated, is proportional to the cube of the linear dimensions, whereas the radiating surface is only proportional to the square of the dimensions.

Turning now to the effect of frequency on alternators, whether generators or motors: suppose we take an ordinary alternator, consisting of a double crown of poles with an armature revolving between them. Say the frequency is 100 at a given speed. Call this machine A. If now we imagine that pairs of adjacent poles are merged into one, so as to give half the number of poles, each of double the area, the same being done with the armature coils, the machine will have a frequency of 50 at the same speed. Call this machine B. Since the total polar area is unchanged, the total flux will be the same as before; and therefore to get the same volts, the turns of wire on the armature need not be increased, but, of course, the turns per section in B are double that of A. Since the number of spaces between adjacent poles has been halved, the diameter of B will be less than that of A. Further, the length of wire required for both armature and field will be reduced in the ratio 2 : $\sqrt{2}$, and therefore for a given loss in both the weight of copper in B will be half that in A, while the weight of the machine will remain practically unchanged. Now, since the self-induction per coil $\propto N^2, \times i, \times S$, where S is the sectional area, that of the whole armature B will be double that of A. Now, the number of alternations of each armature coil are in B twice as great as in A, whereas the alternations per field coil are unchanged. From this it follows that for a given lag of current, the armature reaction would in machine B be double that in A; but since the self-induction is greater the reaction, and therefore the drop in volts as the load increases, will be more than double that in machine A. This drop will be especially noticeable on a motor load. The armature reaction has to be reduced, either by decreasing the number of conductors on it, which means increasing the field strength (and with it the weight), or by increasing the magnetic reluctance from pole to pole (and, therefore, the exciting current). The machine having the larger number of poles will therefore probably be lighter than the other, but more expensive, on account of the extra labour entailed in machining, &c. In the case of asynchronous motors (single phase or polyphase) self-induction is necessary for efficient running at light load; in fact, it is found that the current taken at light load is very nearly proportional to the number of poles, and so also is the starting current, and consequently in this case the frequency should be kept as low as possible.

We thus see that the periodicity to be adopted depends entirely on the character of the load, with small house-to-house transformers, and little or no secondary circuits; high frequencies should be employed (say, up to 120 alternations), for which reason they are common in the United States. With large transformers grouped in parallel, such as are usually met with in England, a somewhat lower frequency may be employed with advantage (say, up to 90 alternations); whereas, if a motor load is expected, as apparently is the case on the Continent, a considerably lower periodicity is advisable (not exceeding 60 alternations per second, say).

In considering the relative economy of transmission by the various alternating systems, two perfectly different cases arise. 1st. When the maximum voltage allowable is fixed, say from considerations of economy, safety, &c., as will usually be the case in primary circuits, and in all long-distance transmissions. 2nd. Where the effective voltage is alone of importance, as will be the case in the secondary circuit. Now the power transmitted by an alternating curent is proportional to the effective voltage, whereas the pressure tending to break down the insulation is the maximum potential difference. In a continuous-current system the maximum volts and effective volts are one and the same. With an alternating current, however, the maximum volts are $\sqrt{2}$ times the effective volts (assuming the curve E.M.F. to be a true-sine curve), thus if the effective volts are 100, the maximum volts will be 140. The same reasoning, of course, holds good for the current; and, therefore, the copper in the mains is less usefully employed in an alternating than in a continuous-current system. Taking first the single-phase alternating. If the maximum volts in the line are

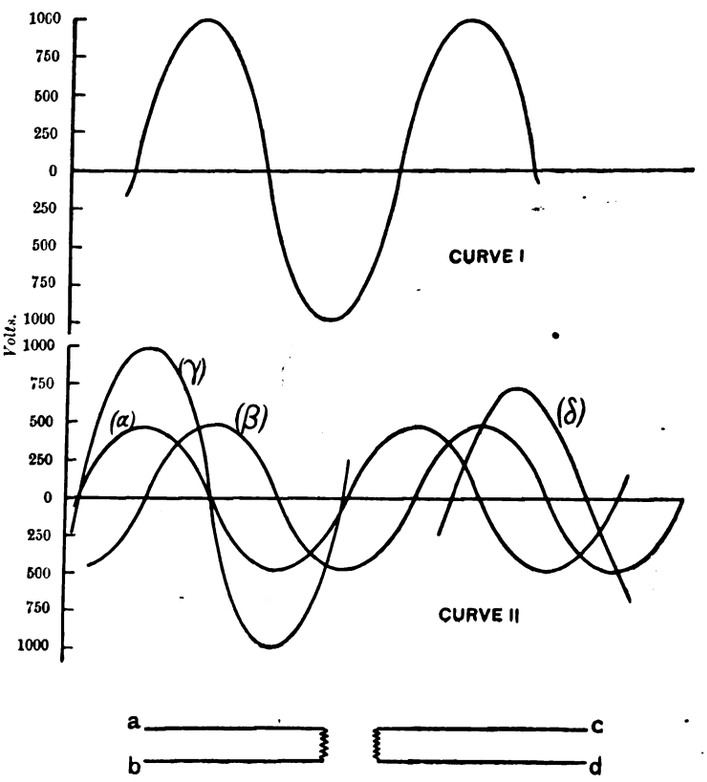


FIG. 5.—*Curve I.: One Phase, two Wires*, showing P.D. between the two Mains. *Curve II.: Two Phase, four Wires.* ($\alpha$) and ($\beta$) gives potential above earth of points $a$ and $c$ respectively. ($\gamma$) gives P.D. between $a$ and $b$, and ($\delta$) the P.D. between $a$ and $c$.

represented by one, the effective volts, as we have said, will be only $\frac{1}{\sqrt{2}}$. A continuous current transmission could be employed, working at, say, 1,000 volts; whereas the effective volts of the alternating system, having the same maximum pressure, would be only 700, and consequently the copper required would be twice as great (since for a given efficiency of transmission the weight of copper varies inversely as the square of the volts). If the effective pressure alone is fixed, the two systems are equally efficient as regards weight of copper.

Coming next to the E.M.F. curve of a two-phase system (curve II., Fig. 5), it will be seen that not only is there the potential difference between the two ends of the same main to be considered, but also that between the two separate mains—the former, however, being the greater—the copper required will be the same as in the case of the single-phase. As to the result of combining two of the mains into a common return (curve III., Fig. 6), it must be observed that the current in the latter is only $\sqrt{2}$ times that in each of the other two mains it replaces. Hence it would seem that there should be a saving of 25 per cent. of copper for the same line

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loss. Further consideration, however, will show that this only applies to the case in which the effective pressure is alone fixed, for it will be seen that the maximum potential is raised to 1,400 volts. It can therefore be shown that if the maximum potential is fixed at 1,000 volts, the effective pressure would be so far lowered that, instead of saving copper, the weight of the line would actually be raised to 291, as compared with 100 for the continuous-current system.

In the case of a three-phase system with six wires (curve IV. Fig. 7), it will be seen, first, that the sum of the energies in three of the wires at any instant is equal to zero, and that, therefore, if the further ends are simply joined up into a so-called neutral point, no common return is needed, as it would have to carry no current: this is known as the star coupling. Secondly, that the two waves differing by 120deg. may be replaced by a third, differing from each by 60deg.; hence the six mains may be replaced by three, each of the same size as before: this is known as the mesh coupling. The maximum potential in each case is 1,730 volts, and the effective volts are 700, as before. It can be shown that if the maximum potential has to be reduced to 1,000, the copper required will be 150, as compared with the 100 required with the continuous system. Where the effective voltage alone is fixed, the weight of copper comes out to 75 only.

The above considerations simply give the relative weight of copper required for the line in the various systems; but except in overhead transmission, the cost of a high-tension line is by no means proportional to the weight of copper used.

The approximate results obtained by taking the cost of insulation into account are given in Table II., high-tension single-armoured cable designed for working at 3,000 volts being assumed. Further, in an actual transmission, the line loss would not be kept constant in all the systems, but decreased in that employing the least copper, according to Kelvin's law. The table will, however, serve to roughly indicate the relative economy of the various systems. It will be seen that the three-phase is considerably the most efficient in both the primary and secondary circuits, and it may be remarked that it is much more largely used on the Continent than the two-phase. The continuous current is merely entered for the sake of comparison, and not as being necessarily a possible substitute for the alternate current.

Alternate-current motors may be divided into single phase or polyphase, of the synchronous or non-synchronous type. The disadvantage of the single phase is, of course, that it will not start by itself, and the synchronous type (in common with all other synchronous motors) requires a continuous current to excite the field-magnets. Self-starting single-phase motors are used to some extent in small sizes, but are, as a rule, found to be inefficient, and the starting gear somewhat complicated. In large sizes the question of self-starting is often of less importance. As an example of a transmission by single-phase synchronous motors, the lighting of Cassel may be cited. The installation consists of a generating station, situated at a distance of about four miles from the town, and comprises two Oerlikon alternators, each of 100 H.P., driven by water power. The average fall is about 4ft. 6in., but at times of very low water the turbines are supplemented by steam power. Current is transmitted at 2,500 volts to two sub-stations in Cassel, where it is converted by rotary transformers, each consisting of two continuous-current generators, direct coupled to an alternator, which acts as a motor. Current is distributed to a three-wire network at 110 volts. When it is wished to start up (the plant not being run during the day), the order is given from the sub-station by telephone. One of the continuous-current generators is then run round as a motor by the secondary cells with which the station is provided. So soon as the alternate-current motor has got up its correct E.M.F., a synchronising lamp is switched in (a double knife-edge switch, allowing either voltmeter or lamp to be inserted as required). When synchronism is reached, the motor is switched in, and a load gradually put on the continuous-current generators. The whole operation is extremely simple, occupying say half a minute. It would probably have been even more so had the high and low-tension boards been somewhat nearer together. As it is, two men are required, one for each switchboard. At the generating station, the turbine and dynamo rooms are connected by a ship's telegraph apparatus, so that the turbines can practically be regulated from the switch gallery. Nearly all transmissions of power are now, however, carried out by the so-called "drehstrom" motors, chiefly of the three-phase, non-synchronous type. Polyphase generators are made in a variety of forms, and need not be described here. One type, however, designed by von Dolivo-Dobrowolski, may perhaps be mentioned, as it is somewhat peculiar in having no sliding contacts whatever. The magnet consists of a ring of U section, slotted out to form poles, and the single exciting coil, fixed inside the armature, is stationary. In large sizes the copper required for both field and armature coils in machines of this type amounts to only 5lb. per horse-power.

Turning next to motors, we find that in small sizes the motors employed are usually of the induction type, with short-circuited armature. In large sizes, however, in order to avoid the great rush of current at starting, the motors are either allowed to get up speed on a loose pulley, or a starting resistance is employed. This resistance is usually inserted in the armature circuit, since for a given current a greater torque is thus obtained than if it be placed in the main circuit. As the armature usually rotates, contact rings must be provided. The current is often led through a water resistance, which in the case of a three-wire star coupling, which is generally used, consists of three cells having three of the plates (one from each cell) connected together so as to form the neutral point. For driving hoists, or wherever large starting torque is required, no

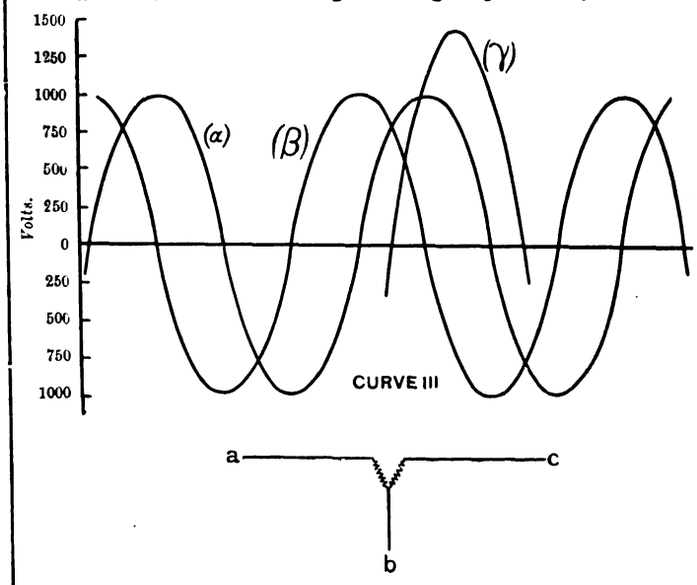


FIG. 6.—*Curve III.: Two Phase, three Wires.* (α) and (β) correspond to (γ) Curve II. and give P.D. before joining up into a common return. (γ) gives P.D. between *a* and *b* or *c* and *b*.

starting resistance is employed, and a slip of as much as 12 per cent. is allowed, thus lowering the plant efficiency, but giving a torque at starting of two or three times the normal. It would appear that the efficiency of three-phase plant is nearly, if not quite, as high as that obtained in Germany with continuous-current machines, three-phase motors having an efficiency of as much as 94 per cent. It is found in practice that polyphase motors will give about 30 per

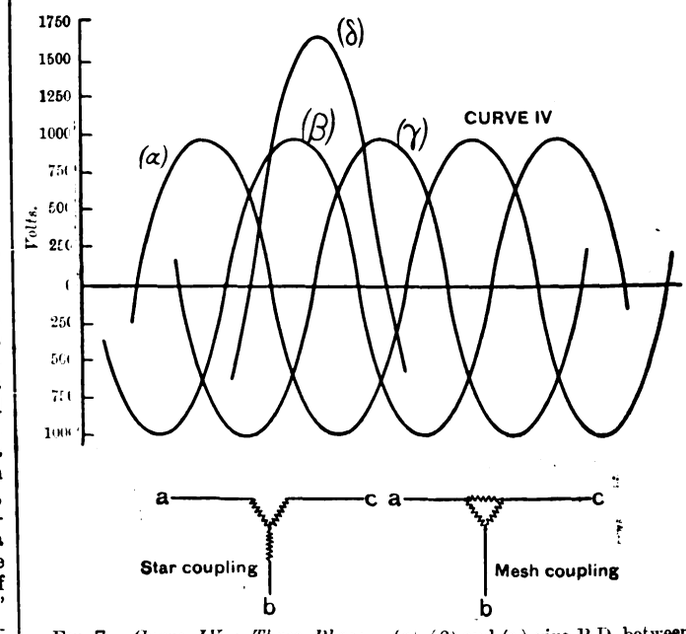


FIG. 7.—*Curve IV.: Three Phase.* (α), (β) and (γ) give P.D. between Terminals of each of the Three Pairs of Mains (with Six separate Wires). (δ) gives P.D. between *a* and *b* or *c* and *b* (either Star or Mesh Coupling).

cent. greater output with 7 or 8 per cent. better efficiency than single-phase machines of the same price and weight. Polyphase transformers, however, cost, as a rule, considerably more than single-phase. It may be remarked that it is the almost universal practice now in both generators and motors to embed the conductors in slots or holes drilled round the periphery of the armature and field. This has three advantages: (1st) reduction of air-gap;

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(2nd) mechanical strength; (3rd) reduction of eddy currents in the conductors, thus obviating the necessity for stranding them.

As an example of a three-phase installation, we may take that employed at the Dresden Railway Station. The area to be lighted by arcs and incandescent lamps extends for a distance of five miles on either side of the generating station. The plant consists of three flywheel alternators each of 300 H.P., designed by Messrs. Siemens and Halske, of Berlin. The current is generated at 115 volts, and transformed up to 3,000 volts. It appears to be the usual practice on the Continent to generate at a low voltage, say, 80 to 120, and then to transform up before transmission, as, though additional transformers are required, the generators are cheaper and less liable to breakdowns. There being a large number of motors on the circuits, many of them working hoists and lifts, and therefore taking a large starting current, a special device was necessary to prevent the lighting circuit being interfered with. This device consists of running two generators in parallel, but coupling up one of them to two mains only, all the lamps being joined across the terminals of these two mains (Fig. 8). This device, due to Mr. Ulbricht, appears to be entirely successful, and it must be admitted that the lamps, both arc and incandescent, burn remarkably steadily, even under these most trying conditions.

At the works of the Maschinen Fabrik Oerlikon at Zurich the tools in the various shops are all driven by three-phase motors of the non-synchronous type, no starting resistances being employed. Where it is necessary to run lamps and motors on the same circuit, a fourth wire is run from the neutral point of the generator to the lamps, which are connected between this wire and one of the other three mains.

At the works of Messrs. Siemens and Halske, at Charlottenburg, continuous-current motors are exclusively employed. The Allgemeine Elektricitäts Gesellschaft, of Berlin, also employ continuous-current motors in their shops, supplemented, however, by a few three-phase motors, chiefly, probably, as an experiment.

With regard to the various systems of charging for current, it may be remarked that for power required for purposes such as running motors, heating, or cooking, considerable reductions in price are made. In England this reduction is also frequently made; but experience of this system in central stations seems to have

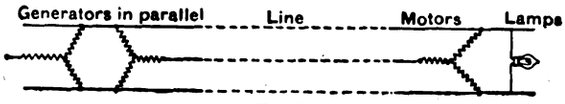


FIG. 8.

shown that it is extremely inconvenient to have to charge two different prices, involving, as it does, two separate meters, special leads, &c., and the impossibility of taking current for heating, say off any ordinary wall socket. In Paris motors are in considerable use for driving elevators, &c., as the price charged in that town for hydraulic power appears to be rather high. The motors installed amount to about 330 kilowatts, or two per cent. of the power required for the total number of lamps wired. The average size of motor is about 3 H.P. In Berlin the motors installed amount to nearly 1,500 H.P., or 12 per cent. of the total output. The price charged there for motor current, which in 1891 was 3d. per unit, was subsequently reduced to 2½d., and in the new station in course of erection we are informed by Mr. Addenbrooke that it is to be only 1·1d. per kilowatt hour. This price, which is probably as low a figure as has ever been reached, applies, of course, only to motors taking current for a large number of hours at a time. In one case in England, where power is used on a large scale, the works' cost, including depreciation, comes out to our own knowledge to a third of a penny per kilowatt hour, but the experiment of selling current at little over one penny per unit is one which will be watched with interest.

Mr. Addenbrooke informs us that for all-day and night load, there is no doubt but that energy can be generated for electrolytic work, including all costs and depreciation, at something like 0·25d. per unit, while for an all-day load for charging batteries, even at a considerable difference, say a mile or two, energy could be furnished under 3s. 4d., depending upon the load.

In a large number of cases the central-station voltage is regulated by automatic means, and various other devices of a self-acting nature are to be found. A few examples may perhaps be of interest. In continuous-current stations, fitted with storage plant, the regulating cells are often switched in and out, automatically, by means of a constant pressure relay. In one device, employed by Messrs. Schuckert, a small motor is kept continually running. The relay causes it to gear in one direction or the other into a wheel connected with the switch lever of the cells. These are, therefore, automatically switched in or out, as may be required to keep the station voltage constant. In other cases a small motor, permanently geared to the switch lever, is caused to revolve in the required direction by a relay, actuating a reversing switch. In alternating stations, where secondary cells are not available, the field-magnet exciters are often automatically regulated by a relay in parallel with the main circuit. In this case, of course, either of the above principles could be employed to switch resistance coils in and out. Another method is to cause the relay to raise or lower a number of contacts into a bath of mercury, by which means the coils to which they are connected are short-circuited one after the other.

At Berlin there are two systems employed, by which not only is the existence of a fault made known, but also the exact feeder on which it occurs. In one of them a pilot wire is led from the mid-point of the three-wire system at the station, round a relay to the junction-box of each feeder. Should the main become earthed, a current will flow through the relay. This rings the bell, and allows a small indicator to fall, disclosing the number of the feeder to which the pilot wire was attached. This method is due to Herr Agthe, and is said to work extremely well. Another method, due to Dr. Kallman, is also in use. He employs a single pilot wire for each feeder, earthed at as many points as possible, and passing through a relay to earth at the station. Should a considerable leak occur, a current will flow round the relay and set the bell ringing. A similar method can be employed to detect the presence of water in the junction boxes. The end of a pilot wire is bared and placed a short distance above the bottom of the box, from which it is insulated. The other end is connected to the plus or minus pole of the generator, and should sufficient water be present to earth the bared wire, a current will pass through the relay.

An ingenious method of regulating the speed of the engines is employed at Dresden. A small motor on the engine serves to move a counterweight on the governor, in or out as may be required. It is thus possible to control the speed of each engine from the switch gallery, a most important consideration where alternators are regularly run in parallel. At this station also between each main and the earth, is connected a Kelvin electrostatic voltmeter, by means of which it is possible at a glance to determine the insulation resistance of the whole system.

In conclusion, we would urge the immense importance of a close acquaintance with the methods in use in other countries, as if it is true that experience must be bought, it is equally true that it can often be bought at other people's expense.

## LOCAL DEVELOPMENTS OF AN AMERICAN CENTRAL STATION.*

BY W. S. BARSTOW.

The time has been rapidly approaching when the public, realising the enormous value of electricity as a commodity, is no longer willing that the few should enjoy its benefits, but demands that it be placed within the reach of the many on the same basis as the necessities of life. Unwilling to wait for the fulfilment of the prophecies of the manufacturer as to a reduction in price, the public turns to its legal advisers, thinking itself entitled to some reward for the franchise which it has granted. With the beginning of legislation begin the worries of the manufacturers; for in many cases legislation, fraught as it is with politics, kills industries in its endeavour to sustain its own popularity. The time has already passed when new and improved machinery alone will accomplish a reduction in the cost, and it remains to the central-station manager to study and plan many economies which can be brought about only through peculiar conditions of localities. As a doctor diagnoses a case before prescribing a remedy, so the central-station man must study the effects of locality upon the cost of production. As the cost per unit of the product manufactured depends upon the quantity of gross business, as well as upon the generating economies in the cost of a single unit, it is necessary to take every advantage, not only of improved methods of operation, but also of new devices for utilising the product. Every company supplying current has its own peculiar conditions and surroundings, so that great care must be taken that what proves beneficial to one will not result in disaster to the other.

Among the many Eastern American cities there are perhaps few places where the effects of surroundings are so strongly felt as in Brooklyn, N.Y., where the scattered centres of population, caused by the enrolling into one city of numerous small adjacent towns which have not yet had sufficient time to amalgamate in their business interests, offer problems of distribution uncommon to many localities.

The Edison Electric Illuminating Company, of Brooklyn, started in 1889 with a well-constructed modern station and six thousand 16 C.P. lamps connected. With its only plant located in the heart of the city proper its progress was natural and success was rapidly attained, but after the cream of the business had been secured it still became necessary, as a matter of future business interest, as

* From *Cassier's Magazine.*

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well as of public policy, to extend its operations into less profitable districts. This called for increased investment, which would not at once pay its interest charge, and in order that the new business might not prove a burden on its receipts it became necessary to force the business along the lines already laid by providing additional uses for its manufactured product.

Thus it was that six months after the starting of the first district station the Company began the development of the low-tension arc lamp. In the fall of 1890, although all low-tension arc lamps up to this time had been a commercial failure in the United States, and one of the greatest high-tension lamp experts had stated that they would never be a success, the Edison Company, of Brooklyn, prevailed upon the Universal Arc Lamp Company and the Electric Construction and Supply Company to furnish 50 sample lamps, promising that, should either be able to develop a successful lamp, an order for 500 would be forthcoming. The failure of the Universal arc lamp and the success of the Ward lamp are well known, and the popularity of the low-tension meter arc lamp can be best seen by the following list of connections of 1,200 C.P. low-tension lamps to the system of the Brooklyn Edison Company: first year 590; second year 908; third year 1,778; fourth year 2,600; fifth year 3,800.

Having launched its low-tension arc lamp project, the Company began to look to an extension of business into new territory. The fact that the gross receipts of the Company during the first three months of operation hardly equalled its operating expenses, somewhat dampened the enthusiasm of the stockholders as regards the building of additional stations. With a view therefore of "pioneering," underground tie line systems were devised, and two feeders, each 10,000ft. in length, were laid to new distributing centres. At the terminals of these were placed central-station switchboards, from which extended the Edison underground system of feeders and mains. The value of this method of entering a new district and supplying it with current from the parent station until it had developed sufficiently to support a separate station can be seen by the following result, compiled at the end of the first year's operation. The cost of current per unit supplied to the new district was, during the first year, only 30 per cent. of what it would have been had the same current been supplied by a separate station, necessarily operating at low efficiency. In other words, the cost of current generated at the parent station plus the loss in transmission and interest and depreciation on line, was 30 per cent. of what the current would have cost at a 24-hour separate station at the distributing end of the tie line. The difference in cost showed a profit from the very start of the new district. This system was successful in enabling the Company to start in new territories without loss to its net receipts. These districts have since that time increased in size, so as to financially warrant their being supplied from separate stations. In this way the commercial business of the Company has been rapidly developed throughout the city of Brooklyn.

Up to 1892 attention had been paid only to the commercial side of the business, for all city lighting was being undertaken by a high-tension arc company. When, however, the latter announced his intention of entering the commercial field it was most natural that the Edison Company should decide to try its fortune in city lighting. With no completely-developed practical system of low-tension lighting suited to the conditions of the high-tension specifications, it nevertheless, in 1893, tendered a bid for all the street lights along the lines of its underground Edison mains. Everything was done to prevent the Company from securing the contract; but low price and business-like methods prevailed, and the contract was awarded, all lamps to be erected and burning in 60 days. In this time were developed, designed and put into actual commercial operation 600 low-tension street lights. With a view of holding the contract in years to come, every economy was carefully studied, and although several details in construction have been modified, yet the original system, as developed in 1892, is in operation to-day.

One of the first problems to suggest itself was the turning on and off of lamps which were in connection with continuous supplied mains. The very large expense incurred by providing attendants for this purpose can be seen at once. The lamps averaged 500ft. apart, and as a twenty-minute interval was allowed between the lighting or extinguishing of the first and last lamps it was impossible for one attendant, walking 1½ miles in that time, to control more than 15 lamps. This meant the employment of 40 men to simply attend to the controlling of the lamps. This would mean an expense, at $4 per man, of $160 per week, or $8,320 per year, for the lighting and extinguishing. In order to reduce as much as possible this great expense a clock switch was hastily devised for the purpose, at a total first cost of $3,600, and a total maintenance and repair cost of $2,800 annually; and this switch is still in successful operation, completely controlling at present more than 800 street lamps at a saving of about $5,000 annually.

The successful installation of a low-tension street-lighting system, and its ornamental character and good service, soon gave the Edison Company the opportunity of purchasing the entire stock of its competitor in street lighting, the Citizens' Company, with its valuable overhead franchise. After all final arrangements of ownership were completed and the efficiency of the new high-tension system was increased by remodelling the Citizens' stations, it was decided to extend the usefulness of the overhead franchise by the installation of an alternating-current system which should "pioneer" in those districts beyond the reach of the present Edison underground mains and tie line systems, and thus prepare the way for additional low-tension stations.

Appreciating the great advance that was being made in alternating distribution, it was necessary not only to adopt the very best system for the purpose in view, but also to so modify the system that it would fulfill all the requirements of local conditions. If the system was to prepare the way for an Edison three-wire low-tension underground system, it must conform to it as much as possible from the start, so as to reduce the loss in investment when the change was made. Therefore a careful study was made of single, two, and three-phase, and mono-cyclic systems, and the two-phase system was adopted as being most similar to the Edison three-wire system in mechanical details. In this system all feeders are four-wire and are constructed overhead. The mains in the city are underground Edison three-wire mains, a large manhole taking the place of the feeder junction box. In this manhole are placed two large transformers for not less than 300 lights each. Thus, a complete secondary three-wire distribution system is formed and to it are connected regular Edison three-wire services and three-wire system of house wiring. Mechanical meters are used and the entire secondary system is modelled and constructed similar in every respect to the Edison three-wire underground system. In fact, the entire network of mains can be disconnected from the high-tension distributing alternating feeder, and connected with a three-wire low-tension feeder with no knowledge whatever to incandescent customers. Such an arrangement enables the Company to instal permanent underground distributing mains which at a later day can at once be connected to a standard Edison low-tension system, and the high-tension feeder supplying them can be extended into new territory beyond.

Brooklyn, unlike many neighbouring cities, has numerous small summer resorts whose period of active life lasts about four months, and these months represent the lowest output of the large Edison system. In order to secure the benefit of this class of business, at the beginning of the present year feeders, eight miles in length, were extended to these popular resorts, and many profitable contracts were made. This load will equalise the work of the steam plants of the Edison Company in such a way that high steam economy in the stations is maintained throughout the year. Thus, under one roof, and connected to the same boiler plant, on different engines, operate the low-tension Edison city and the alternating suburban resort systems, whose combined outputs so vary during the year that they counterbalance one another. In order to effectually reduce to a minimum the cost per unit in a generating station, it is necessary to increase the number of units output, so as to lessen as much as possible their share of fixed charges, and also to reduce the cost per unit manufactured by station and distribution economies. The city low-tension lighting system, by making the minimum load of the station equal to its smallest unit at full load, has made it possible to operate the plants at a high point of efficiency as regards coal and labour costs. With the latest and most reliable machinery in operation, the cost of repairs has been maintained at a low figure, the sum of $450 per month representing the entire cost of all steam plant repairs to three stations aggregating 8,000 H.P. operating at a maximum. The repairs to the electrical plant in the same stations average $150. All detailed accounts of operations of the Company are "per kilowatt hour," so that any fluctuation in the cost of the different items of manufacture, distribution or general expenses can be seen at the end of each week, and investigation made at once. While the Company has, year by year, increased its efficiency in cost of production, it has not neglected the customer. At the beginning of the present year, a general reduction was made in the price of current, which effected, to a marked degree, the customers of the Company. The schedule of discounts is based upon the meter readings, on hours burning per 16 c.p. lamp per month, and also considers the size of the installation. In this way the Company is protected in the case of poor customers, the small but good customers are satisfied, and large customers are shown the advantage of good central-station service. Thus the Company, by good service, a voluntary reduction in cost and price of product, and its business policy of reaching out for new business, has been able to preserve the goodwill of the public—the keynote of the success of all corporations.

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**King's College, London.**—Particulars are issued of the course of instruction in engineering, applied science, &c., for the Session 1896-7, and copies of the syllabus of the day and evening classes can now be obtained.

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## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August 28, 1896.*

**Bell Telephone and Western Union Telegraph Companies.**—On August 22nd it was rumoured in Boston that the Western Union Telegraph Company had absorbed the American Bell Telephone Company. Although reports of this nature are started periodically, each time they come with a freshness that in one sense startles the electrical world. They come so often and are as frequently denied, that those whose business it is to follow such matters now look upon these reports as part of stock-jobbing plans. Everyone who was available, who would be most likely to know whether there was any truth in the story or not, denied that such an arrangement had been made. The Western Union Telegraph officials of this city knew nothing about the matter, and some even went so far as to state that nothing of the sort was ever contemplated. The fact, however, that the present contract between the two companies will expire in November next, leads to the reasonable inference that it will either be renewed on some other terms, or there will be open warfare between the two giant companies. The probability of the latter event, however, is very remote, because the financial condition of the Western Union is such that it would be extremely unwise, to say the least, to engage in a warfare of this sort with such a strongly intrenched corporation as the Bell Company. And the idea that the Western Union Company could absorb the Bell is looked upon as somewhat ridiculous, when the relative financial condition of the two companies is considered. The telephone company without question is in a better position to engage in the telegraph business than the telegraph company is to engage in the telephone business. To do this the telegraph company would have to establish local exchanges and rebuild many of its line wires; whereas the telephone company to engage in telegraph business would simply have to place telegraph instruments in its offices, and it would have a first-class plant. The sentiment regarding the relations between the two companies is, however, that another arrangement will be patched up between them.

**Promotion of Engineering Education.**—The Society for the Promotion of Engineering Education held a meeting in Buffalo, N.Y., on August 20th, 21st, and 22nd. President Mansfield Merriman read a Paper on "The Past and Present Tendencies of Engineering Education." The present status of engineering education in the United States he regarded as the result of a rapid evolution which has occurred in consequence of changes of opinions as to the aims and methods of education in general. The tendency to industrial and technical experimentation which the latter consideration induced led to the development of the scientific school in the Engineering College. He deprecated excessive specialisation, and made a passing commendation of hard work in the college. Increased attention to mathematics, especially applied mathematics, was recommended. The marvellous development of electrical theory and practice has tended to make that the most important part of physics, leading to undue neglect of other branches. Prof. T. C. Mendenhall introduced a resolution favouring the passage by Congress of the Bill establishing the metric system, which resolution was unanimously adopted.

**Compressed Air Motor Cars.**—The latest explanation given for the introduction of this system on the surface lines of this city is that the cars were not put on the lines in expectation of their general adoption, but rather as a substitute for the regular system when traffic is light. Compressed air cars, it may be noted, are being introduced only on the lines of the Third Avenue and Metropolitan Traction Companies, which lines are operated by cable power. It is, therefore, manifestly uneconomical to operate several miles of heavy cable in the dead of night when traffic is light for the purpose of hauling a few passengers. A system that will enable the companies to shut down their regular plant and take care of the light traffic between 12 o'clock at night and daylight would appeal to the favour of the managers; and it is for the purpose of taking care of this traffic, so it is stated, that the new system is being exploited. So far the few cars that are operated on this system seem to work with considerable satisfaction, and appear to be under perfect control of the driver.

## CORRESPONDENCE.

### PRINGLE AND KENT'S SURFACE RAIL ELECTRIC TRAMWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As prominence has been given to a statement of Mr. Arnot's, made in his report to the Tramway Committee of the Glasgow Corporation, we shall be pleased if you will give prominence in some way to our views in reply. We quote you Mr. Arnot's opinion, as taken from the Glasgow *Daily Record* of August 4th:—

"The many devices used by the several inventors of these closed-conduit systems are, to say the least of it, exceedingly ingenious; but when one considers the large numbers that will be placed under the roadway one hesitates to recommend them. In one system there would be about 19,000 switches under the streets of Glasgow, and if one of these switches failed to act after the cars had passed, 500 volts would be on the streets between the knob and the rail. The same objection applies to all these systems, that should a failure take place in the working of the mechanism, either the cars would fail to start, or a dangerous pressure would be placed on the surface of the street."

We enclose you a cutting from the *Railway World*, which embodies our reply. You will thus be enabled to see Mr. Arnot's contention, and also our views.—Yours, &c.,

SHARP AND KENT.

EXTRACT.

"In the recently issued report of the Glasgow Town Council's Sub-Committee on mechanical motors, short descriptions were given of the principal conduit systems, closed and open, for electric tramways, and serious objection was taken to the whole of them as compared with the trolley-wire system. In regard to the closed conduits in particular, the feeling was expressed that serious danger to the public might arise should any of the magnetic switching devices get out of order, as the full potential of the working current might be turned on to the surface contact points or rails when these were not covered by the car. Messrs. Pringle and Kent, whose system was one of those reviewed by the Sub-Committee, have promptly responded to the views which have been expressed. They admit that moving machinery cannot be relied on to work indefinitely without the possibility of a breakdown, but they point out that in the light of the experience obtained with other distributors the possibility is very remote. Still, in the interests of safety it is necessary to have some devices which can be relied upon to immediately cut out a distributor should it fail to follow the movement of a car, and so cause a surface rail with the full line of voltage on to be exposed. The device which Messrs. Pringle and Kent provide for the purpose may be thus described: a magnetic cut-out is inserted in series between each distributor and the main supply conductor, and as long as a small current is allowed to flow through the cut-out the connection is maintained. When the car is being supplied with current the flow through the cut-out actuates it; but when the car is at rest or running light a comparatively high resistance is brought into circuit in place of the car motor, so that a small current continues to flow through the distributor just sufficient to hold in the cut-out. Should, therefore, a distributor fail to follow the advance of a car, as soon as the last collector on the car has left the live section rail, the cut-out is demagnetised and cuts out the distributor before the live section can be exposed beyond the base of a car. The inventors point out that this device involves but little additional outlay, seeing the number of distributors per mile on the Pringle and Kent system is so small. It is now hard to see what further steps could be taken on Messrs. Pringle and Kent's system to improve it or render it safer, so long as the designers can only work with models. It will be when they get the actual tramway—subject to the usual street conditions—equipped on their method that the practical test will come, and all the little improvements and adjustments suggested by experience can be made."—*Railway World*, September, 1896.

## BOOKS RECEIVED.

"Transactions of the Institution of Mining and Metallurgy of London." Vol. IV. Edited by Arthur C. Claudet. (London: Published by the Institution.)

"Elementary Mechanics, including Hydrostatics and Pneumatics." By Oliver J. Lodge, F.R.S. (London: W. and R. Chambers.) Price 4s. 6d.

"Universal Directory of Railway Officials, 1896." Compiled by S. Richardson Blundstone. (London: The Directory Publishing Company.) Price 10s.



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# TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

**SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The New Edition for 1897 is in active preparation, and circulars and full information will shortly be forwarded. The Subscription price remains 5s., postage 9d.; abroad, 6s. 6d., post free.**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The NEW EDITION is NOW READY. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson M.I.E.E., &c., fully illustrated; price 12s. 6d. NOW READY.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the atest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. is also ready; price 7s 6d. (abroad 8s.). Prospectus on application.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issu of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

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TENDERS INVITED.—The Electric Lighting Committee of the Borough of Morley invites tenders for the supply and erection of (*a*) Lancashire boilers and fittings, feed pump, &c.; (*b*) steam alternators and exciters, motor-alternator, accumulators, steam and exhaust pipes, valves, &c.; (*c*) switchboard and instruments; (*d*) overhead crane; (*e*) underground work, cables and stoneware culverts; (*f*) transformers and switchboards; (*g*) arc lamps, posts and accessories, and (*h*) meters. Plans, specification, &c., may be obtained of the consulting engineer (Mr. Robert Hammond), Ormond House, Great Trinity-lane, London, E.C., on and after the 16th inst. Tenders must be addressed to the Town Clerk (Mr. R. Borrough Hopkins), Town Hall, Morley, Yorks., by Wednesday, October 14th. Further particulars are given in our advertisement columns.

——— The Lord Provost, Magistrates and Council of Edinburgh invite tenders for the wiring of the Burgh Assessments Office, High-street. Specifications, &c., can be obtained at the office of the resident electrical engineer, 5, Dewar-place, and tenders must be sent to the Town Clerk (Mr. Thomas Hunter, W.S.), City Chambers, Edinburgh, by Tuesday, the 22nd inst. Some further information appears in our advertisement columns.

TENDERS INVITED.—The Corporation of Swansea invites tenders for (*a*) the supply and fixing of cables, casings, switch and fuse boards and all sundry fittings and materials for installing the electric light in the Swansea Market; and (*b*) the supply and erection of a temporary generating plant, including gas engine, generator, and main switchboards, together with the maintenance of the same, for twelve months. Specifications, &c., may be obtained from the engineers (Messrs. Kincaid, Waller and Manville), 29, Great George-street, London, S.W.; and tenders should be sent to the Town Clerk (Mr. Jno. Thomas), the Guildhall, Swansea, by 4 p.m. on Thursday, the 24th inst. Additional particulars are given in our advertisement columns.

——— Tenders are required for the extension and alteration of the electricity station buildings in Gas-street, Oldham. Tenders to Mr. A. Andrew, Gas and Water Offices, Oldham, by the 15th inst.

——— The French Telegraph Department invites tenders for the supply in two lots of gutta-percha insulated telegraph cables. Tenders should be sent in to the Direction Générale des Postes et des Télégraphes, 103, Rue de Grenelle, Paris, by the 14th inst.

——— The Société Nationale des Chemins de Fer Vicinaux invites tenders for the electrical equipment of about 14 miles of suburban railway at Charleroi and elsewhere, on the overhead trolley system. The specification can be had on payment of 1fr. from the Company, Rue de la Science 26, Brussels. Tenders must be sent in by October 28th.

ESTIMATES REQUIRED.—The Vestry of St. Mary Magdalen, Bermondsey, invites estimates from electrical engineers for preparing a report as to the advisability of establishing electricity supply works, the best system of distribution to be employed, &c. Further particulars appear in our advertisement columns, and additional information may be obtained at the Town Hall. Estimates should be sent in to the Vestry Clerk (Mr. Frederick Ryall), Town Hall, Spa road, Bermondsey, London, S.E., by 4 p.m. on the 23rd inst.

TENDERS ACCEPTED.—The authorities of the Devon and Exeter Hospital have received the following list of tenders for the electric lighting of the hospital buildings. Dr. J. A. Fleming is consulting engineer, and Mr. Charles Cole, of 50, High-street, Exeter, architect for the work.

| | Wiring. | Cable to laundry. | Total. |
|---|---|---|---|
| Massingham and Co., Taunton *(accepted)* | £498 17 6 | £17 10 0 | £516 7 6 |
| Whitehead and Co., London | 975 0 0 | 56 0 0 | 1,031 0 0 |
| Engel and Master, London | 963 15 0 | 57 5 0 | 1,021 0 0 |
| Laing, Wharton and Down, London | 845 16 0 | 21 10 0 | 867 6 0 |
| Electrical and General Engineering Co., London | 833 0 0 | 39 19 0 | 872 19 0 |
| Knapman, Hodder and Co., Cardiff | 791 0 0 | 15 0 0 | 806 0 0 |
| Fowler, Lancaster and Co., Birmingham | 737 5 6 | 37 11 10 | 774 17 4 |
| Blacking & Letheren, Exeter | 735 0 0 | 20 0 0 | 755 0 0 |
| L. V. Riley and Co., London | 690 0 0 | 28 0 0 | 718 0 0 |
| J. A. Edmondson, Leeds | 670 0 0 | 65 0 0 | 735 0 0 |
| Watford Engineering Company, Watford | 665 0 0 | 20 0 0 | 685 0 0 |
| Veale and Co., St. Austell | 659 0 0 | 20 0 0 | 679 0 0 |
| Christy Bros., Chelmsford | 659 10 9 | 13 6 0 | 672 16 9 |
| King, Mendham & Co., Brist'l | 599 13 6 | 36 16 9 | 636 10 0 |
| F. W. Ball and Co., Bristol | 595 5 0 | 12 15 0 | 608 0 0 |
| Lord and Shand, Totnes | 590 0 0 | 6 0 0 | 596 0 0 |
| L. Alwyn, London | 578 15 2 | 11 5 0 | 590 0 2 |
| Barclay and Son, London | 542 5 0 | 21 0 0 | 563 5 0 |
| W. J. Furse & Co., N'ttingh'm | 525 0 0 | 22 10 0 | 547 10 0 |
| City Electric Works, Exeter | 490 0 0 | 18 0 0 | 508 0 0 |

——— The Belfast City Council has accepted the tender of Messrs. Wm. Coates and Son for the fitting up of an electric lighting installation at the gas works.

——— The Shoreditch Vestry has accepted the tender of Messrs. Macfarlane and Co. for the supply of combined arc and incandescent lamp posts at £527. Messrs. Laing, Wharton and Down omitted to take into consideration the cost of mains to the motors in their tender of £428. 9s. 6d. for Contract 6, and therefore the firm have withdrawn. The contract has been let to Mr. G. A. Hemingway (the next lowest tenderer) at £442. The Vestry has also accepted the tender of the Electrical and General Engineering Company for wiring underground conveniences at £39.

——— The Electric Lighting Committee of the Glasgow Corporation has resolved to make material additions to the supply mains both outside and within the compulsory area in the centre of the city, and it has been decided to accept the following tenders for the supply of cable:—Callender Company, 1,566 yards of 1in. cable at £961. 11s.; 2,722 yards of ½in. cable, at £532 per mile; and four miles of ¼in. cable, at £1,360. The Prescot Company, 763 yards of ½in. cable, at £603 per mile. The Silvertown Company, one mile of ¼in. india-rubber cable, at £368 per mile, and two miles of cable at £108 per mile.

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TENDERS RECEIVED.—The Bath City Council received 20 tenders for the supply of electrical plant. The tenders have been referred to the consulting engineer (Mr. R. Hammond) for consideration and report.

WORKS FOR SALE.—Particulars are given in our advertisement columns of engineering works and foundry (with engines, boilers, machinery, &c.), which are for disposal. The premises are suitable for carrying on a general engineering business, are situated at Mains Loan, Dundee, and are within four minutes of a railway station. Applications to Messrs. Shield and Kyd, Dundee.

BUSINESS FOR DISPOSAL.—An electrical engineer in the North is desirous of disposing of his business or of taking a partner. The turnover for the last 12 months has been £3,000, and there is £400 worth of stock. The business was established in 1890, and can be bought for between £500 and £600. Letters addressed to "S. C. B.," *Electrician* Office, will be forwarded.

APPOINTMENTS VACANT.—The Electric Lighting Committee of the County Borough of Huddersfield invites applications for the post of working mechanical engineer at the municipal electric supply station. Salary £2. 10s. per week. Some further information will be found in our advertisement columns, and applications should be sent in not later than Monday, the 21st inst.

——— An electrical engineer is required for a high-tension alternating-current station of an electric supply company. Commencing salary £150 per annum. Further particulars appear in our advertisement columns, and applications should be addressed to B. C., c/o *Electrician* office, 1, 2 and 3, Salisbury-court, Fleet-street, London.

——— The Blackburn Town Council invites applications for the appointment of assistant engineer at the electricity works. Salary £125 per annum. Applications to the Town Clerk, Blackburn, by 18th inst.

——— The governing body of the Northern Polytechnic Institute require a lecturer in mathematics, and a junior demonstrator and laboratory assistant in engineering, physics, and chemistry. Applications by the 14th inst. to the Principal of the Polytechnic, Holloway-road, N.

——— An Assistant Master (principally for Science) is required at the Port Talbot (Glamorgan) Intermediate Schools. Salary £130, with liberty to take evening classes. Applications to the Head Master by 16th inst.

BANKRUPTCY.—The first meeting of creditors in the failure of George Ludwig Schultz, lately trading as an iron and steel merchant, under the style of George Schultz and Co., at 90, Cannon-street, E.C., took place on the 2nd inst., at Bankruptcy-buildings, Carey-street, W.C. The receiving order was made upon the petition of Messrs. Fossick and Co. (Limited), 145, Cannon-street, and the statement of affairs furnished showed total liabilities £2,554, of which £2,354 was expected to rank, and assets *nil*. The debtor commenced business as an iron and steel merchant on Oct. 1, 1894, and carried it on down to April last. No proposal was made, and the matter was left in the hands of the Official Receiver to be wound up in bankruptcy. The public examination is fixed for 13th prox. The following are the creditors in this failure:—Fossick and Co. (Limited), London, £402; C. Jennings, London, £202; Barraud, Rigge, and Jupp, London, £200; A. Ellis, London, £151; W. Schultz, £75. 17s. 6d.

BENNETT AND DRUCE (IN CHANCERY).—Mr. James Todd, receiver and manager in this matter, yesterday (Thursday) called a meeting of creditors of the firm, to place before them the exact position of the partnership accounts. A detailed statement was presented to the creditors.

DISSOLUTIONS OF PARTNERSHIP.—The partnership subsisting between Messrs. F. Thomas Smythies Taylor, William Taylor and Herbert William Hobson, scientific instrument makers, of Leicester and Charing Cross-road, London, under the style of Taylor, Taylor and Hobson has been dissolved by mutual consent. The business will be continued by Messrs. T. S. and W. Taylor under the same title. Mr. W. S. Hobson, who is well-known to the customers, remains in the firm.

——— The partnership hitherto existing between Messrs. John A. Russell and R. F. Barrett Lennard, carrying on business as electrical engineers and contractors, at 135, Victoria-street, has been dissolved by mutual consent, and Mr. Russell has commenced business at 49, Victoria-street, London, S.W., under the title of Russell and Russell.

BROCKIE-PELL ARC LAMP (LIMITED).—The Secretary of this Company informs us that the telegraphic address "Illuminers London," has been registered. As previously stated, the offices of the Company have been removed to 97, Queen Victoria-street, E.C., to which address all communications should be sent.

BUSINESS CHANGES.—We are asked by Mr. A. Montagu Shepherd to state that he has ceased to act as London and district representative for Messrs. P. R. Jackson and Co. (Limited), and that his address is now 32, Albany-road, Ealing, W.

REMOVAL.—Messrs. Calvert and Co., electrical engineers, state that they have been compelled to remove to more commodious premises at 4, St. Mary's-street, Manchester.

"TAUNTON" DYNAMOS AND MOTORS.—A new price list of the Taunton machines is now ready, and can be obtained of the Newton Electrical Works (Limited), Taunton. The illustrations clearly portray both large and small machines, combined plants, switch-boards and switches; and the text includes instructions and diagrams for fixing and working the Taunton motors. An excellent view of the combined Taunton-Willans steam dynamo plant is illustrated on page 5.

MASCHINENBAU AKTIEN-GESELLSCHAFT NÜRNBERG (VORMALS KLETT).—This well-known and old-established firm send us particulars of their works and manufactures. The firm was established in 1837 by the late Herr Johann Friedrich Klett, and at present employs over 3,000 hands at the extensive works at Nürnberg and at the branch at Gustavsburg, near Mayence. The Company's manufactures include steam, gas and oil engines (special attention being paid to electric lighting requirements), boilers, pumps, cranes and lifts (electric, hydraulic and hand), cars for electric tramways and railways, material testing machinery, &c. The firm has acquired a well-earned reputation in their iron bridge building and construction department, and views are given in the particulars to hand of the bridge over the North Sea and Baltic Canal, which has a span of 156 metres, and of the great central railway station at Munich, both of which were made and constructed by this firm. In addition the firm have built the viaduct over the Wupper near Müngsten (which is 480 metres long, and is stated to be the highest structure of the kind in Europe), the bridges over the Rhine near Mayence and the Isar near Grosshesselohe and numerous other bridges, which are a standing tribute to the firm's technical and artistic skill.

FIRE.—We learn that the fire at the works Electricité et Hydraulique at Charleroi resulted in the complete destruction of the arc-lamp carbon stores, where close upon a million carbons were stocked. To prevent any delay another warehouse has been converted into a carbon store, and the Company are manufacturing at the rate of from 10,000 to 15,000 carbons per day. The grinding and packing plant was uninjured, so that the only loss was that of the stocked carbons.

SANITARY INSTITUTE.—Particulars have been forwarded of the course of lectures and demonstrations for sanitary officers and students for 1896, given by the Sanitary Institute at the Parkes's Museum, London, W. The course of lectures includes ventilation, warming, and lighting, and, of course, a long list of subjects of special interest to sanitary officers and students.

ELECTRIC SUPPLIES CATALOGUE.—Mr. G. Braulik, of Upper Thames-street, forwards a formidable price list and complete catalogue of electric light supplies, bound in red cloth, which contains illustrated particulars and prices of an infinite variety of accessories of all kinds used in electric light, telegraph, telephone and bell work, electro-medical appliances, &c. The book is made up of six sections dealing with special branches, and the trade will appreciate the care taken in its compilation.

NEW PRICE LIST.—A new price list has been issued of electrical accessories and electric light fittings by Messrs. A. Vandam and Co.

COLONIAL EXHIBITS.—In response to a despatch from Mr. Chamberlain to the Colonial Governors, a number of articles of colonial manufacture were sent to this country, and a sample collection has been on view at the London Chamber of Commerce, Botolph-lane, Eastcheap, for some time past. Owing to the number of visitors which this collection has attracted, it has been decided to keep the exhibition open until to-morrow (Saturday). Admission can be obtained on presentation of business card.

"ELECTRIC POWER."—We are notified that this American magazine has ceased to exist.

"ALTERNATING-CURRENT STATIONS ON GANZ AND CO.'S SYSTEM."—This is the title of a well-got-up pamphlet just issued by Messrs. Ganz and Co., of Budapest. It mainly describes the devices of Zipernowsky, Déri and Bláthy for alternating-current work, and points out the many advantages the system possesses. There are also detailed descriptions of stations built on this system, among others the plants at Budapest, Vienna, Rome, Tivoli-Rome, Venice, St. Petersburg, Innsbruck, Carlsbad, &c. The work is well-written and beautifully illustrated with views and plans of generating stations, power transmission plants, &c.

ELECTRO-HARMONIC SOCIETY.—The eleventh season of this society commences with the concert on the last Friday in the current month, and the remaining five concerts will be held on the last Fridays in October, November, January, February and March. In these hard times members will be grateful to learn that, notwithstanding the Committee has decided to incur increased expenditure in keeping up the standard of musical excellence of these concerts, no increase will be made in the members subscriptions.

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PRESENTATION.—Mr. William Bulloch, C.A., accountant to the Electric Construction Company, was presented, on the 31st ult., at Wolverhampton, with a silver tea service and salver, in honour of his approaching wedding, by the members of the Company's staff at Wolverhampton and London. Mr. A. B. Blackburn, manager, who made the presentation, referred to the good feeling existing among the officials of the Company, and he expressed the good wishes of the subscribers to the presentation for Mr. and Mrs. Bulloch's future happiness.

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ABERDEEN.—Messrs. A. S. Blackman (borough electrical engineer) and D. Nicol (harbour engineer) have now presented their report on the electric lighting of the quays. They propose that one row of electric lamps should be erected about the middle of the quays, of such illuminating power and of such height and distance apart as to provide sufficient light over the whole area of the quays, provision being also made for the supply of movable arc or incandescent lamps for the use of shipowners at the quays. The necessary current would be supplied by the Corporation. The whole of the mains and branch conductors would be laid and maintained by the Council, while the lamps and pillars would be erected and maintained by the Harbour Commissioners. The total cost of the scheme is estimated at £9,336, made up as follows:—Mains and branch conductors for lighting circuit, including culverts and trenching, £5,000; ditto for power circuit, £1,750; 60 10-ampere lamps with posts, £1,620; 8 10-ampere lamps in sheds, £96; 6 portable ditto for shipping, with conductors, £120; 3 30-ampere beacon lights, with pillars, £750.——A special meeting of the Town Council was held on Wednesday for the purpose of further considering the proposal of the Directors of the Great North of Scotland Railway Company to acquire the local tramways and work them in conjunction with a system of light railways which the Company proposed to construct, and which would radiate from various points of the city. A provisional agreement had been entered into with the Company for the purchase of the lines, and it was also proposed to introduce electric or some other improved system of mechanical traction. After considerable discussion it was decided, by 21 votes to 8, not to sanction the scheme, as it was desirable that the tramway system of the city should be in the hands of the City Council.

ALLEGED EMBEZZLEMENT.—At the Bournemouth Police Court yesterday (Thursday) Edward Charles Offer was charged, on a warrant issued several months ago, with embezzling £420, belonging to the Bournemouth and District Electric Supply Company, between January, 1893, and March of the present year, during which time he held the post of Secretary to the Company. Offer disappeared from Bournemouth just prior to the issue of the warrant, and was arrested at Gillingham, Dorset, on Wednesday. The prisoner was remanded until Monday.

ALTRINCHAM.—At a special meeting of the District Council on Wednesday a deputation from the Manchester Carriage and Tramways Company waited upon the Council in reference to the construction of a tramway from their system at Stretford, through Sale and Altrincham, to Peel Causeway. It was explained that the Company intended to employ horse traction for the present, though powers would be obtained for introducing electric or other motive power, if necessary. A second deputation from a Manchester Syndicate also waited upon the Council. In this case it is proposed to at once lay down electric tramways, and also carry the lines through Stretford and Chorlton-cum-Hardy to Stockport. A special meeting of the Council will be called to consider the matter.

ASYLUM LIGHTING.—Plans for the electric lighting of the Sunnyside Asylum and Infirmary, Montrose, have been prepared, and will be considered at the next meeting of the Asylum Board.

BEXHILL.—The District Council has decided to oppose the application of a local syndicate for a Provisional Order, unless powers are conferred on the Council to purchase the electric lighting undertaking at any time.

BIRKENHEAD.—Work in connection with the electric-lighting scheme is in a forward condition. The erection of the machinery at the generating station and the laying of the mains will, it is anticipated, be completed by the middle of this month, when current will be available for consumers in the central districts of the town, where mains have already been laid. It has been arranged to introduce the electric light into the Town Hall as soon as possible, the building having been already wired for that purpose. The charge for current to private consumers has been fixed at 6d. per unit.

BLACKBURN.—At a recent meeting of the shareholders of the Blackburn Tramway Company the proposal to adopt electric traction on the sections at present worked by horses was agreed to. The Corporation offer to carry out the electrical equipment of the lines, and to supply electric current. It is calculated that a considerable saving in working expenses will be effected by the change in the system of traction.

BRADFORD.—The half-yearly statement of the Gas and Electricity Committee, presented at Tuesday's meeting of the Town Council, stated that the electricity department was progressing satisfactorily, and the Committee recommended the reduction of the cost of current for motive-power purposes from 3½d. to 2½d. per unit, the reduction to take place from January 1st next. The new buildings were going on satisfactorily, and much of the new plant was ready for being fixed. The trade profit for the half-year amounted to £3,578, against £3,176 in 1895, or 4·24 per cent. on the capital expenditure, against 4·73 per cent. last year. The net profit, after deducting interest and sinking fund, was £1,007 (1·19 per cent.), against £968 (1·47 per cent.) last year. The capital outlay had been £84,351, against £67,112 in 1895. There was an increase in the output at the station of 35,954 units. It has been decided to extend the electric light mains up Little Horton-lane, Church Bank, and Barkerend-road at a cost of £850.——The Council has increased the salary of the mechanical engineer at the station (Mr. W. Jones), from £143 to £170 per annum.

BURY ST. EDMUND'S.—At the meeting of the Town Council on Tuesday Alderman Lake, a strenuous advocate of electric lighting, asked the Town Clerk if it were probable that the Local Government Board would sanction the formation of a Company having for its object the indemnity of the Council for the period of 20 years against loss from supplying the borough with the electric light, the Company to receive all profits which might be made during the same period. In reply the Town Clerk confessed his inability to answer the question, but as the Council was applying for an Order the Board of Trade might be asked to insert clauses to embody the proposal, and if they agreed probably the Local Government Board would also sanction the departure. The scheme would, however, be quite unworkable unless the Corporation had a free hand with regard to the working of the undertaking and as to the price to be charged for current. Alderman Lake said he felt confident electricity supply works would be a financial success. He strongly complained of a statement made by a speaker at a recent meeting of the Ratepayers' Association, to the effect that the electric light had been a failure at Blackburn, and that a 6d. rate had to be levied to defray the expense incurred. In consequence he wrote to Blackburn, but found that there was no foundation for the assertion. He was then told that a mistake had been made, and that Blackpool was meant. In reply to a communication, the Town Clerk of the latter town wrote: "It is not true that a 6d. rate has been levied in Blackpool to pay for the electric light. The financial result of the last year's working was a balance of £281. 1s. 1d., being a profit for the year carried to the general district rate account." Rash statements such as these, the worthy alderman pointed out, were to be deplored, and were calculated to prevent progress.

CHELTENHAM.—The Town Council had again under consideration the proposal for the construction of an electric tramway between Cheltenham and Cleeve Hill, a distance of three miles. It was explained that it would be necessary to adopt the standard gauge of 4ft. 8½in. for the tram lines, as the gradient up Cleeve Hill was a somewhat steep one. In approving the principal of the scheme, it was resolved that the route to be proposed by the Corporation to the promoters be from the Midland Station, along Queen's-road, Lansdown-place, Bayshill-road, St. George's-place, St. James's-parade, St. James's-square, Ambrose-street, St. George's-street, St. Margaret's-road, North-place, North-street, to the Gas Offices, Albion-street, and Portland-street; Portland-street to Evesham House; thence to Prestbury-road and along Prestbury-road to the borough boundary.——The Council has decided to apply to the Local Government Board for sanction to borrow an additional sum of £2,150 for electric light extension purposes. It is proposed to light the Promenade and High-street by means of 58 arc lamps, which will be placed in the centre of these thoroughfares. At present there is an equivalent of 8,050 8 c.p. lamps connected, and there are orders in hand for 1,150 more.

CHURCH LIGHTING.—St. George's Roman Catholic Cathedral, Southwark, is at present being wired for the electric light by Messrs. F. A. Donnison, Berlyn and Co. The high altar, however, will not be included. We hear that about 1,000 lights will be required.

COLCHESTER.—Col. J. Ord Hasted, R.E., held a Local Government Board inquiry at Colchester on Friday last into the application of the Town Council to borrow £18,000 for electric lighting purposes. The Town Clerk (Mr. H. C. Wanklyn), who appeared in support of the application, stated that the Council obtained a Provisional Order in 1893, and the borough surveyor (Mr. H. Goodyear) submitted and explained the plans of the proposed electricity station. The consulting electrical engineer (Mr. W. H. Massey) gave details of the proposed system of distribution, machinery and the cost (which had been obtained from estimates submitted by the contractors). The Inspector said that the sum of £100 for the temporary plant for lighting the Military Hospital, which had been included in the application, could not form part of the loan. It

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was proposed to employ the low-tension three-wire system, with storage batteries. Provision was made for increasing the normal capacity for an hour. There would be three 180 H.P. steam engines coupled direct to the dynamos, which would be capable of supplying current to about 4,000 lights, but the switchboard and buildings were provided for a larger number in view of extensions. The Council had decided to defer street lighting for the present. The mains were capable of taking more current than it was at present proposed to use, in view of future extensions. The feeders were laid down on such a system that all gas explosions owing to their presence would be impossible. They were providing mains for 4,360 yards of streets. Tenders had been obtained for carrying out the work (buildings excepted), and it had been decided to place the order provisionally in the hands of the Electric Construction Company, of Wolverhampton and London. There was some opposition to the scheme on the ground that the rates were already high, and that as there was no prospect of making the electricity supply station a financial success for the first two years, the undertaking would be a burden on the rates for some time. The Mayor (Alderman Wicks) said that he had not taken any part in the question during his year of office, but he favoured the application. Already there were some three or four private installations in the town, and he thought that lighting should be in the hands of the Corporation. They did not take it up as a speculation, but as a matter of policy. There was a large military establishment in the district, and the buildings were recently increased by the erection of a large hospital and of more substantial infantry barracks. The military demanded the electric light, and there was a considerable claim on the Corporation, as representing the general interests of the town, that this thing should be acceded to.

COVENTRY.—The Local Government Board has sanctioned the Council's application for power to borrow £13,000 for electric light extension purposes.

CROYDON.—The municipal buildings were lighted electrically for the first time on Monday last. The Town Hall is illuminated by means of 1,000 16 c.p. lamps.

DEWSBURY.—At the last meeting of the Town Council it was stated that the report of the borough electrical engineer for the past half-year showed a deficit of £139 in the electricity department; but there was every reason to expect that when the annual statement was presented the accounts would show a profit. The Council has decided to extend the mains to Wilton-street.

DUDLEY.—The sub-Committee recently appointed by the Streets and Gas Committee has presented a report recommending the Town Council to establish electricity supply works. Before coming to this decision the Committee sought the advice of Mr. F. Harman Lewis (the Wolverhampton borough electrical engineer), who gave it as his opinion that there was every prospect of a well-designed and carefully-managed electricity supply station in Dudley proving a financial success. The Council was recommended to commence by laying down plant capable of supplying current to about 8,000 8 c.p. lamps, and the capital expenditure entailed by this scheme would amount to £23,500. At the meeting of the Town Council on Monday Alderman Bagott moved the adoption of the Committee's report. He urged the Council to apply for a Provisional Order, as he did not wish to see Dudley following the example of Liverpool, where the Corporation had to give £400,000 for an electric lighting company's undertaking. The motion was agreed to, and a sub-Committee was formed for the purpose of further considering the matter.

DUTCH EAST INDIES.—In the Budget of the Dutch East Indies recently presented to the Second Chamber of the Dutch States-General, provision is made for laying a cable between Atjeh and Lombok.

ECCLES.—As we previously stated, the Town Council's application for permission to borrow £20,000 for electric lighting purposes has been refused by the Local Government Board. The Board states that "they are advised that the scheme is not altogether satisfactory, and in particular that, in a compact district like Eccles, a continuous current with a low pressure should be used, and not an alternating current with high pressure and transformers as proposed, inasmuch as under the latter system accumulators cannot be used, and heavy expense would be incurred in keeping the dynamos running all day. The proposal of the Town Council to avoid this expense by cutting off electricity for eight hours every day would result in serious inconvenience to those who may wish to use electricity for other than lighting purposes. Further, the Board are advised that the land proposed as the site for the generating station is too small for the purpose, and that the stipulation in the lease as to the carrying on of any business which was, or could or might be deemed a public nuisance or a private annoyance or inconvenience to the neighbourhood, might very probably lead to litigation after the works had been set up." An offer has been received from Edmundson's (Limited) to take over the Provisional Order, and to carry out the provisions thereof.

EDINBURGH.—The Electric Light Committee has presented its estimates for 1896-7. The estimated expenditure is put at £20,325, against £13,985. 18s. in 1895-6. The expenditure is made up as follows: Generation of current, £5,425; distribution, £835; public lamps, £1,740; rent, rates and taxes, £1,220; expenses of management, £1,635; interest and contribution to sinking fund, £9,470. The revenue for the year is estimated to produce £24,475, against an estimated revenue of £12,640, and an actual revenue of £16,721. 4s. 6d. in 1895-6. The revenue estimate has been computed as follows: Sale of current, £16,500; charges for arc lamps, £7,875; miscellaneous, £100.

ELECTRIC ORGAN AT WORCESTER CATHEDRAL.—A new organ has been installed by Mr. Hope-Jones at Worcester Cathedral, where the festival of the Three Choirs has been held this week. The organ is described to us as absolutely unique, and a marvel of electrical science. Mr. Hope-Jones has also erected a large organ at Lord Burton's church, in Burton-on-Trent, upon the same principle as that at Worcester Cathedral. This organ is the admiration of local musicians, and has, we learn, given great satisfaction.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from September 2nd to September 8th, with the ports of destination:—

*Aden*—£422 (including £31 telegraph apparatus). *Argentina*—Buenos Ayres, £470 (telegraph material); Rosario, £135. *Australasia*—Fremantle, £125 (telegraph material); Melbourne, £981 (including £593 telegraph material); Sydney, £340; Wellington, £824. *Belgium*—Antwerp, £326 (fuses); Ostend, £40. *British Guiana*—Demerara, £18. *China*—Shanghai, £47. *Denmark*—Copenhagen, £20. *Egypt*—Alexandria, £165 (telephone stores). *Germany*—Hamburgh, £10. *Gibraltar*—£13. *Holland*—Amsterdam, £50; Flushing, £42. *Japan*—Kobe, £334. *Malta*—£93 (telegraph material). *Mexico*—Vera Cruz, £27. *North Borneo*—Labuan, £29 (telegraph material). *Perim*—£34,887 (telegraph material). *Portugal*—Lisbon, £24 (telegraph material). *Russia*—St. Petersburg, £12. *Siam*—Bangkok, £24 (telegraph material). *South Africa*—Cape Town, £780 (including £85 telegraph material); Durban, £545; Lourenco Marques, £416 (telegraph material); Port Elizabeth, £546. *Spain*—Seville, £9. *Straits Settlements*—Penang, £93 (telegraph apparatus); Singapore, £432. *Sweden*—Gothenburg, £48 (telegraph material); Stockholm, £503 (including £294 telegraph material). Total, £42,831.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows:—

*Australasia*—Townsville, £1,534; Launceston, £120. Total, £1,654.

GARSTON.—The District Council has decided to carry out the electric lighting scheme recently prepared by Mr. F. H. Medhurst, and application is to be made to the Local Government Board for sanction to borrow £25,000 for the purpose.

GLASGOW.—The Tramways Committee has now resolved to recommend that the tramway manager and engineer should be sent to America for the purpose of collecting further information about electric traction. The Corporation has purchased the Govan and Ibrox tramway for £7,500.——The City Council has accepted a tender to light the St. Andrew's Halls electrically for £1,100. The engineer's estimate of the cost of the work was about £1,700.

HAMMERSMITH (LONDON).—The Vestry has received between 130 and 140 applications for the position of resident electrical engineer. The applications have been referred to the Electric Lighting Committee, with a view to selecting not more than six and not less than three names, from whom a final choice is to be made.

HATHERLEIGH (DEVON).—The Parish Council has renewed the contract for gas lighting during the coming winter; but the Lighting Committee has been instructed to consider and report upon the best means of more effectively lighting the town.

LEATHERHEAD (SURREY).—Notice of motion in favour of applying for a Provisional Order has been given for the next meeting of the District Council.

LEVENSHULME (MANCHESTER).—The District Council have received a notice from the Manchester Electric Supply Company of its intention to apply for a Provisional Order. A notice of motion in favour of the Council itself applying for an Order has been given by a member.

NOTTINGHAM.—At a special meeting of the Town Council on Monday it was decided, on the recommendation of the Parliamentary Committee, to introduce a Bill in the next Session of Parliament giving the Council authority to take over the existing tramway system and to make extensions thereto. The Council also seeks power to employ mechanical traction.

SHOEBURYNESS (ESSEX).—The District Council is considering a proposal to construct an electric tramway from Shoeburyness to Southend. Mr. Alfred Dickinson, of Birmingham, is consulting engineer to the scheme.

SOUTH AFRICA.—The Kimberley Borough Council intends to establish electricity supply works. At the outset it is only proposed to put down plant capable of supplying current to about

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2,000 private lights; but the station will be constructed to receive plant of double this capacity, should extensions be necessary.——It is stated that the Government of the South African Republic has sanctioned a scheme for providing the Rand with a comprehensive system of electric tramways which shall connect Johannesburg with some of the populous suburbs along the main reef.——The Standard Buildings Company of Johannesburg have decided to put down an independent electrical plant for the electric lighting of the buildings which they are erecting. The order for the plant has already been given out.——An electric lighting plant is being erected at the Bultfontein United Mines, and it has been decided to put down a similar plant at the Balmoral Mine. An electric pumping plant has been ordered for the Vogelstruis Deep Mine.

SOUTHAMPTON.—The Local Government Board has approved of the purchase of the undertaking of the Southampton Electric Light and Power Company for £21,000 by the Town Council, and has sanctioned the application to borrow £54,000 for this purpose, and for making additions to the plant at the station, extending the electric light mains, &c.

SOUTH SHIELDS.—In presenting the report of the Electric Lighting Committee at the last meeting of the Town Council, Alderman Rennoldson said that their electric lighting installation had proved satisfactory in every respect. During the fortnight the arc lights had been running not a single hitch had occurred, and it was now proposed to erect nine additional arcs in Ocean-road at an estimated cost of £425, and eight in Fowler-street at an estimated cost of £378. Altogether the Committee had spent nearly £27,000, and they had a small balance in hand. They had connected up 1,300 8 c.p. lamps; there were premises being wired which would require several hundreds more, and since the lighting of the streets had commenced applications had come in very quickly. There was therefore every indication that the electric light undertaking would be a great success.

TONBRIDGE.—The District Council has authorised the Electric Lighting Committee to expend a sum not exceeding 20gs. in obtaining a report from an electrical engineer on the cost of establishing an electricity supply station in the district.

WAREHOUSE LIGHTING.—Messrs. W. and J. T. Costigane, of Glasgow, have decided to instal the electric light at their warehouse. The contract has been placed with Messrs. Wm. Ramsay and Co., and provides for the erection of 11 10-ampere 2,000 c.p. arcs for lighting the windows in Trongate and Stockwell-street on the outside, 15 3-light clusters of 150 c.p. for inside of windows, 14 clusters of 75 c.p. for counters, a 3-light cluster for cash desk, a 3-light cluster for main stair, and 14 3-light clusters for mantle department. Messrs. Ramsay are also fitting up the Bonanza Warehouse in Argyle-street, where it is proposed to illuminate the outside of the windows by means of eight 2,000 c.p. arcs.

WEST LOOE (CORNWALL).—The Parish Council proposes to invite tenders for lighting the town by electricity, gas, or oil, and a sum of £50 has been voted for lighting the village during the next year.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

August 12, 1896.

17,879. V. M. CORNELY and L. C. H. DAUTEL. London. Improvements relating to electric batteries.

17,890. E. TILMANN and C. K. LEXON. London. Improvements in batteries for the electric lamps of cycles.

17,906. A. T. SNELL, C. E. GROVE, and A. F. HILL. London. Improvements in crossings of electric conductors for electric railways and tramways.

August 13, 1896.

17,915. A. J. IRELAND and C. W. G. LITTLE. London. Improvements in means for manipulation of electric lamps.

17,951. A. DE PUYDT and M. PONCIN. London. Improvements in continuous current generator dynamos or motor dynamos.

August 14, 1896.

18,005. D. COOK. Richmond. Improvements in electro-magnetic gearing.

18,046. M. M. BROTHY and J. D. F. ANDREWS. London. Improvements in electric accumulators or secondary batteries.

18,053. R. WOOD. London. Improved means or appliances for supporting revolving shafts, and the arrangement of rotary motors and dynamos in connection therewith.

18,076. F. H. DAVIES and C. O. BASTIAN. London. Improvements in or relating to direct-current dynamos and electro-motors.

August 15, 1896.

18,103. M. MCA. GILLESPIE and W. R. WYNNE. London. Improvements in electricity and other supply meters.

18,107. J. JACKSON. Coventry. Improvements in and relating to electric lights and installations.

18,134. G. HEYS-JONES. London. Improvements in and connected with electric conductors and in means for making connections therewith, the invention being particularly applicable for theatres and the like.

August 17, 1896.

18,196. J. D. F. ANDREWS. London. Improvements in the construction of tubes and tubular electric conductors.

18,205. E. H. CARQUEVILLE. London. Improvements in electrically-operated carillons.

18,220. J. Y. JOHNSON. London. An improved meter or apparatus for registering the consumption of alternating electric current. (Messrs. Hartmann and Braun.)*

August 18, 1896.

18,273. H. H. LAKE. London. Improvements in dynamo-electric machines. (Robert Lundell and E. H. Johnson, United States.)*

18,317. F. C. ESMOND. London. A new or improved device for use in connection with electric railways.

August 19. 1896.

18,319. A. J. WESTMANCOTT. London. A new or improved electric hand-lamp for general or special purposes.

18,324. H. W. PARKES. London. Improvements in motors applicable to machinery, velocipedes, steam, gas, or electric engines, and the like.

18,364. J. T. KNOWLES. London. An improved electric motor, or dynamo-electric machine. (James Harold de Thierry, Italy.)

18,408. J. DORSON. London. Improvements in the production of electric light.

August 20, 1896.

18,454. J. M. HUISMAN and H. C. GOVER. Glasgow. Improvements in incandescent electric lamps.

18,464. E. ORLING. London. Improvements in electric gas lighters. (Date applied for under Patents, &c., Act, 1883, Section 103, April 23, 1896, being date of application in Sweden.)

18,469. G. MIDDLETON. London. Improved method of and means for attaching telegraph and other wires to insulators.

18,479. M. J. P. O'GORMAN. London. Improvements in the manufacture of electric cables.

18,485. W. MORISON. New York. Improvements in acid-proof electrical non-conducting articles and composition therefor.

18,497. H. W. SULLIVAN. London. Improvements in electrical measuring and signalling instruments.

August 21, 1896.

18,508. J. EDMONDSON. Halifax. Improvements in arc lamps.

18,549. J. B. WHITTEMORE. London. Improvements in or relating to electrical primary batteries.*

18,550. E. J. CLUBBE, A. W. SOUTHEY and the ELECTRIC MOTIVE POWER COMPANY (LIMITED). London. Improved steering and speed-regulating apparatus for motor carriages.

18,551. E. J. CLUBBE, A. W. SOUTHEY, and the ELECTRIC MOTIVE POWER COMPANY (LIMITED). London. Improvements in and relating to the suspension or supporting of engines or motor carriages.

18,570. F. DANNERT. London. Improvements in electric batteries.*

August 22, 1896.

18,580. W. MCGEOCH. Glasgow. Improvements in and relating to electrical ceiling roses, switches and the like.

18,593. J. F. KELLY. London. An improvement in electrical apparatus.*

18,628. J. F. BACHMANN, A. VOGT, C. C. WEINER, J. KIRCHNER and A. KÖNIG. London. Incandescence body for electrical glow lamps and process of manufacture of the said body.*

18,632. H. HIRST and G. E. FLETCHER. London. Improvements in holders for incandesence electric lamps, also applicable to the holding of the shades or reflectors thereof.

18,648. R. KENNEDY. Bradford. Improvements in electrical storage or secondary batteries.

18,649. R. KENNEDY. Bradford. A new or improved recording electricity meter.

18,651. H. H. LAKE. London. Improvements in commutator-brushes for dynamo-electric machines or electric motors. (R. Lundell, United States.)*

18,652. H. H. LAKE. London. Improvements relating to electric railways. (Robert Lundell, United States.)*

August 24, 1896.

18,666. B. W. C. BOTHAM. Hassocks. Improvements in means for the construction of submerged or partially submerged permanent ways for cars driven by electricity, steam or other motive power; also for steep grade permanent ways for cable cars and the like.

78,669 M. VOLK, Brighton. Improvements in means for suspending the electric conductors used in electric railways, tramways, and the like, known as the trolley wire.

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18,680. H. GEORGIN. Brussels. Fixed contact apparatus for use with railway electric brakes.

18,704. H. ALLEN and O. PEARD. London. Improvements in connection with electric traction systems.

18,711. W. N. WRIGHT. London. Appliance for preventing noise in wheel gearing of pumps, or any machine or machinery driven by electric or any other power.

August 25, 1896,

18,785. C. J. SCHWARZE. London. Improvements in telephonic apparatus.*

18,786. H. H. LAKE. London. An improved system of control for electric motors. (Elmer Ambrose Sperry, United States.)*

18,830. F. J. LONGTON. Lancashire. Automatic electrical indication of the names of stations in each separate compartment of trains in motion.

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

13,957. NEW. Trolley systems of electric propulsion and in apparatu therefor.

14,493. HOLLICK AND HOLLICK. Electro-motors and dynamos.

14,627. BROWN and NEILSON. Electric fire alarms.

15,024. ANDREOLI and ANDREOLI. Electrolytic production of amalgams and their utilisation.

15,868. ANDREWS. Arc lamps.

15,985. QUINCEY and COLLINS. Electric contact making and breaking apparatus.

16,019. JOHNSON (SWAN). Incandescent electric lamps and their holders and fittings.

16,521. BERSEY. Overhead systems of electric traction.

16,898. BINSWANGER. Wall socket and plug for electric lighting and kindred purposes.

17,063. WILLSON. Electric smelting. (Date applied for under International Convention, 20th February, 1895.)

17,505. HOEPFNER. Electrodes.

17,741. VAN KERCHOVE. Device for indicatin the duration of telephonic conversation.

18,305. CROMPTON. Means of supporting and insulating electric conductors within culverts or like conduits.

18,369. AMEN. Electric locomotives.

18,588. PARTRIDGE and BERRY. Fusible cut-out or safety devices for electric conductors.

18,935. PROBERT and MOY. Apparatus employed in regulating electromotive force in alternating-current circuits for theatre lighting or other useful purposes.

19,353. JAHNSSON. Electric gas lighting apparatus.

1896.

6,480. TURNER. Rail bond for use on electric railways and for like purposes.

11,441. ADAMS. Electric arc lamps.

12,344. NAGLO. Method of indicating at a telephone station whether the telephone lines are engaged or not.

13,046. EVANS. Cleats for electric and other wires and the like.

13,264, THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED (Armstrong). Regulating induction electric motors.

13,723. GERMAN and HULLER. Incandescent electric lamps.

14,005. VAN DER VALK. Apparatus for automatically closing and opening by electrical agency the barriers of railway level crossings.

14,187. HOLMES and SIEMENS BROS. AND CO. (LIMITED). Portable electric drill.

14,442. ESSICK. Telegraphy.

14,449. STOCK. Microphones.

15,031. THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED (Steinmetz). Dynamo-electric machines and methods of compounding the same.

## NEW COMPANIES, STATUTORY RETURNS, &c.

*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1896, pages *318-346, &c., &c.*

**GENERAL WORKS CONSTRUCTION COMPANY (LIMITED).**—This Company has been registered, with a capital of £200,000, in £10 shares, to construct, execute, equip, maintain, develop or acquire, in the United Kingdom or elsewhere, railways, tramways, electric light and power supply works and telephone exchanges, and to carry on the businesses of contractors for public and other works, mechanical engineers, metallurgists, smelters, &c. The subscribers, with one share each, are: B. C. Cass, D. T. Fender, C. Hae, C. S. Meik, E. E. Pearson, S. G. Robinson and A. C. Schonberg.

**MILLET'S PATENT MOTOR WHEEL AND CYCLE COMPANY (LIMITED).**—This Company has been registered, with a capital of £100,000, in £1 shares, to carry on business as manufacturers of and dealers in motors of every description; also as electricians, mechanical engineers, machinists, wire drawers, metallurgists, galvanisers, electroplaters, &c. The subscribers, with one share each, are: V. Earle, H. Triggs, H. Le Marchant, H. Pope, H. C. Mills, A. Fichet, and G. Hitchen.

**MADEIRA ELECTRIC LIGHTING COMPANY (LIMITED).**—The statutory return of this Company to May 21st has just been filed. The capital is £20,000, in £1 shares; 8,719 have been taken up. and 6,000 have been issued as fully paid. The full amount has been called on the remainder, and £1,721. 10s. has been paid, leaving £997. 10s. in arrears.

**MIDLAND ELECTRIC LIGHT AND POWER COMPANY (LIMITED).**—The annual return of this Company to June 2nd has been filed: 3,139 shares have been taken up out of a capital of £50,000, in £10 shares, and 3,132 have been issued as fully paid. The full amount has been called and paid on the remainder.

**NATIONAL COMPANY FOR THE DISTRIBUTION OF ELECTRICITY BY SECONDARY GENERATORS (LIMITED).**—The annual return of this Company to July 31st has been filed. The nominal capital is £500,000, divided into 3,000 Preference shares and 47,000 Ordinary shares of £10 each; 2,669 Preference and 20,000 Ordinary have been taken up, and 1,000 of the former and all the latter have been issued as fully paid. The full amount has been called on the remaining 1,669 Ordinary shares and £17,690 has been received, including a sum of £1,000 paid on 100 forfeited shares.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 2½ per cent. (Sept. 10, 1896). Price of silver, 30½d. per oz. (Sept. 10th). Consols (2¾ per cent.) 111⅛—111⅜ for money, 111⅝—111¾ for account; 2½ per cent. 107½—108 (Sept. 10th). Stock Exchange Settling Days: Consols, Oct. 1st; Stocks and Shares Continuation Days, Sept. 14th and 28th; Ticket Days, Sept. 15th and 29th; Pay Days, Sept. 16th and 30th; Mining Share Carry-over Days, Sept. 12th and 26th.

**BABCOCK AND WILCOX (LIMITED).**—The annual report of the Directors to June 30th last states that the profit during the year amounted to £72,445. From this amount has been written off purchase of business account the sum of £20,000, leaving £52,445, and after adding the balance from last account (£4,830) there was a sum of £57,276 available for dividend. An interim dividend, at the rate of 6 per cent. per annum, was paid on the Preference shares for the half-year to December 31st, and 5 per cent. for the first six months of the year on the Ordinary shares, and the Directors now recommend for the half-year a dividend at the rate of 6 per cent. per annum on the Preference shares and of 10 per cent. on the Ordinary shares, placing £25,000 to reserve, and carrying forward £5,276. The Directors state that owing to the increase of the business it has been found necessary to provide larger works, and for this purpose ground has been bought at Renfrew, where suitable works are being erected, which, it is expected, will be completed within the next two months.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended September 6, 1896, were £848, against £839 in the corresponding week of 1895, an increase of £9. The total receipts for the half-year are £9,181, against £8,508 for the corresponding period of 1895, an increase of £673.

**EDISON ELECTRIC ILLUMINATING COMPANY.**—There are a number of companies with this title in the States; and evidently to encourage a demand in this country for their securities, English papers are being furnished with records of the financial working of the concerns. Reports to hand from the New York Company show that large increases are being made over last year's earnings, a similar result being reported by the Brooklyn Company. In the former case a net increase of $62,267, and in the latter of $78,719 for the July working is reported.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company in August, 1895, were £24,400, and the total receipts during the period from January 1st to August 31st were £188,000, against £182,200 and £202,800 in the corresponding months of 1894 and 1895 respectively.

**LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—The annual return of this Company to May 15th has just been filed. The nominal capital is £400,000, in £10 shares; 37,548 shares have been taken up, the full amount has been called and paid.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 6th inst. amounted to £1,212. The amount for the corresponding week last year was £1,324. Decrease, £112.

**STOCK EXCHANGE NOTICE.**—The Stock Exchange Committee has appointed Tuesday, the 15th inst., a special settling day for the Provisional Certificates of the £100,000 Four and a Quarter per Cent. First Mortgage Debenture Stock of Willans and Robinson (Limited), and has ordered the same, as well as the further issue of £100,000 Five per Cent. Debenture Stock (in lieu of the provisional certificates now quoted) of the City of London Electric Lighting Company (Limited) to be quoted in the official list.

**WESTERN UNION TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company recommend the payment of the usual quarterly dividend of 1¼ per cent. for the September quarter. The statement for the quarter shows a net revenue of $1,600,000 compared with $1,850,000 for the corresponding period of last year. The surplus, after providing for dividends, is $164,000, as against $114,000.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price September 2. | Price Wednesday, September 9. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Sept., 5. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | £ s. d. | | | |
| | | | **TELEGRAPHS.** | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 52 54 | 52 54 | 4 12 7 | Jan., Apr., July, Oct. | 52½ | 52½ |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 97½ 98½ | 97½ 98½ | 5 1 6 | " " | 98½ | 97⅝ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 9½ 9⅝ | .. .. | .. .. | 9⅝ | 9 |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 6 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ 9½ | 8½ 9½ | .. .. | .. .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15½ 15¾ | 15½ 15¾ | 4 8 11 | Mar., June, Oct., Dec. | 15¾ | 15½ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | 160 170 | 160 170 | 4 3 0 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine xd | 12½ 13½ | 12½ 13½ | 5 13 6 | February and August | — | — |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. xd | 20½ 21½ | 20½ 21½ | 4 13 .. | " " | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ 4½ | 3½ 4½ | 4 8 11 | April and October | — | — |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107⅞ 110⅞ | 107⅞ 110⅞ | 4 2 5 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10½ | 9½ 10½ | 4 3 0 | Jan., Apr., July, Oct. | 9¾ | .. |
| 400,000 | 10 | 5/6 | Eastern | 18 18½ | 18 18½ | 3 10 3 | " " | 18⅛ | 18½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 1 6 | " " | 19⅛ | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 3 0 3 | May and November | 135 | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 104 107 | 4 14 4 | February & August | 106½ | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 18½ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅝ | 18½ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 3 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 4 17 1 | January and July | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 16 2 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 109 | 106 109 | 3 13 7 | February & August | 107⅜ | 106½ |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111¾ 114¾ | 111¾ 114¾ | 3 10 11 | May and November | 112½ | .. |
| 180,227 | 10 | 3,9 | Globe Telegraph and Trust | 11½ 11⅝ | 11½ 11⅝ | 3 15 7 | Jan., Apr., July, Oct. | 11⅝ | 11⅜ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 18 18½ | 18 18½ | 3 5 9 | " " | 18⅞ | 18½ |
| 150,000 | 10 | 5/0 | Great Northern | 24 25 | 24 25 | 4 0 0 | Jan., April, and July | 25 | 24½ |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue xd | 104 107 | 104 107 | 4 13 6 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 53 56 | 53 56 | 4 9 3 | May and November | 55¼ | 54½ |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures xd | 109 112 | 109 112 | 5 7 2 | March & September | — | — |
| £100,000 | £100 | 4% | *Pacific European Tel.4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 7 | " | 109½ | 109 |
| 11,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | .. | .. |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 140 145 | 140 145 | 4 2 9 | " " | 141 | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 6 | 5 6 | 6 0 0 | January and July | 5½ | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) xd | 102 105 | 102 105 | 4 15 3 | March & September | 103¼ | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. .. | January and July | .. | .. |
| £150,000 | 100 | 8% | Do. 8 per Cent. Debentures, 1902 | 99 101 | 99 101 | 7 15 9 | June and December | — | — |
| 88,321 | 10 | 0/6 | West India and Panama | 1⅛ 1⅜ | 1⅛ 1⅛ | .. .. | — | — | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 12 | 5 0 0 | May and November | .. | .. |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | — | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 10 11 | June and December | .. | — |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8¼ 9½ | 8¾ 9½ | 4 17 4 | May and November | .. | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 7 7⅝ | 7 7⅝ | 5 0 0 | — | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 2¾ | 2½ 2¾ | .. .. | — | — | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 107 | 103 107 | 5 12 8 | February & August | — | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 107 | 103 107 | 5 12 8 | " " | — | — |
| $1,177,000 | $1,000 | 7% | * Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 4 2 | May and November | — | — |
| £164,300 | £100 | 6% | * Do. 6 per Cent. Sterling Bonds (red.) xd | 100 105 | 100 105 | 5 14 3 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chili Telephone (fully paid) | 3½ 4 | 3½ 4 | 5 0 0 | — | — | — |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const.& Manufacturing | ⅜ ⅝ | ⅜ ⅝ | .. .. | — | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ½ ¾ | ½ ¾ | 5 14 3 | Yearly | .. | .. |
| 484,597 | 5 | 2/6 | National | 7⅛ 7¾ | 7½ 7¾ | 3 11 0 | June and December | 7¾ | 7⅝ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | " " | .. | — |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 19 | 17 19 | 3 8 7 | " " | 17½ | — |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅞ 7 | 6⅞ 7⅛ | 3 17 2 | — | 6⅞ | — |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 3 11 | January and July | .. | .. |
| 58,000 | 5 | 4/0 | United River Plate | 3¾ 4¼ | 3¾ 4¼ | 4 14 2 | July | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 101 103 | 101 103 | 4 15 3 | January and July | 104 | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| — | 5 | .. | Birmingham Electric Supply (fully paid) | 8 | 8 | .. | .. | .. | .. |
| .. | 5 | .. | Do. (£4 paid) | 4¾ | 6 | .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 16 17 | 16 17 | 2 18 10 | February & August | 16⅛ | 16 |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17½ 18½ | 17½ 18½ | 3 4 10 | January and July | .. | .. |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 132 136 | 132 136 | 3 14 1 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. .. | — | .. | — |
| £30,000 | £5 | 2/6 | Charing Cross & Strand Electricity Supply Corp. | 9¼ 9¾ | 9¼ 9¾ | 2 16 5 | — | 9⅜ | — |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — — | — — | .. .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. .. | — | .. | — |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 13¾ 14¼ | 13¾ 14¼ | 4 4 3 | — | 14⅜ | .. |
| 8,322 | £5 | .. | House-to-House Electric | — — | .. .. | .. .. | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | — — | — — | .. .. | January and July | — | — |
| 111,000 | 5 | .. | London Electric Supply | — — | 1 1½ | .. .. | — | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13 14 | 13 14 | 2 17 2 | — | 13¾ | 13½ |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 123 | 120 123 | 3 14 3 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 11½ 12½ | 12 13 | .. .. | — | 12½ | — |
| .. | .. | .. | Rand Electric | 1⅞ 1⅞ | 1⅞ 1⅛ | .. .. | — | .. | — |
| 19,980 | £5 | 2/6 | St. James and Pall Mall | 12 13 | 12 13 | 2 19 8 | — | 13⅜ | — |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 6 8 | — | .. | .. |
| 59,900 | 5 | 3/0 | Westminster Electric Supply (fully paid) | 11 12 | 11 12 | 2 18 4 | — | 11⅞ | 11⅜ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1½ 1⅞ | 1⅝ 1⅝ | .. .. | — | 1⅝ | 1½ |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1½ 2 | 1¾ 2 | .. .. | — | 1⅝ | 1½ |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures xd | 110 113 | 110 113 | 3 19 8 | March & September | .. | — |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref | 2 2½ | 2 2½ | .. .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1¾ 2¼ | 1¾ 2¼ | 6 13 4 | February & August | 2⅛ | 2¼ |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 6 4 | January and July | 106½ | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. — | — — | .. .. | — | — | — |
| 110,000 | 2 | 1/0 | Electric Construction xd | 1⅝ 1⅝ | 1⅝ 1⅝ | 3 1 6 | — | 1⅜ | .. |
| 12,845 | 2 | 2/9½ | Do. 7 per Cent. Cumulative Pref. xd | 2½ 3½ | 2¾ 3½ | 4 6 2 | September | .. | .. |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ¾ 1 | ¾ 1 | .. .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. .. | — | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 22 23 | 21½ 22½ | 4 8 11 | February & August | 22½ | 22⅛ |
| £200,000 | 100 | — | * Do. 4 per Cent. Debentures | 107 110 | 107 110 | 3 12 9 | March & September | .. | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ¾ 1 | ¾ ⅞ | .. .. | .. | 19 | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 40 43 | 40 43 | 4 3 10 | March and July | 4½ | 4⅜ |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 104 107 | 104 107 | 4 14 4 | January and July | .. | .. |
| £100,000 | 10 | 6/0 | W. T. Henley's Telegraph Works Ordinary xd | 18 19 | 18 19 | 4 10 1 | March & September | .. | .. |
| £30,000 | 10 | 7% | Do. 7 per Cent. Preference xd | 18½ 19½ | 18½ 19½ | 3 11 10 | " " | 19 | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock xd | 110 115 | 1 0 115 | 3 18 3 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1⅜% | City and South London Railway Con. Ordy. | 51 53 | 51 53 | 2 16 7 | January and July | 52½ | 52 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15 | 14½ 15 | 3 6 8 | " " | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 138 | 136 138 | 2 18 0 | May and November | — | — |
| 37,500 | £10 | 2½ | Liverpool Overhead Railway | 13½ 13⅝ | 13½ 13⅝ | 2 4 9 | — | .. | — |
| 10,000 | 10 | 5% | Do. 5% Preference | 16⅜ 17⅜ | 16⅜ 17⅜ | 2 17 7 | — | — | — |
| 115,000 | Stock | 4% | Do. 4% Debenture | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July | — | — |

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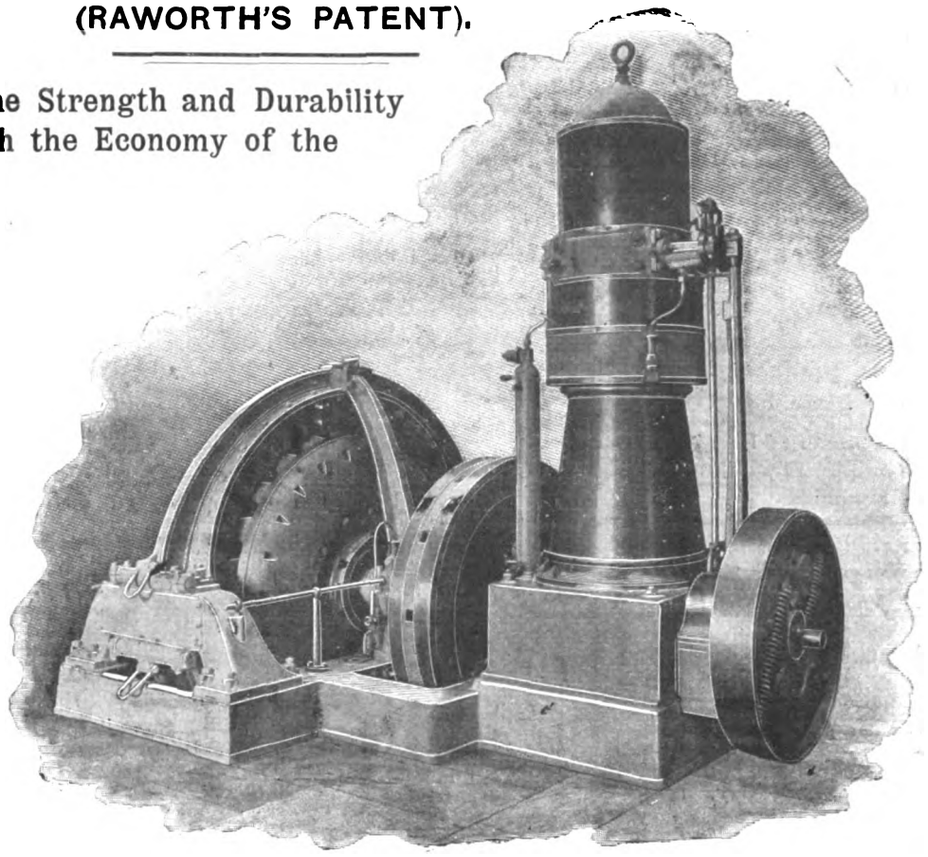

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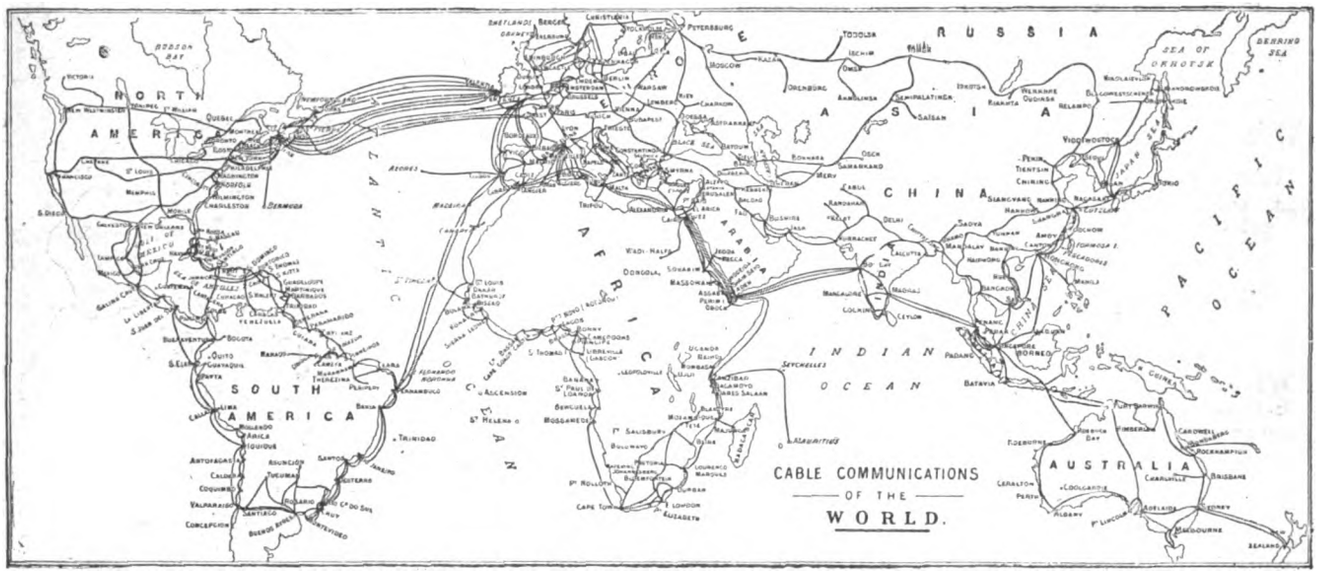


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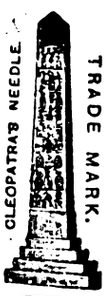


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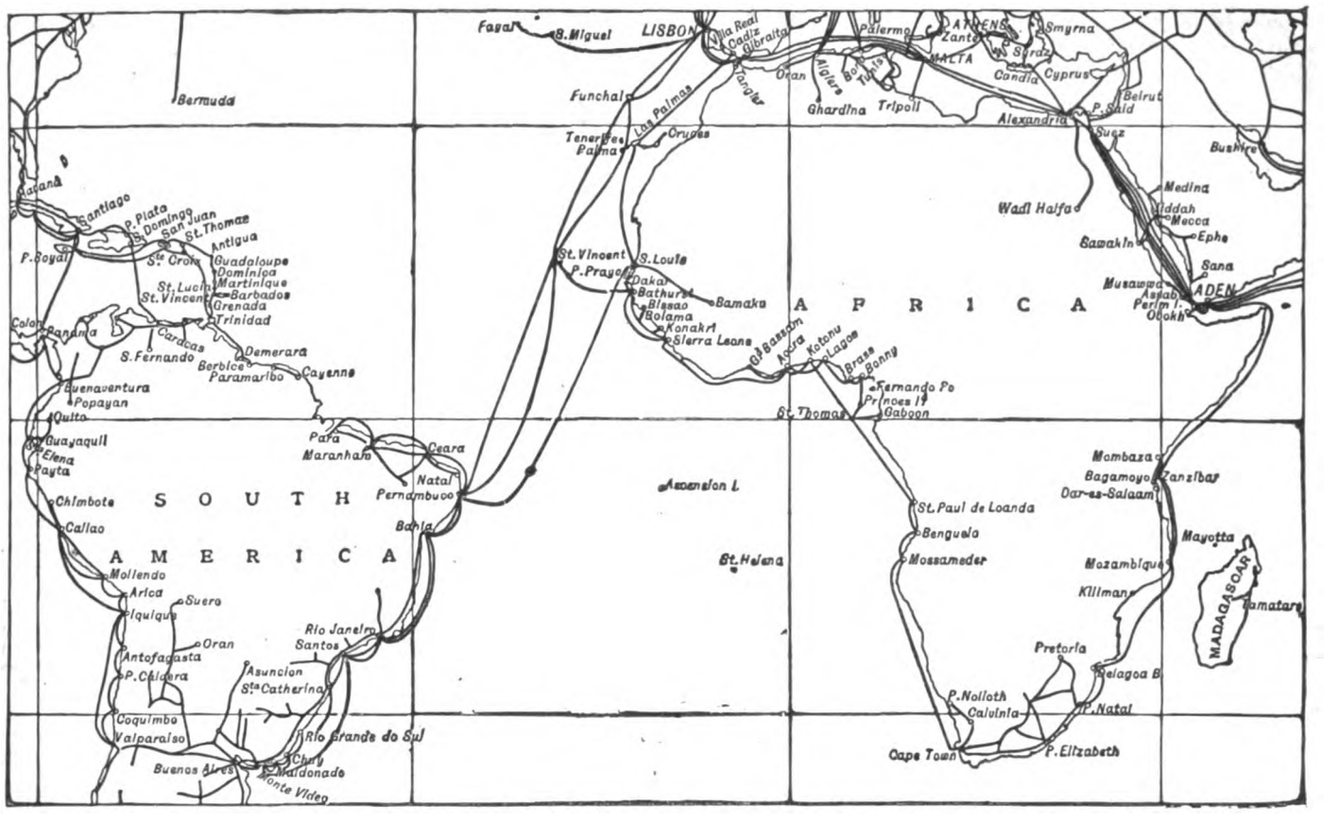


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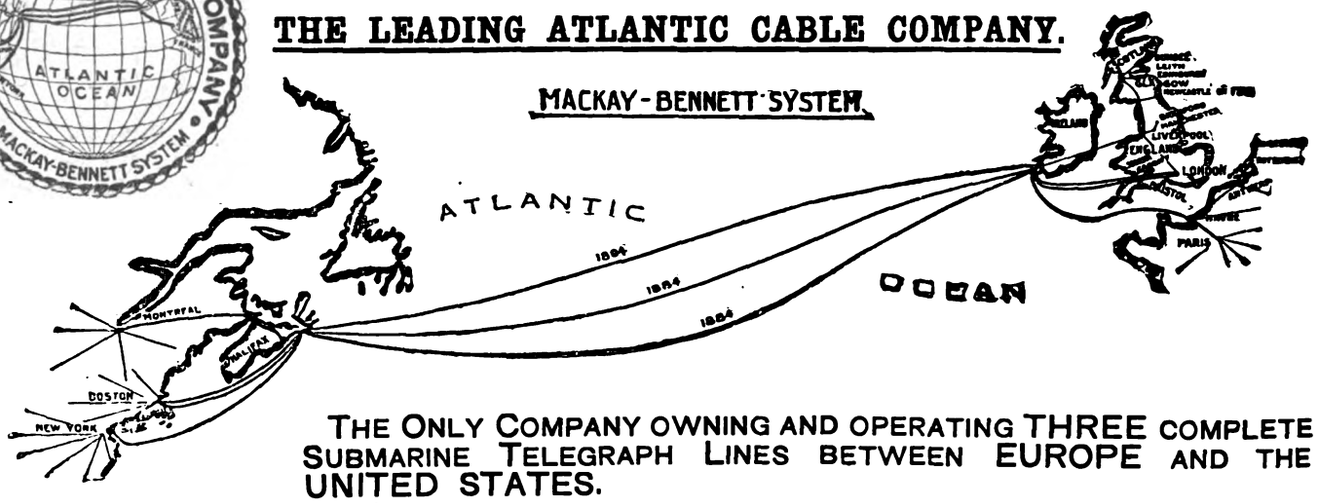


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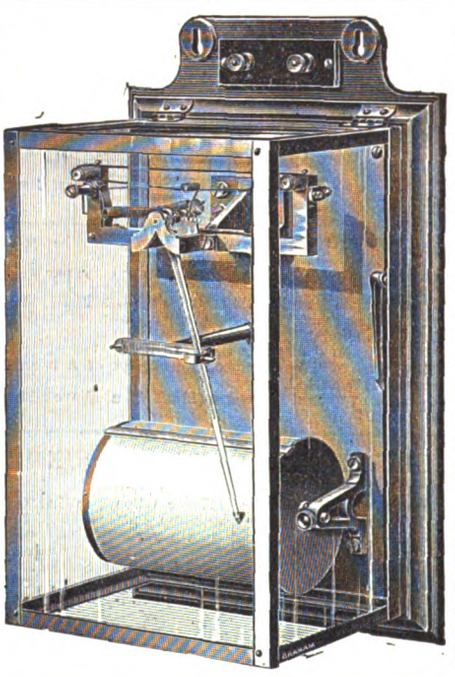

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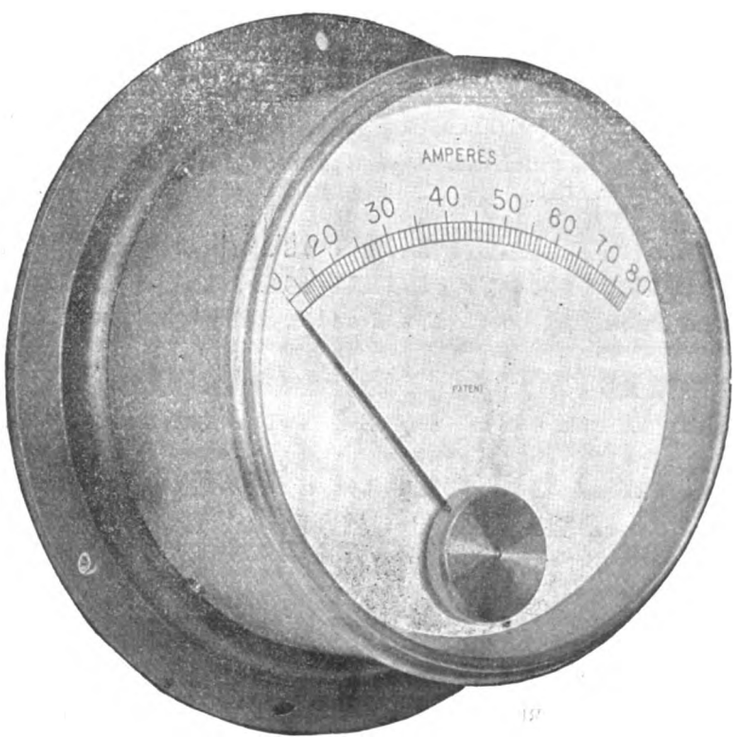


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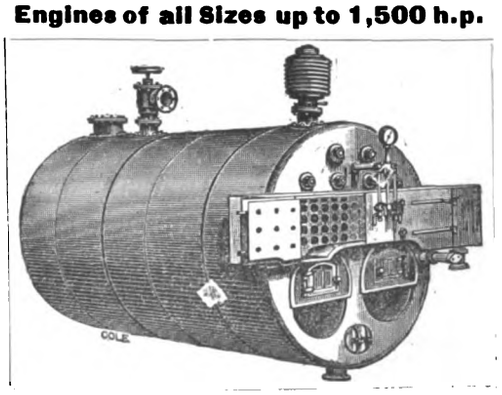

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ESTABLISHED 1861—1878.

No. 957. [Vol. XXXVII. No. 21.] FRIDAY, SEPTEMBER 18, 1896. PRICE SIXPENCE.


## NOTES.

PROF. J. J. THOMSON'S Presidential Address to the Mathematical and Physical Section of the British Association deals, as is customary, with a variety of subjects, though the main topic is Prof. RÖNTGEN'S great discovery. Prof. THOMSON sees no reason to alter his opinion, an opinion held by most English physicists, that cathode rays are nothing more occult than "negatively charged particles moving with high velocity," and he gives good reasons for his belief that the discovery of Lenard rays is no way incompatible with this hypothesis. Coming to Röntgen rays, Prof. THOMSON gives an admirably lucid *exposé* of the Helmholtz theory of dispersion, and sums up our knowledge in regard to the true nature of X-rays in the following words:—"Though there is no direct evidence that they are a kind of light, there are no properties of the rays which are not possessed by some variety of light." The address concludes with an account of the "heroic attempts" of Prof. LODGE and of Prof. THOMSON himself "to set the ether in motion." At the Cavendish Laboratory experiments are in progress to detect movement of the ether in the neighbourhood of an electric vibrator; so far the results are entirely negative. We hope with Prof. THOMSON that these experiments "may throw some light on the properties of that medium which is universal, which plays so large a part in our explanation of physical phenomena, and of which we know so little."

IN the Paper by Herr W. LEICK, which we print this week we have a valuable contribution to magnetic data in the careful redetermination of the properties of electro-deposited iron. In the hands of former experimenters various contradictory results had been obtained. Herr LEICK'S patient investigations now clear up the discrepancies, and show that films of pure iron so deposited not only acquire a permanent magnetism during deposition in even so feeble a magnetic field as that of the earth, but also possess a great coercive force, resembling, in this respect as well as in mere hardness, the hard and brittle varieties of steel.

INCIDENTALLY Herr LEICK notes two magnetic properties apparently peculiar to *thin* films of iron as the result of their thinness. The thinner they are the nearer does the ratio of their permanent magnetism to their temporary magnetism approach toward unity. Apparently the infinitely thin film of iron ought to retain all its temporary magnetism, and give a square-topped hysteresial loop. Further, with films so thin that there is no appreciable room for internal eddy currents, it makes no difference to their residual magnetism whether the currents are switched off slowly or suddenly. In this case the ordinary precautions for gradually diminishing the current may be neglected. It would be interesting to know if these properties—observed in electro-deposited films—are confirmed in thin laminæ of iron prepared by other processes. It is a pity that Herr LEICK did not seem to be aware of the method of depositing iron commercially used in the process of *aciérage*. No one who has ever worked this process would for a moment expect it to yield a *soft* quality of iron.

IN another column we publish a brief account of some further investigations by Prof. ROÏTI on X-ray phenomena. Amongst other things Prof. ROÏTI attempted to obtain X-rays using sulphuric acid as the anti-cathode; but the dissociation of the acid was the only result of impinging a cathode beam upon $H_2SO_4$. That the degree of exhaustion of the generating tube is the proximate cause of the quality of X-ray emitted by it, receives a further confirmation at the hands of Prof. ROÏTI, who finds that if he arranges a series of tubes in the order of the penetrative power of the rays given out by them, their order of merit remains the same when different induction coils and different electromotive forces are used. X-rays have so far exhibited so many perplexing properties that it is satisfactory to find that a ray which will penetrate one substance comparatively easily will likewise easily pass through others. It only needed a differential selective action here to have made confusion worse confounded. Prof. ROÏTI also brings out very clearly the futility of erecting a scale of transparency for X-rays without at the same time specifying not only their source, but the path they have traversed before falling upon the fluorescent screen and the material of the screen itself.

ACCORDING to M. BOUVIER'S Report, a translation of which from the *Comptes Rendus* is given in the present number, we gather that the French Postal Department in Tonquin has been much disturbed by the breakdown of their subterranean lead-covered cores due to the attacks of white ants. This appears to have been a novel experience to their officials. The very full description given by M. BOUVIER of the results of his examination of a faulty specimen of cable submitted to

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him and the suggestions he has made in order that future trouble may be avoided are very much to the point. Notwithstanding the statement that leaden bullets were riddled by insects in the Crimea, we prefer to believe that accidental holes or imperfect joints in the lead tube were the prime cause of the mischief by permitting entry to these raiders. We should have liked more information as to the general condition of the lead covering, as it is a well-known fact that lead is quickly attacked by the action of certain soils, especially those of a clayey nature, and that such action may be avoided by the free use of a tarry compound.

When the present telegraph cable system in the East was first established continual trouble was experienced in maintaining the land connections between cable houses and stations in perfect or even in working order; and it was proved that in the main the white ant, occasionally assisted, however, by the *Laodicea antennata*, was responsible for the difficulties. Tar and silica, and also arsenic, were amongst the remedies applied, but all resulted in failure; for wherever the iron wire sheathing of the cable permitted of his access to the interior, so surely did the white ant find his way in, and attacked the core. The subsequent adoption of the "pipe-line system" of land connections in 1874 put a stop to all mischief of this nature. Examinations made of several faults of this class removed from soil similar in many respects to that of Haiphong show that the attention of the white ant is drawn to the cable by the presence of the usual jute outer and inner servings, and that though he bores into the gutta-percha, it is more because it stops his progress than for any preference or liking he has for it. Jute and fibrous materials generally are his special delight.

M. Bouvier's suggestions, if properly carried out, will, no doubt, assist in the satisfactory maintenance of the line; but, if practicable, the method now obtaining in cable companies of enclosing gutta-percha-covered conductors in pipes kept full of water should be adopted, as this system, wherever adopted, has proved a thorough success.

In his first Cantor lecture on "Applied Electro-Chemistry" which we reprint this week, Mr. Swinburne apologises for indulging in elementary economics. No apology is needed. If it were made compulsory for all promoters of electro-chemical undertakings to go through a course of elementary economics, there would perhaps be fewer such schemes and a smaller percentage of financial failures. It is not considered orthodox in these enlightened days to openly avow that one has found the Philosopher's Stone, but there is a distinct hint of some such discovery in the prospectuses and preliminary puffs of many electro-chemical ventures. One would scarcely think on reading these documents that we live in a world the ruling commercial principle of which is "nothing for nothing and precious little for sixpence."

A careful reading of the Circular relating to the Official Vocabulary of Code Words issuing from the Berne Bureau, will show all interested in codes, or code compiling, that the Second Edition of the Official Vocabulary will take up a very different position to that which it was intended the first should occupy. The compilation issued some time ago claimed to be, but was not, a Vocabulary for use in code telegraphy, from which every word had been eliminated which could in any way be easily mistaken for another word. The next will merely be a list of the words available in the authorised languages, with the addition of proper names; and the work of eliminating unsuitable words will, as heretofore, be left to code and code vocabulary compilers. It is, therefore, of capital importance to all users of codes, as well as to the Telegraph Administrations, that it should be thoroughly understood that the words which may appear in the second edition cannot safely be used as they stand; and that unless extensive elimination of words too closely resembling each other from telegraphic, typographic, orthographic, caligraphic and phonetic points of view be made, the result will be an enormous increase of errors in messages, and consequent loss of time and money to those telegraphing in code, as well as to the Telegraph Administrations.

The decision of the Conference is most sensible, and, in fact, is the only one which the circumstances of the case admit of. Under this new arrangement there should be no disarrangement of codes which consist only of legitimate words; and we would suggest that in sending a copy of such codes to Berne a request should be made that, before deciding not to insert in the Vocabulary any words in such codes or Vocabularies, on the ground of their being made-up words, the compiler should be allowed the opportunity of justifying their validity; and in coming to a final decision on this point it is much to be hoped that the Berne officials will not be pedantic. It should further be pointed out to the International Bureau that if we allow for the enormous number of words which must be struck out to obtain a good telegraphic code, a quarter of a million words is nothing like enough. In one case in our knowledge a million and a quarter words were reduced to 120,000 when the necessary revisions had been made. That is to say, if possible, ten times as many words should be given in the Official Vocabulary as the largest code is likely to contain. With a liberal use of proper names drawn from Directories and Gazetteers and of inflections there should be no difficulty but that of time in obtaining an ample supply of words and producing a Vocabulary which shall be of immense value to all concerned, and give finality to a long vexed question.

Quite a minor state of panic has arisen in the good city of Limerick due to the invincible belief of the law adviser to the Corporation that a Provisional Order confers upon the holder thereof, not only the proud privilege of temporarily making the streets in a mess and permanently supplying current under statutory conditions, but of summarily extinguishing all other electric light undertakings in the area covered by the Order. It is true that Prof. Kennedy has not lent the weight of his name to so strange and so unfounded a piece of legal heterodoxy; but, nevertheless, the minor state of panic continues to exist. When we consider that it is expressly laid down in Section I. of the Act of 1888, that the granting

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of a Provisional Order confers no monopoly, and that nothing but the good sense of the Board of Trade prevents the granting of a second Order, even in an area already covered by a municipal electrical undertaking, we are at a loss to imagine where the erroneous notion could have arisen, that an hotel proprietor or a big shopkeeper, who cares to bother himself with a gas-engine and battery of accumulators, cannot light his own premises or oblige a friend next door with a few watts. Sections 2 and 3 of the Act of 1882 are said to be the basis of this iron tyranny, but we have searched them in vain for anything to support it.

**Correspondence.**—Owing to pressure on our space this week we have been compelled to hold over a portion of our correspondence.

**Telephonic Communication between France and Belgium.**—A long-distance telephone line is being erected between Paris, Dunkirk and Ostend.

**Battersea Polytechnic.**—We have received a copy of the prospectus of the day and evening classes to be held, during the ensuing session, at the Battersea Polytechnic. Classes and laboratory instruction are arranged for electro-technical and allied subjects.

**Obituary.**—The death is announced, from Naples, of Sig. Palmieri, Director of the Vesuvius Observatory. Sig. Palmieri was appointed Director of the Vesuvius Meteorological Observatory in 1854, and did good work in connection with atmospheric electricity.

**Birkenhead.**—It is announced that the Corporation of Birkenhead are now prepared to offer to the public a supply of electrical energy. The total capital expenditure up to the present is estimated at about £21,000. Distribution is on the three-wire system at 460 volts.

**Appointment.**—Mr. A. P. Trotter has been appointed by the Council of the London Chamber of Commerce an honorary correspondent of the Chamber at the Cape in regard to electrical matters, the necessary permission to act in this capacity having been obtained from the Cape Government.

**Goldsmiths' Institute, New Cross.**—The classes in electrical engineering, and magnetism and electricity commence on Monday, the 28th inst. A special course of mathematics for electrical engineering students will commence in November if a sufficient number of entries is received. Additional particulars will be found in our advertisement columns.

| Cable Interruptions. | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique | Dec. 19, 1895. |
| Monte Alegre—Santarem | May 5, 1896. |
| Para—Maranham | Aug. 6, 1896. |
| Bahia—Rio de Janeiro | Sept. 4, 1896. |
| Penang—Medan | Sept. 7, 1896. |
| Loanda—Benguela | Sept. 13, 1896. |

**A Novel Electric Locomotive.**—An electric locomotive of a novel type is said to be about to be tried experimentally on the lines of the Manhattan Railway Company, New York. The engine is to carry a secondary battery, which will be charged by current obtained from a third rail as the motor moves over the line. The charge thus obtained will enable runs of 15 to 20 miles to be made over rails not electrically equipped.

**Water-Power Utilisation in France.**—From official statistics, says *Engineering*, water-power would seem to have taken an extraordinary development in France, as it appears that there are more factories using water than steam. Thus, out of a total of 118,655 separate workshops, 59 per cent. generate their power by water, though the hydraulic plants are, it is true, much smaller than those run by steam.

**Institution of Civil Engineers.**—Mr. A. S. E. Ackermann wishes us to state that as he finds by the postmarks many members are still away on their holidays, and also as the Colonial replies will not arrive for some time, he will be obliged if members on their return will kindly send in their answers to his circular (relating to the mode of election of Council) at their earliest convenience, if they have not already done so. He states that the results so far are very encouraging, the ratio of approvals to disapprovals being as 5 to 1.

**Discharge of Electrified Bodies by X-rays.**—In the *Comptes Rendus*, Vol. CXXIII., No. 10, Signor Emile Villari briefly describes some experiments carried out by him, which corroborate in a striking manner the belief of M. Perrin and others that the discharge of electrified bodies by X-rays is a secondary phenomenon, due to air molecules dissociated by the rays travelling along the lines of force and striking the body at the point at which the rays impinge. Signor Villari assisted the ionic movement by blowing a powerful blast along the lines of force, and succeeded in increasing the rate of discharge of an electrified body; by blowing the same blast *across* the line of the rays he considerably diminished the rate of discharge.

**"The Horizontal Steam Engine."**—We have received from Messrs George Philip and Son a small book with the above title, containing coloured and "dissected" drawings of a horizontal engine fitted with Meyer's variable expansion gear. The letterpress, which is translated from the German of Herr Chr. Volkert, embodies a brief description of the various parts of an engine of the above type, as well as a short consideration of the methods of steam distribution by means of D and expansion slide-valves. The construction and use of Zeuner valve diagrams is also explained, the illustrations being very clear. The whole would give a young student a very good idea of the working of a steam engine, and might also be read with interest by the "general reader."

**Electric Tramways and Submarine Cables.**—The Cape Town electric tramway was opened on August 6th, and, owing to the neglect of ordinary precautions, bids fair to prove something more than a nine days' wonder. From the papers it would seem that on the opening day the traction current, finding no other easy way home, ran along a telephone wire, fusing it *en route*. The wire fell, and somewhat shocked an unhappy half-caste. Subsequently the telephone exchange narrowly escaped providing roast pig *à la Hoti* for the entire Chinese population of Cape Town, and this notwithstanding that the particular circuit selected by the truant traction current was protected by a $\frac{3}{4}$in. fuse; indeed, it was the arcing at the fuse that caused the mischief. But more important, more interesting, and more puzzling, than these trifling episodes are the disturbances in the submarine cable circuits, which terminate quite close to the present terminus of the tramway. According to the local papers, the running of the Cape Town electric cars can be "heard" at Accra on the West Coast. "Electricians" are said to be "hard at work endeavouring to discover some remedy for so serious an upset of the old order of things. . ." Probably nine-tenths of the trouble would be eliminated if the tramway company were to lay down an adequate return, properly connect to earth, and generally act according to Cocker; then the cause of the remaining tenth could be carefully and elaborately investigated.

**Brighton-Rottingdean Seashore Electric Railway.**—The Board of Trade have held an official examination of the Brighton and Rottingdean Electric Seashore Railway, which runs, at high tide, through about 12ft. of water, (see *The Electrician*, Nov. 8, 1895, p. 53). The Board was represented by Major Marindin, of the Railway Department, and Major Cardew, of the Electrical Department. On the trial trip the car was put to some severe tests. Various obstructions were put on the rails, such as masses of timber and concrete, heaps of flint and chalk, large iron sleepers, and so on; but the car simply brushed them all aside as so much soft snow, and passed smoothly on its way—so smoothly, in fact, that a pail of water which had been placed on the back of one of the "bogies" was not upset, nor was any of the water spilled. The return journey was at length started upon, when the rails were well covered with water, the depth of which, for the last half-mile, was considerable. Major Cardew was picked up at Brighton, and another start for Rottingdean was made forthwith. At Rottingdean an inspection was made of the machinery department. The inspectors expressed themselves as perfectly

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satisfied in every way with the new railway. The inspection was made under circumstances well calculated to severely test the safety of this novel mode of travelling, there being an equinoctial tide with a rough breeze. It is understood that the car will travel at a speed of about five and a-half miles an hour at high tide, and from six to seven miles an hour when the tide is out. The engines which supply the motive-power are at Rottingdean, and are of 120 horse-power.

**Physical Institutions and Electric Tramways.**—The following is from the *Frankfürter Zeitschrift*:—

"As already noticed, the junction of the Halle electric tramway with the horse-tramway in the same town is not to be allowed, as it would necessitate taking the electric conductor on the Sprague system, through the Grosse Ulrichstrasse, and past the Physical Institute. Expert opinions have been obtained with regard to the opposition of the staff of the Institute. Prof. Slaby, of the Charlottenburg Technical College, has given it as his opinion that the conductor should be allowed to be taken through the street, under certain restrictions intended to prevent the current influencing the work of the Institute. However, according to to-day's *Saale Zeitung*, the final decision of the Minister of Public Works is very unfavourable. This decision may be summed up as follows:—It cannot be denied that the system of working which the Allgemeine Electricitäts Gesellschaft (the leaseholders of the tramway) have in view is of a kind to affect the working of the Physical Institute. But it is not right to expect that the Physical Institute should have to devise means to lessen or neutralise the disturbance; and, besides, the precautions proposed are not considered sufficient, as they only ensure the protection of one single instrument, while the Physical Institute has frequently to work with a number of instruments at the same time. The tramway company must be allowed to make experiments with all suggested remedies, and then to prove indisputably that the arrangements they propose to adopt will prevent a disturbance of the work of the Institute if the proposed extension be carried out on the Sprague system. These experiments will have to be carried out at a distance from the Institute. If the Company does not see its way to do this they may construct the new line with underground conductors, or work with accumulators, or use any power other than electricity, and whatever is the most desirable from economical reasons."

The action of the Minister, says the *Electrotechnische Zeitschrift*, "will affect not only the Sprague system, but any other which uses the rails as return conductor. Thus university towns that shelter Physical Institutes in their midst will, to their own loss, be obliged to wait a long time for a transformation in their means of traffic which shall bring these up to date."

**The Troubles of the Borough Electrical Engineer.**—We had occasion recently to inquire of a municipal engineer why the station over which he presides had been so long a building. His reply was somewhat as follows:—The prevailing feature in my Electricity Committee is that it will rarely decide anything that can be deferred until the following week. On my appointment I found that an idea possessed the members of the Committee that they could erect the proposed electricity works on a hopelessly small site, and it took me some time to rid them of this notion. Thereupon a member of the Committee took upon himself to find a suitable site; but being a busy man he was unable to devote much time to the job, and as it was a difficult job it was several months before the purchase of the land was completed. A Sub-Committee was then formed to make the usual grand tour; but as it was composed of extremely busy gentlemen, it was not until nine months after my arrival on the scene that the grand tour commenced. Specifications were then drawn up, and a large number of tenders were received, and considerable time was occupied in examining them and preparing the necessary report. The report was referred to the Sub-Committee, which devoted considerable time to its consideration, though the difficulty was to induce the Sub-Committee to meet. Hence it was much more than a year after my appointment before the tenders were accepted. The only body which lost no time was the Local Government Board, which readily gave its consent after the local inquiry had been held. Difficulties then arose in connection with the foundations of the building. The main cause of the delay was, therefore, the anxiety of the Council, Committee, and Sub-Committee to see to everything themselves.

**South Shields Municipal Electric Lighting Station.**—The following are a few particulars relating to this station, which came into operation at the beginning of the present month:—The boilers are of the marine type, having an evaporative capacity of 5,000lb. of water per hour at 160lb. working pressure. The engines are vertical triple-expansion, driving direct. The engines are by Messrs. MacLaren, of Leeds, and are specially designed to have a very low consumption of steam at half, three-quarter and full load. The alternators are of the fly-wheel ironclad type, and were made by Messrs. Ferranti; they run at 125 revolutions. There is also a small plant, with a compound engine of 35 I.H.P., to which is coupled a 15-kilowatt alternator for the hours of light load, and a 10-kilowatt spare exciter. The total capacity of the station is 215 kilowatts. This will allow of 6,000 8 c.p. lamps being lighted at the same time, which means some 14,000 lamps connected to the circuit. There are also two rectifiers, each capable of supplying current for 30 lamps. The system of distribution is by high-pressure alternate-current feeders, with low-pressure distributors, the pressure being reduced by transformers placed in cast-iron boxes under the streets. There are at present 14 arc lamps erected. On each of the arc lamps there are incandescent lamps, which will be turned on at midnight when the arcs are switched off. The high-pressure mains are rubber-insulated concentric Silvertown cables, laid in cast-iron pipes. The distributors are rubber-insulated single cables, also laid in cast-iron pipes. The low-pressure service joints are made by cutting the cast-iron pipe and bolting on a cast-iron Tee, in which a mechanical joint is made, the Tee being then filled up with compound. The whole work, including the buildings, was designed by Mr. J. A. Jeckell, the Borough Electrical Engineer, and the specifications were drawn up by him, there being no consulting engineer or architect appointed. The Electric Light Committee are so pleased with the arc lamps in the streets (these have been running since August 17th) that they have recommended the Council to increase the number of street arcs from 14 to 31. There is every appearance that the electric light will prove as great a success in South Shields as it has proved in other towns where the plant has been properly designed.

**Contemporary Electrical Science.**—A somewhat sensational application of magnetometric methods to archæological questions is being made by G. Folgheraiter, whose communications on the subject will be found in the *Atti dei Lincei*. It aims at nothing less than the determination of the inclination of the earth's magnetic force in bygone ages from the magnetisation observed in Tuscan and other vases. The author proved, by imitating the manufacture of such vases in baked clay, that during the process of firing they are slightly magnetised by the earth's field. Assuming that they were placed upright in the furnace, and that the magnetisation was permanent, conclusions may be drawn with regard to the field of the earth at the time. The relation between its direction and that of the magnetisation is being investigated by means of experimental cones and cylinders placed in various positions.——There is also an interesting paper by Pettinelli and Marolli on the electric conductivity of hot gases. All gases have, according to these observers, approximately the same resistance when heated. At a temperature of 600°C. they begin to conduct appreciable currents. At 800°C. there is a sudden increase of the conductivity to ten times its value. It is the temperature at which dissociation sets in. After that the increase is slower. The gases examined were enclosed in a porcelain tube, and their temperature was given by the resistance of a platinum spiral. The influence of the size and the substance of the cathode was paramount. A porous cathode increased the conductivity very considerably, probably on account of the greater number of contacts with dissociated particles. The substitution of carbon for iron increased the conductivity a hundredfold at the temperatnre of the Bunsen flame, but only three or fourfold at 800deg. Metallic oxides and palladium electrodes also increase the conductivity of the gas. The current varies inversely as the distance between the electrodes if it exceeds 2mm. Below that it increases less rapidly.——In the *American Journal of Science* for September, Prof. Rood, of Columbia University, gives a detailed account of his experiments on the reflection of X-rays from polished surfaces of platinum, speculum metal, and tinfoil. The uniform result was that these surfaces reflected about half the radiation received in a regular geometrical manner, and the other half diffused, not as by a dull surface, but as by an imperfectly polished surface, the rays not having strayed much from the regular path.

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## PROF. J. J. THOMSON.

Prof. Thomson, the President of Section A at the meeting of the British Association now being held at Liverpool, has advanced Physical Science in many directions, and especially in the direction in which the way was pointed out by Clerk Maxwell, his great predecessor in the Cavendish Chair of Physics at Cambridge. It is as an Electrician that we present his portrait to our readers to-day, and on his electrical researches we shall chiefly dwell in this sketch of his life and work.

Prof. Thomson was born at Manchester in 1856. Educated first at a private school, he entered Owens College at the age of 14. At that time Barker was the Professor of Mathematics, and Stewart and Roscoe were the Professors of Physics and Chemistry. To the excellent grounding of Barker's mathematical teaching, and to the stimulating effect of the experimental training of Stewart and Roscoe, we must, no doubt, largely ascribe the set of his mind towards physical work. Thomson remained at Owens five years, and in his last year there he published his first paper; an experimental research showing that mere contact of two dissimilar bodies produces in them opposite electrifications, each of the same kind as that manifested when the two are rubbed together, and suggesting that the contact gives the polarisation of which the friction enables us to take advantage.

On leaving Owens in 1876, Thomson entered Trinity College, Cambridge. In 1880 he graduated as Second Wrangler and obtained the Second Smith's Prize. In the same year he was elected a Fellow of his College, and later was appointed an Assistant Lecturer.

In Thomson's undergraduate years Maxwell still held the chair of Physics, and his ideas and methods were now beginning to penetrate down to the undergraduate level, and to saturate the minds of all the more earnest students of Mathematical Physics. Naturally, then, we find that Thomson's first Paper after his degree was inspired by his study of Maxwell's work. It was on the "Electromagnetic Theory of Light," and among other results he found that if light travels in a medium itself moving in the direction of propagation, the velocity is increased by half the velocity of the medium, a result already obtained experimentally by Fizeau in the case of water. Later, in his "Recent Researches," he returned to this point, and showed that the result obtained differs according to the preliminary assumptions made; and Prof. Lodge's experiments have sufficiently shown that the subject is still full of difficulties.

A year later, in 1881, this was followed by a Paper investigating the motion of electrified particles in a magnetic field. He applied his results to the phenomena of a Crookes tube, assuming Crookes' explanation of a stream of charged atoms starting from the cathode, and he showed that the magnetic deflections observed by Crookes were of the kind given by his theory.

In the following years Thomson was occupied with a research on the value of "$v$," carried out in the Cavendish Laboratory under Lord Rayleigh, and with investigations on vortex motion. These were published in the *Philosophical Transactions*, and in 1883 he received the Adams Prize for an Essay on Vortex Motion, a most important contribution to the subject. Applying the ideas of vortex motion to electrical theory, he began in 1883 his great work on the electrical discharge in gases by publishing a theory of that discharge on the supposition that a gas molecule consists of two vortex rings in a fluid strung on the same axis, and successively going through each other. The electric field he supposes to consist of some kind of distribution of velocity in the surrounding fluid. If the velocity is in one direction parallel to the common axis, the rings tend to separate, in which case he shows that there is a reduction of the velocity of the surrounding fluid; that is to say, the molecule tends to break up into separate atoms, and in so doing absorbs the electrical energy. The theory gives a reduction of pressure along the lines of force, and an increase at right angles to them, in accordance with Maxwell's theory. I think we can trace in this Paper that, though the author had firmly grasped the idea that the discharge is essentially molecular dissociation, he still held what we may call the crude form of dissociation, and had not yet come to see the importance of the Grotthus chain, which he afterwards used to solve so many difficulties.

In 1884 Thomson was elected a Fellow of the Royal Society, and later in the same year, at the age of 28, he was chosen to succeed Lord Rayleigh as Cavendish Professor. It is hardly necessary to say that he maintained the reputation conferred on that chair by his predecessors, and that the Cavendish Laboratory continues under him to be a school of research of which all English physicists are proud.

In the following years he published, among others, Papers on the oscillations of charges on spheres and wires, in the latter applying his results to the propagation of such currents as those of the telephone along wires and cables. He was working, too, experimentally at the electric discharge in gases, feeling his way, we may say, in the subject.

In 1885 and 1887 he contributed two Papers to the *Philosophical Transactions*, which he amplified in his work on "The Applications of Dynamics to Physics and Chemistry," published in 1888. In the general methods of Lagrange and Hamilton any mechanical system is described not merely by distances, velocities and momenta of the masses concerned, but by quantities analogous to these. Thomson applies their methods to a physical system in which the quantities describing the system are the ordinary quantities of physical measurement. By known results he obtains relations which must hold between these quantities, and then from the relations he obtains other results which may not hitherto be known. As an example, v. Ettinghausen and Nernst have found that if heat is flowing along a thin plate of an electric conductor placed in a magnetic field, there is an electromotive force perpendicular to the plane containing the lines of heat flow and the lines of magnetic force. This gives a relation which shows that, if the effect holds also in a dielectric, then a heated dielectric placed in an electric field may produce a magnetic field. The work is a mine of suggestions for future research. Unfortunately many of the results predicted are so small that we must wait for their verification until our experimental methods are able to deal with higher decimal places than they have yet attained.

After the publication of Hertz's experiments Thomson made some notable contributions, theoretical and experimental, to the subject. Determining the resistance of various electrolytes, he showed it to be the same for the currents in Hertzian waves with a frequency of $10^8$ as for steady currents. But if the electromagnetic theory of light is true, the electrolytes are perfect insulators for waves with a frequency of $10^{15}$. Hence "the molecular processes which cause electrolytic conduction must occupy a time between $10^{-8}$ and $10^{-15}$ of a second." He also measured the specific inductive capacity of various dielectrics by making them in turn the insulator between the two plates of a Hertzian vibrator, and measuring in each case the length of the issuing waves. From this it is easy to compare the capacities. The values of K agreed with those required by the electromagnetic theory of light; and it is especially worthy of note that with a frequency of $25 \times 10^6$ the value of K for a glass plate was 2·7 or $1{\cdot}65^2$, practically the square of the refractive index for light waves; while for the same glass plate the tuning-fork method gave values between 9 and 11. "The discrepancy is probably due to the cause which produced the phenomenon of anomalous dispersion in some substances, and indicates the existence of molecular vibrations having a period slower than 25,000,000 per second."

Continuing the work on the discharge in gases, in 1890 Thomson showed that certain gases, when heated to the dissociation point, become good conductors, another link in the chain of evidence which he was gradually forming to show that the discharge is electrolytic, and that the dissociated atoms of a molecule are, the one positively, the other negatively charged. When the effect of heat is to break up the molecule into atoms, the charges on the electrode may be regarded as neutralised by the charges on the dissociated atoms; or rather, in the light of later theory, it may be said that the tubes of electric induction stretching from anode to cathode will more easily find chains of molecules on the point of dissociation through which they will pass, and whose disso-

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ciation they will complete. The tubes themselves will break up and discharge their energy in completing the dissociation. In his next Paper, "On the Velocity of Propagation of Electric Disturbance," he makes full use of the idea of Grotthus chains of molecules stretching through the gas, and shows that when such a chain becomes the seat of electric strain, it tends to break up, the atoms re-pairing, and leaving free a positively charged atom at one end and a negatively charged one at the other. He regards the striations as being groups of such chains, each striation being, as it were, a separate electrolytic cell with + atoms turned out at one end and − atoms turned out at the other. The spaces between are regions of combination of the − of one set of chains with the + of the next. We might expect such spaces to be proportional to the mean free path, for as this increases, so also will the average distance travelled before re-pairing occurs. Observation gives fair confirmation of this. The increase of strength of a layer of gas with diminishing thickness finds an explanation, and he points out that if the distance between the electrodes in a tube is less than the distance between two striæ, then the recombination may not occur sufficiently rapidly, unless the velocity of the atoms is very much increased or extra energy is supplied. In other words, the resistance to the discharge is increased, and this is in accordance with experiment. The dark space at the end of the positive glow is, he supposes, a region where the heat of recombination has produced sufficient dissociation to render the gas easily conducting.

Now came a most important Paper describing an experimental determination of the motion and velocity of the glow in an ordinary exhausted tube by the revolving mirror method. The glow was found to start always from the anode, and to move almost to the cathode with a speed nearly that of light. This speed far exceeds anything which could be attributed to the atoms themselves, for with such speed they would require immensely more energy than that supplied by the current. The travelling glow is therefore the propagation of a condition. The electric strain entering the tube passes down the Grotthus chains of molecules from the positive end, and with the speed of light, producing interchanges of partners along the line.

All these views are set forth much more simply if the electric field and its changes are described by Faraday's induction tubes and their motion; and Thomson now turned to a development of the theory of these tubes, which will be found in his "Recent Researches."

His well-known experiments on the discharge in tubes without electrodes, and on the effect of a magnetic field in such tubes, still further confirmed his view of the nature of the discharge. Some experiments on the electrolysis of steam brought out the remarkable result that an arc discharge turns out the oxygen positively charged, so that it goes to the cathode while the hydrogen is negatively charged and goes to the anode. A spark discharge of a certain length exactly reverses these effects, and turns out the electrolytes at the ends at which they appear in the electrolysis of water. This experiment thus showed that the same atoms could have charges of either sign.

In 1894 the revolving mirror method was applied to measure the velocity of the cathode rays in a Crookes tube. The interval of time between the commencement of phosphorescence on two patches at different distances from the cathode on starting a discharge was measured in a hydrogen tube, and the velocity of the exciting agent was found to be $1{\cdot}9 \times 10^7$ cm./sec. a hundred times greater than the velocity of mean square of hydrogen molecules at 0°C, but only a thousandth part of the velocity of the glow in a less exhausted tube. The velocity of the atoms on Crookes's theory of the rays may be calculated from the known fall of potential at the cathode, and the known charge carried by a known mass of dissociated hydrogen. Equating the electrical energy lost to the kinetic energy gained, Thomson found a velocity almost identical with that given by his experiments.

Combining this with his previous investigation on the magnetic action on electrified particles, it seems impossible to have any further doubt of Crookes's explanation that the so-called rays are truly a stream of electrified atoms. It is a misfortune that we still continue to describe the phenomenon thus, instead of terming it the cathode stream.

Last year further experiments were made to show that gases are electrolysed by the discharge, and the spectroscope was brought into the service. In one experiment a tube was divided in the middle by a metal plate perpendicular to its axis, and the spectra of the gases on the two sides of the plate could readily be compared. The same element was turned out from some compounds with a positive, and from others with a negative charge, and there was evidence tending to show that the spectrum given when the atom is positively electrified is different from that given by the same atom when negatively electrified.

Last December a very important Paper was published in the *Philosophical Magazine*, in which mechanical illustrations are given of the possibility of an atom being at one time positively and at another time negatively charged. It is shown that in one case it will possess more energy probably than in the other. The ideas derived from the illustrations are used to explain the difficulties in the theory of electrolysis, but this Paper is too recent to require an account to be given here.

I have given the fullest account of Prof. Thomson's researches on the electric discharge in gases, for they appear to me to constitute his greatest work. When he took up the subject there was an immense mass of confused and confusing facts. By his theory of Grotthus chains and their electrolysis, and by the series of test experiments, he has gone far to reduce the mass to order and to establish his theory.

We all know the part Thomson has taken in the work on the Röntgen rays, and have read his account of the subject in the Rede Lecture which he delivered a few weeks ago at Cambridge. Besides his contributions to Science in the form of papers and the works already mentioned, Prof. Thomson has edited "Maxwell's Electricity" and has added a third volume, "Recent Researches in Electricity and Magnetism," worthy of the work which it is intended to supplement. He has recently published a text-book on Electricity, which puts the mathematical theory of Electricity in a form useful to students who are unable to attack the difficulties of Maxwell.

Prof. Thomson's work has been recognised by the Royal Society in the award in 1894 of a Royal medal. He has been elected an honorary member of the Manchester Literary and Philosophical Society and of the Royal Society of Turin.

J. H. P.

## ELECTROMAGNETIC THEORY.—XC.*

BY OLIVER HEAVISIDE.

(*Continued from page 565.*)

§ **364.** There are several ways of obtaining a full development of the solution (61), one or two of which may be done here, with side matters. We have to find the time integral of $\epsilon^{-\rho t}\mathrm{I}_0(\sigma t)$, and a first way is to shift the exponential to the left, thus

$$\frac{1}{p}\epsilon^{-\rho t}\mathrm{I}_0(\sigma t) = \frac{\epsilon^{-\rho t}}{\rho}\frac{\rho}{p-\rho}\mathrm{I}_0(\sigma t) = \frac{\epsilon^{-\rho t}}{\rho}u, \text{ say.} \qquad (74)$$

Here the operation $(p-\rho)^{-1}$ to find $u$ must be done by integrations, like the $p^{-1}$ from which it arose. So

$$u = \left(\frac{\rho}{p} + \frac{\rho^2}{p^2} + \frac{\rho^3}{p^3} + \ldots\right)\left(1 + \frac{\sigma^2t^2}{2^2} + \frac{\sigma^4t^4}{2^2 4^2} + \ldots\right). \qquad (75)$$

This is integrable at sight, making

$$u = \rho t\left(1 + \frac{\sigma^2t^2}{2^2 3} + \frac{\sigma^4t^4}{2^2 4^2 5} + \ldots\right) + \rho^2t^2\left(\frac{1}{\lfloor 2} + \frac{\sigma^2t^2}{2^2 3.4} + \frac{\sigma^4t^4}{2^2 4^2 5.6} + \ldots\right)$$
$$+ \rho^3t^3\left(\frac{1}{\lfloor 3} + \frac{\sigma^2t^2}{2^2 3.4.5} + \frac{\sigma^4t^4}{2^2 4^2 5.6.7} + \ldots\right) + \ldots, \qquad (76)$$

where the law of the coefficients is obvious, every set being the integral of the preceding one. Therefore, by (61),

$$\mathrm{C} = \frac{\mathrm{V}}{\mathrm{L}v}\epsilon^{-\rho t}\left\{\mathrm{I}_0(\sigma t) + \left(1 - \frac{\sigma}{\rho}\right)u\right\} \qquad (77)$$

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expresses the complete development in one form, showing the C due to steady V when all four properties of the circuit are in operation. The part involving $u$ goes out when there is no leakage.

As a check upon (77), another way may be indicated. We have

$$C=\frac{V}{Lv}\epsilon^{-\rho t}\left(1-\frac{\sigma}{p}\right)\left(1-\frac{\sigma^2}{p^2}\right)^{-\frac{1}{2}}\epsilon^{\rho t}, \qquad (78)$$

by the first of (52). Here write out the operand $\epsilon^{\rho t}$ in full, then operate on it by $(1-\sigma^2/p^2)^{-\frac{1}{2}}$ expanded in rising powers of $p^{-2}$, and then operate on the result by $(1-\sigma/p)$. We shall obtain (77), after a little rearrangement of terms. There is nothing particular to notice in the process, so the details need not be given.

§ 365. But with a view to finding possible better forms of the function $u$, do (78) without expanding $\epsilon^{\rho t}$ first, so that the result is in terms of $\epsilon^{\rho t}$ and its integrals. We then get

$$C=\frac{V}{Lv}\epsilon^{-\rho t}\Big\{I_0(\sigma t)+\left(1-\frac{\sigma}{\rho}\right)\Big(\epsilon^{\rho t}-1+\tfrac{1}{2}\frac{\sigma^2}{\rho^2}(\epsilon^{\rho t}-e_2)+\frac{1.3}{2.4}\frac{\sigma^4}{\rho^4}(\epsilon^{\rho t}-e_4)+\frac{1.3.5}{2.4.6}\frac{\sigma_6}{\rho_6}(\epsilon^{\rho t}-e_6)+\ldots\Big\}, \qquad (79)$$

where $e_n$ is the sum of the first $n+1$ terms of the series for $\epsilon^{\rho t}$. Now, in (79) the inside exponential is cancelled by the outside one. The part of C not containing $t$ may therefore be exhibited separately. Thus,

$$\frac{1}{Lv}\left(1-\frac{\sigma}{\rho}\right)\left(1+\tfrac{1}{2}\frac{\sigma^2}{\rho^2}+\ldots\right)=\frac{1}{Lv}\left(1-\frac{\sigma}{\rho}\right)\left(1-\frac{\sigma^2}{\rho^2}\right)^{-\frac{1}{2}}=\left(\frac{K}{R}\right)^{\frac{1}{2}}, \qquad (80)$$

by the definition of $\rho$ and $\sigma$. So (79) becomes

$$C=V\left(\frac{K}{R}\right)^{\frac{1}{2}}+\frac{V}{Lv}\epsilon^{-\rho t}\Big\{I_0(\sigma t)-\left(1-\frac{\sigma}{\rho}\right)\Big(1+\tfrac{1}{2}\frac{\sigma^2}{\rho^2}e_2+\frac{1.3}{2.4}\frac{\sigma^4}{\rho^4}e_4+\ldots\Big)\Big\}. \qquad (81)$$

Another modification is got by arranging the function $u$ as it appears in (79) in powers of $\rho t$. We get

$$C=\frac{V}{Lv}\epsilon^{-\rho t}\Big\{\frac{\sigma}{\rho}I_0(\sigma t)+\left(1-\frac{\sigma}{\rho}\right)\Big\{(1+\rho t)+\left(\frac{\rho^2t^2}{\lfloor 2}+\frac{\rho^3t^3}{\lfloor 3}\right)f_1+\left(\frac{\rho^4t^4}{\lfloor 4}+\frac{\rho^5t^5}{\lfloor 5}\right)f_2+\left(\frac{\rho^6t^6}{\lfloor 6}+\frac{\rho^7t^7}{\lfloor 7}\right)f_3+\ldots\Big\}, \qquad (82)$$

where $f_n$ is the sum of the first $n+1$ terms in the expansion of $(1-\sigma^2/\rho^2)^{-\frac{1}{2}}$ in rising powers of $\sigma/\rho$ by the binomial theorem, and the coefficients of the $f$'s are the successive terms, in pairs, of the expansion of $\epsilon^{\rho t}$. It is a curious form. It can be seen to be correct in the two cases $\sigma=0$ and $\sigma=\rho$.

Comparing (82) with (77), we require this identity,

$$I_0(\sigma t)+\left(1-\frac{\sigma}{\rho}\right)u=\frac{\sigma}{\rho}I_0(\sigma t)+\left(1-\frac{\sigma}{\rho}\right)\Big\{(1+\rho t)+\left(\frac{\rho^2t^2}{\lfloor 2}+\frac{\rho^3t^3}{\lfloor 3}\right)f_1+\ldots\Big\}. \qquad (83)$$

or, which is the same,

$$u=-I_0(\sigma t)+1+\rho t+\left(\frac{\rho^2t^2}{\lfloor 2}+\frac{\rho^3t^3}{\lfloor 3}\right)f_1+\left(\frac{\rho^3t^3}{\lfloor 3}+\frac{\rho^4t^4}{\lfloor 4}\right)f_2+\ldots \qquad (84)$$

This may be verified by means of (76), rearranging terms therein.

§ 366. Lastly, compare the results with those got by the process of integration by parts. We have

$$\int_0^t\epsilon^{-\rho t}I_0(\sigma t)dt=\left[\frac{\epsilon^{-\rho t}}{\rho}I_0(\sigma t)\right]_0^t+\int_0^t\frac{\epsilon^{-\rho t}}{\rho}pI_0(\sigma t)dt. \qquad (85)$$

Repeat this process again and again, and we get

$$=\left[\frac{\epsilon^{-\rho t}}{\rho}\left(1+\frac{p}{\rho}+\frac{p^2}{\rho^2}+\frac{p^3}{\rho^3}+\ldots\right)I_0(\sigma t)\right]_0^t$$

$$=\left[\frac{\epsilon^{-\rho t}}{\rho}\frac{I_0(\sigma t)}{1-p/\rho}\right]_0^t=\frac{1}{(\rho^2-\sigma^2)^{\frac{1}{2}}}-\frac{\epsilon^{-\rho t}}{\rho}\frac{I_0(\sigma t)}{1-p/\rho}. \qquad (86)$$

It is to be understood here that $(1-p/\rho)^{-1}$ is done by differentiations. We therefore make (78) or (61) become

$$C=V\left(\frac{K}{R}\right)^{\frac{1}{2}}+\frac{V}{Lv}\epsilon^{-\rho t}I_0(\sigma t)-\frac{VKv}{\rho}\epsilon^{-\rho t}\frac{I_0(\sigma t)}{1-p/\rho}. \qquad (87)$$

This agrees with (81), provided that

$$\frac{I_0(\sigma t)}{1-p/\rho}=1+\tfrac{1}{2}\frac{\sigma^2}{\rho^2}e_2+\frac{1.3}{2.4}\frac{\sigma^4}{\rho_4}e_4+\ldots, \qquad (88)$$

and this may be verified by carrying out the differentiations on the left side. Now we also know that

$$\frac{\rho/p}{1-\rho/p}I_0(\sigma t)=u, \quad \text{as above in (76),} \qquad (89)$$

this being done by integrations.

So, adding the results (88) and (89), this mathematical result follows :—

$$\left(1+\frac{\rho}{p}+\ldots+\frac{p}{\rho}+\ldots\right)I_0(\sigma t)=\sum_{-\infty}^{\infty}\left(\frac{p}{\rho}\right)^mI_0(\sigma t)=\frac{\rho\epsilon^{\rho t}}{(\rho^2-\sigma^2)^{\frac{1}{2}}}, \qquad (90)$$

the summation including all integral values of $m$, including zero.

The results are all consistent. But it is unfortunate that the additional terms brought in by leakage do not seem to be reducible to a single known simple function. If it could be so, then the result could be readily generalised to express the complete wave of current. If not, then we must rest satisfied with one or other cumbrous form of series.

§ 367. Having now got full results as regards V/C and C/V at the origin under different circumstances, we can go on to generalise them in certain cases. Consider (55) for example. Say,

$$C_0=\frac{e}{Lv}\epsilon^{-\rho t}I_0(\sigma t). \qquad (91)$$

This is the current produced at the origin ($x=0$) when the voltage there is $V_0=e\,\epsilon^{-Kt/S}$, $e$ being constant, beginning when $t=0$. If the cable is short-circuited at the origin, $V_0$ may be regarded as a variable impressed voltage inserted. If infinitely long both ways, then the impressed voltage must be $2V_0$. But we may also regard $V_0$ as being produced not by impressed voltage but by an initial state, namely, $V=2e$ initially on the whole of the left side of the origin.

Now, at distance $x$, we have

$$C=e^{-qx}C_0, \quad \text{where} \quad q=\frac{1}{v}\{(p+\rho)^2-\sigma^2\}^{\frac{1}{2}}. \qquad (92)$$

The current must be the same at the same distance on the negative side as on the positive. We may therefore put $\cosh qx$ for $\epsilon^{-qx}$. So

$$C=\cosh qx\,\frac{e}{Lv}\epsilon^{-\rho t}I_0(\sigma t). \qquad (93)$$

Shift $\epsilon^{-\rho t}$ to the left. Then

$$C=\frac{e\epsilon^{-\rho t}}{Lv}\cosh\frac{x}{v}(p^2-\sigma^2)^{\frac{1}{2}}.I_0(\sigma t). \qquad (94)$$

This gives C by direct differentiations, since only the integral powers of $(p^2-\sigma^2)$ are involved. Now

$$(\sigma^2-p^2)I_0(\sigma t)=t^{-1}pI_0(\sigma t)=\sigma^2\frac{I_1(\sigma t)}{\sigma t}, \qquad (95)$$

and generally,

$$(\sigma^2-p^2)\frac{I_m(\sigma t)}{(\sigma t)^m}=(2m+1)t^{-1}p\frac{I_m(\sigma t)}{(\sigma t)^m} \qquad (96)$$

$$=(2m+1)\sigma^2\frac{I_{m+1}(\sigma t)}{(\sigma t)^{m+1}}. \qquad (97)$$

This general property is proved by the differential equation of $x^{-m}I_m(x)$, § 336, equation (2); see also (18), § 337. Applying (96) to (94), we obtain

$$C=\frac{e\epsilon^{-\rho t}}{Lv}\Big\{1-\tfrac{1}{2}\frac{x^2}{v^2}(t^{-1}p)+\frac{1.3}{2.4}\frac{x^4}{v^4}(t^{-1}p)^2-\frac{1.3.5}{2.4.6}\frac{x^6}{v^6}(t^{-1}p)^3+\ldots\Big\}I_0(\sigma t), \qquad (98)$$

and, if we use (97) we get

$$C=\frac{e\epsilon^{-\rho t}}{Lv}\left\{P_0(\sigma t)-\left(\frac{\sigma x}{v}\right)^2\frac{P_1(\sigma t)}{2^2}+\left(\frac{\sigma x}{v}\right)^4\frac{P_2(\sigma t)}{2^24^2}-\left(\frac{\sigma x}{v}\right)^6\frac{P_3(\sigma t)}{2^24^26^2}+\ldots\right\}, \qquad (99)$$

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where $P_m(\sigma t)$ is the function got by dividing $I_m(\sigma t)$ by its first term, so that the first term of $P_m$ itself is unity. Of course the convergent formula is used, equation (23), § 338. Thus

$$P_m(\sigma t) = 1 + \frac{(\frac{1}{2}\sigma t)^2}{1\,.\,m+1}\left(1 + \frac{(\frac{1}{2}\sigma t)^2}{2\,.\,m+2}\left(1 + \frac{(\frac{1}{2}\sigma t)^2}{3\,.\,m+3}\cdots\right.\right. . \quad (100)$$

Now (99) is nothing more than the expanded form of

$$C = \frac{e}{Lv}\epsilon^{-\rho t} I_0\left\{\frac{\sigma}{v}(v^2t^2 - x^2)^{\frac{1}{2}}\right\}, \quad (101)$$

as may be seen by arranging its expansion in a series of powers of $x^2$. Therefore, the last equation is the generalisation required. Comparing with (91), we see that $vt$ is turned to $(v^2t^2 - x^2)^{\frac{1}{2}}$ in the $I_0$ function.

At the time $t$ the region occupied by the current extends only to the distance $vt$ from the origin. Beyond that distance the current is zero. Equation (101) therefore expresses a wave, whose front travels at speed $v$. At the wave front the current is $(e/Lv)\epsilon^{-\rho t}$. Since the $I_0$ function has been tabulated, the shape of the current curve along $x$, at successive moments of time, can be readily calculated.

§ **368**. The above is by far the simplest way of obtaining the wave solution, without prior knowledge. Of course, if it is already known that the formula satisfies the characteristic partial differential equation of C, there is no difficulty in finding the nature of the problem of which it is the solution. But it would not be reasonable to expect people to possess the prior knowledge.

Seeing that the preceding portion of this Chapter contains the treatment of various other cases than this important one, it is desirable to exhibit collected separately the various steps in the process of deduction. First, from the connections of voltage and current,

$$-\frac{dV}{dx} = (R + Lp)C, \qquad -\frac{dC}{dx} = (K + Sp)V, \quad (102)$$

we deduce the characteristic

$$\frac{d^2V}{dx^2} = (R + Lp)(K + Sp)V = q^2V; \quad (103)$$

from which we conclude that

$$V = \epsilon^{qx}A + \epsilon^{-qx}B, \quad (104)$$

is the type of solution required in general when A and B are time functions, and that the $\epsilon^{-qx}$ part is the only one wanted when we send disturbances into an empty cable; so that

$$V = \epsilon^{-qx}V_0, \qquad C = \epsilon^{-qx}C_0, \qquad C_0 = \left(\frac{K + Sp}{R + Lp}\right)^{\frac{1}{2}}V_0, \quad (105)$$

express V and C in terms of $V_0$ and $C_0$ at the origin, which are themselves connected by the third equation. So

$$C_0 = \frac{1}{Lv}\left(\frac{p + \rho - \sigma}{p + \rho + \sigma}\right)^{\frac{1}{2}}V_0 = \frac{\epsilon^{-\rho t}}{Lv}\left(\frac{p - \sigma}{p + \sigma}\right)^{\frac{1}{2}}\epsilon^{\rho t}V_0, \quad (106)$$

by making the operand be $V_0\epsilon^{\rho t}$. Then let $\epsilon^{\rho t}V_0 = \epsilon^{\sigma t}e$, where $e$ is constant; or $V_0 = e\,\epsilon^{-Kt/S}$. This makes

$$C_0 = \frac{e\,\epsilon^{-\rho t}}{Lv}\left(\frac{p - \sigma}{p + \sigma}\right)^{\frac{1}{2}}\frac{p}{p - \sigma} = \frac{e\,\epsilon^{-\rho t}}{Lv}I_0(\sigma t), \quad (107)$$

fully realised. Finally, generalise for the complete wave,

$$C = \epsilon^{-qx}C_0 = \cosh qx\, C_0 = \frac{e\,\epsilon^{-\rho t}}{Lv}\cos\frac{x}{v}(\sigma^2 - p^2)^{\frac{1}{2}}\,.\,I_0(\sigma t), \quad (108)$$

which develops to

$$C = \frac{e\epsilon^{-\rho t}}{Lv}I_0\left[\frac{\sigma}{v}(v^2t^2 - x^2)^{\frac{1}{2}}\right]. \quad (109)$$

If we do not make use of the property of equality of the current at $x$ and $-x$, without discontinuity at the origin, we have

$$C = \cosh qx\,.\,C_0 - \operatorname{shin} qx\,.\,C_0,$$

instead of as in (108), but the additional part will not bring in any new terms, because its first term will involve

$$(p^2 - \sigma^2)^{\frac{1}{2}}I_0(\sigma t) = pI, \quad (110)$$

by (71), and the rest involve complete differentiations upon the first term.

§ **369**. To obtain the formula for the V wave corresponding to (109), there are many ways of working. First, we may use the C formula itself, and the second circuital law. We have

$$-\frac{dV}{dx} = (R + Lp)C = L(p + \rho + \sigma)C$$

$$= \frac{e\,\epsilon^{-\rho t}}{v}(p + \sigma)I_0\left[\frac{\sigma}{v}(v^2t^2 - x^2)^{\frac{1}{2}}\right], \quad (111)$$

by (109).

Therefore V is the negative of the $x$ integral of the right member, provided it is standardised properly, to have the value $e^{-Kt/S}$ at the origin. Now, looking at the expansion (99), we see that its $x$ integral will vanish at the origin, So the real value at the origin must be added on. We therefore get

$$V = e\epsilon^{-\rho t}\left\{\epsilon^{\sigma t} - \left(1 + \frac{p}{\sigma}\right)\left[\frac{\sigma x}{v}P_0 - \left(\frac{\sigma x}{v}\right)^3\frac{P_1}{2^23} + \left(\frac{\sigma x}{v}\right)^5\frac{P_2}{2^24^25} - \ldots\right]\right\} \quad (112)$$

for a complete development of the V wave. There is one time differentiation concerned. We have

$$\frac{p}{\sigma}P_m(\sigma t) = \frac{\sigma t P_{m+1}(\sigma t)}{2(m+1)}, \quad (113)$$

by (100). From this,

$$\left(1 + \frac{p}{\sigma}\right)P_m(\sigma t) = 2^m\lfloor m\,\frac{I_m(\sigma t) + I_{m+1}(\sigma t)}{(\sigma t)^m}. \quad (114)$$

Using this in (112), we obtain the equivalent form,

$$V = e\,\epsilon^{-\rho t}\left\{\epsilon^{\sigma t} - \frac{\sigma x}{v}(I_0 + I_1) + \left(\frac{\sigma x}{v}\right)^3\frac{I_1 + I_2}{\sigma t\,3}\right.$$

$$\left. - \frac{1.3}{5}\left(\frac{\sigma x}{v}\right)^5\frac{I_2 + I_3}{(\sigma t)^2} + \ldots\right\}. \quad (115)$$

The argument of all the I functions is $\sigma t$.

This is not so compact as the C formula. But there is a similar peculiarity in the corresponding formulæ in pure diffusion, the current being given by an exponential formula, the voltage by the error function. *See* §§ 246, 247.

§ **370**. Another way of getting the V formula is more primitive. Do not use the developed C formula, but work from the beginning. Thus,

$$V = \epsilon^{-qx}V_0 = e\,\epsilon^{-qx}\epsilon^{(\sigma - \rho)t}, \quad (116)$$

because the voltage at the origin is $e\,\epsilon^{(\sigma - \rho)t}$. Now for $\epsilon^{-qx}$ put $(\cosh - \operatorname{shin})qx$, and shift $\epsilon^{-\rho t}$ to the left. Then

$$V = e\,\epsilon^{-\rho t}(\cosh - \operatorname{shin})\frac{x}{v}(p^2 - \sigma^2)^{\frac{1}{2}}\,.\,\epsilon^{\sigma t}. \quad (117)$$

Here the cosh part involves only complete differentiations upon $\epsilon^{\sigma t}$, and the potence of $p^2 - \sigma^2$ is zero. Only the first term of the cosh function does anything. So we get

$$V = e\,\epsilon^{-\rho t}\left\{\epsilon^{\sigma t} - \frac{\operatorname{shin}\frac{x}{v}(p^2 - \sigma^2)^{\frac{1}{2}}}{(p^2 - \sigma^2)^{\frac{1}{2}}}(p^2 - \sigma^2)^{\frac{1}{2}}\epsilon^{\sigma t}\right\}. \quad (118)$$

But here

$$(p^2 - \sigma^2)^{\frac{1}{2}}\epsilon^{\sigma t} = (p + \sigma)I_0(\sigma t), \quad (119)$$

by (36). So

$$V = e\,\epsilon^{-\rho t}\left\{\epsilon^{\sigma t} - \frac{x}{v}(p + \sigma)\left[1 - \frac{x^2}{3v^2}(\sigma^2 - p^2) + \ldots\right]I_0(\sigma t)\right\}. \quad (120)$$

Now carry out the differentiations $(\sigma^2 - p^2)$, once, twice, thrice, &c., upon $I_0(\sigma t)$, according to the formula (97) above, and the development (112) immediately results. This is the most direct way of obtaining the V formula. And, just as we derived it from the C formula by the second circuital law, so we may derive the C formula from that for V by a similar process, using the first circuital law.

§ **371**. We are now in virtual possession of the complete tail formulæ arising when electrification spreads and when momentum spreads. First, let there be the charge Q initially at the origin, which may be any point in a cable continuous both ways. Then, at time $t$ later, the voltage and current are

$$V = \frac{Q}{2Sv}\epsilon^{-\rho t}(p + \sigma)I_0\left[\frac{\sigma}{v}(v^2t^2 - x^2)^{\frac{1}{2}}\right], \quad (121)$$

$$C = \tfrac{1}{2}Qv\epsilon^{-\rho t}\left(-\frac{d}{dx}\right)I_0\left[\frac{\sigma}{v}(v^2t^2 - x^2)^{\frac{1}{2}}\right]. \quad (122)$$

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Similarly, let there be initially momentum P at the origin. Then at time $t$ later the current and voltage at $x$ are

$$C = \frac{P}{2Lv}\epsilon^{-\rho t}(p-\sigma)I_0\left[\frac{\sigma}{v}(v^2t^2-x^2)^{\frac{1}{2}}\right], \quad (123)$$

$$V = \tfrac{1}{2}Pv\epsilon^{-\rho t}\left(-\frac{d}{dx}\right)I_0\left[\frac{\sigma}{v}(v^2t^2-x^2)^{\frac{1}{2}}\right]. \quad (124)$$

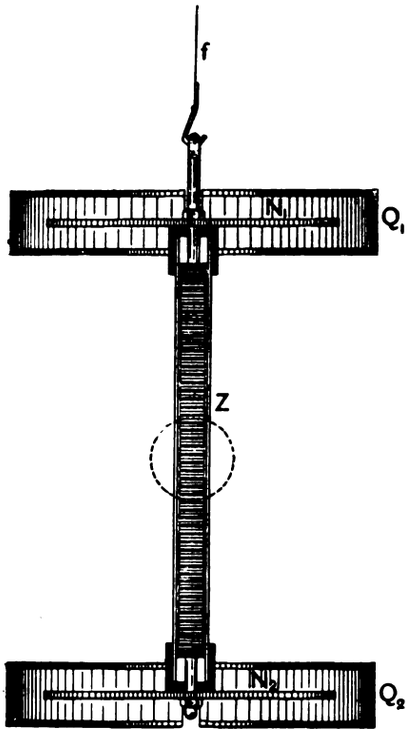
The last pair can be written down from the first pair, by interchanging V and C, P and Q, L and S, R and K.

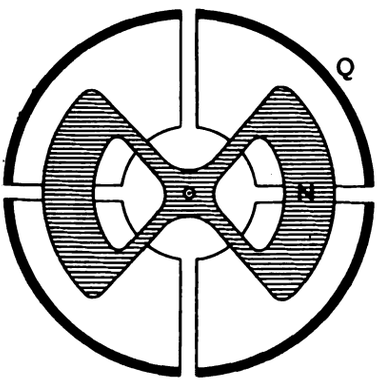
Observe that the spreading of current due to initial charge and the spreading of charge due to initial current take place in precisely the same way, (122) and (124). But the charge due to initial charge and the current due to initial current do not behave similarly, because of the change of sign of $\sigma$ in passing from (121) to (123).

*(To be continued.)*

## A DRY-PILE ELECTROMETER.

A description of a dry pile electrometer is given in a recent article by F. Dolezalek and W. Nernst, in the *Zeitschrift für Elektrochemie*. A Zamboni pile is used as a source of charge,




and the apparatus then takes the form shown in the accompanying figure, where Z is the pile suspended by a quartz fibre $f$, and having a needle $N_1$ at one pole, and another, $N_2$, at the other pole, swinging in the quadrants $Q_1$ $Q_2$. This arrangement, when enclosed in a metal case, and provided with the usual optical reading devices, constitutes an electrometer of great sensitiveness.

In endeavouring to realise the conception thus sketched, the authors found that a sufficiently-powerful pile made in the usual way with (false) silver and gold paper (*i.e.*, essentially copper and tin plates) proved too heavy to be carried by a quartz fibre ; when hung by a silk thread the inertia was unduly great. Investigation showed that the defects of the ordinary Zamboni pile, which give rise to the need for one of unmanageable size, are due less to the poor conductivity of the paper than to the polarisation of the pile. A remedy is found in the substitution of the elements Sn and $PbO_2$ for Sn and Cu. Lead peroxide prepared electrolytically is not only a good depolariser, but is a fair conductor. The improved pile consists, therefore, of tiny discs of "silver-paper" (paper covered with a film of tin on one side), covered on the paper side with a thin film of lead peroxide. Such a pile has 20 or 30 times the voltage of one made with the same number of discs of gold and silver paper. The authors ultimately succeeded in preparing a pile 6·5cm. in length and 4mm. in diameter, which had a potential difference of 1,400 volts. This pile, fitted with two aluminium needles and a mirror, weighed only 3·5 grammes, a weight well within the carrying capacity of a quartz fibre.

On account of the excellent and now fully-recognised torsional qualities of a quartz fibre, the electrometer, when suspended by a fibre 7cm. in length, gave a reading of 60mm. on a scale at a distance of 2 metres, with a difference pressure of 0·01 volt. As it was possible to reckon to one-tenth of a scale division, the limit of sensitiveness of the instrument may be set down at $10^{-5}$ volt. A certain disturbing influence, due to the fluctuation of the moisture of the air, has to be reckoned with; but this can be eliminated by closing the small glass tube containing the pile, and, as an additional precaution, keeping the air of the electrometer case approximately dry by exposing in it vessels of calcium chloride or sulphuric acid. Small differences of sensitiveness, *e.g.*, up to a maximum of 5 per cent. during a four weeks' observation, may be caused by variations of temperature which affect the working of the pile itself, and alter the relative position of the needles and the quadrants by reason of the different coefficients of expansion of the materials of which the instrument is constructed.

The authors sum up the advantages which they claim for their instrument in the following statements:—

1. The sensitiveness of the apparatus is about 100 times as great as that of existing quadrant electrometers.
2. The capacity of the apparatus is about $10^{-5}$—$10^{-6}$ of that of the ordinary capillary electrometer.
3. The instrument is always ready for use, it needs no charging battery, and is readily transported.

In a footnote appended to the article it is mentioned that in 1891 Mr. Vernon Boys endeavoured, without success, to use a Zamboni pile as an integral part of an electrometer. The pile oscillated in a horizontal plane, and its inertia and want of constancy caused its ultimate abandonment.

## THE CHLORATE OF POTASH WORKS AT NIAGARA FALLS.

BY ORRIN E. DUNLAP.

The new plant of the Chemical Construction Company at Niagara Falls is now in operation. This factory is located further east than any other plant on the Niagara Falls Power Company's lands, and is, therefore, more distant from the power house than are the other factories built there. This Company will make chlorate of potash on the Blumbenberg plan, chlorate of soda, chlorate of barium, &c., while later on it expects to make chloroform and iodoform. Eight acres of land have been leased from the Niagara Falls Power Company, and the power lease makes available 4,000 H.P. At present only 500 H.P. is in use, and the factory covers but a small portion of the land leased. It will thus be seen from these facts that the Company has made ample provision both in the matter of power and space for the enlargement of their plant in accordance with the dictates of their judgment and the

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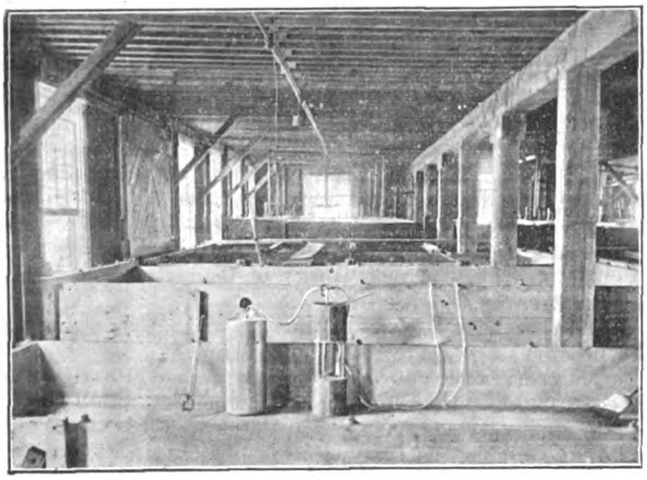
demand for their goods. As it stands to-day the plant is composed of three frame buildings, the main structure being two stories high, 125ft. long by 63ft. wide, and the transformer house 60ft. long by 40ft. wide. This building is also two stories in height. The third building is used as a storage building, and is located in the rear of the main building.

The process is started by dissolving the muriate of potash in five large tanks, each 10ft. in diameter and 6ft. deep, each having a capacity of 3,000 gallons. These tanks are located in the rear of the main building, two of them being in the storage room. From these tanks the solution is pumped by steam to the upper floor of the main building, where it passes through filters, and then into a storage tank of 4,000 gallons capacity. From this tank the solution is tapped off for use in the pot room, 90ft. by 65ft. in size, and which is also on the second floor. This pot room is an interesting place. The main switchboard controlling the flow of the current is on the east side of the building and above the transformer room. In addition to this main switch, each pot has a switch by which it can be thrown in or out of circuit. The iron pots are 60 in number and porcelain lined. They are said to be the largest porcelain-lined tanks ever made in the United States, and the largest ever used for this purpose. In length they are about 8ft., the width being 4ft. or 5ft., which makes a large casting. They were made by Messrs. Dawes and Myler, of New Brighton, Pa., and it is said that the shrinkage between the iron and the porcelain lining was so much as to cause considerable trouble in their manufacture, but as they stand to-day they are fine samples of good work. The pots are all insulated one from the other, and also from the floor. It is in these pots, or tanks, that the muriate solution is decomposed, forming the chloride, which is allowed to run down to the first floor into porcelain-lined crystallising tanks or pans, then into lead-lined pans, and finally into wooden pans shown in the accompanying illustration, after which it is shovelled up and thrown into a centrifugal dryer. It is then placed in the dry room, where the remaining moisture is removed, after which it goes into the packing room, where it is put up in 100lb. kegs and sealed for shipment. From the time the muriate solution enters the pot room to the time the chlorate is ready for shipment about 24 hours elapse. The present capacity of the plant is about one ton of chlorate of potash per day.



Tank Room of the Chlorate of Potash Works.

The electrical equipment of this factory was manufactured by the Westinghouse Company. It consists of two rotary transformers of 250 H.P. each, and four static transformers which give 3,000 amperes at 60 volts. The current is supplied by the Niagara Falls Power Company, and comes to the factory over cables laid along the ground, the subway not yet being extended to this point. As received the current is of the two-phase alternating variety at 2,200 volts pressure, which is converted into direct current by the rotaries. No other factory in Niagara Falls uses so much copper for conductor purposes as is found in the plant of the Chemical Construction Company. From the transformer building 12 copper bars, each 5in. wide by $\frac{3}{8}$in. thick, carry the current to the main building, where it is distributed to the 60 pots by copper bars 4in. wide by $\frac{1}{2}$in. thick.

To-day chlorate of potash is worth from 9 to 10 cents per pound wholesale, in net ton lots, the supply for the United States coming mainly from Germany, England, France and Switzerland. The consumption averages 5,000,000lb. per year in the United States alone. Since the passage of the McKinley Bill no duty has been imposed on it, but before that time the duty was 3 cents per pound. The uses of chlorate of potash are very numerous, and it enters into the composition of such diverse articles as matches, blasting compounds, smokeless powders, coloured lights, and cough mixtures; it is, of course, an oxidiser.

Chlorate of potash is to-day made by three electrical processes—namely, those employed by Gall and Montlauer, of France, by Franchot and Gibbs, o Buckingham (Canada), and that employed by the Chemica Construction Company of Niagara Falls. Herr Kolbe was, it is said, the first to demonstrate the possibility of producing chlorates by electrolysis; but the fact was also noticed about the same time by Mr. John T. Sprague, of Birmingham, who refers to it in his book.

## A TELEGRAPH CABLE ATTACKED BY WHITE ANTS.*

BY E. L. BOUVIER.

The Postal and Telegraph Department has lately submitted for my examination at the Entomological Laboratory of the Museum, a short length of telegraphic cable from Haiphong (Cochin China) which had been eaten away by some insects. From the particulars communicated to me it seems that the period of destruction must have been singularly short; for the cable, laid in very good condition in July, 1894, showed signs of loss of insulation early in 1895, eventually deteriorated more and more, and had to be replaced at the beginning of 1896. Thus barely two years sufficed to render the cable useless. Nevertheless, this cable had been very carefully manufactured, and one would have thought this would have rendered it impervious to attack.

Laid in cement for nearly the whole of its length, it contained three stranded conductors, each one formed of seven wires and covered by alternate layers of gutta-percha and chatterton. The three conductors were laid up together with three small tanned cords (wormings), which filled in the intervals. A serving of tanned jute was wound round spirally on the cylinder thus formed; two cotton tapes also tanned, but laid on in the opposite direction, held the whole together. Finally, the entire cable was covered with a lead tube.

The investigations made at Hunoi did not give any particulars of the organism which had caused the mischief. It was reported to the Minister: "This is the first time that an occurrence of the kind has taken place at Tonquin. Up to this date white ants, teredo and wood lice have left intact the gutta-percha of our cables, and even that of the covered wires used for station connections.

"It seems, moreover, that the nature of the soil where this cable was laid should have protected it from land insects. The ground of the town of Haiphong, situated very slightly above the level of the sea, is, in fact, muddy, constantly damp, and somewhat salt: it would seem more suitable for marine animalculæ. It was, however, a small land insect which caused the damage."

In opening the piece of cable which had been forwarded to me, I found two systems of galleries, which led from each end towards the middle of the length, without, however, meeting. The direction of these galleries was from the circumference to the centre; but the lead tube and the copper wires were untouched, tunnels were found in the servings of cotton and jute, which drew nearer to each other in the "wormings," and were combined partly in these cords, and partly in the gutta-percha, thus laying bare

* From the *Comptes Rendus*, Vol. CXXIII., No. 8.

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the copper wires, and ending in a *cul-de-sac*. The galleries were from 2mm. to 3mm. in diameter, and seemed partly filled up with loose *débris*, which was in all probability excretory matter. I examined these remains with a magnifying glass and a microscope. In one of the ends of the cable I could not find any characteristic traces; but in one of the two nearly parallel galleries at the other end I discovered the somewhat mutilated head of an insect, and in the second a head provided with mandibles and other jaw appendages. With the aid of M. Poujade, assistant at the laboratory, I examined these two heads, which were those of white ants, and very evidently represented the remains of the authors of the mischief. Although I was not able to examine a sufficient length of the cable, I am inclined to think that each gallery was bored out by a single worker. In any case, it may be affirmed that the enemy penetrated at different points into the interior of the lead tube, as the tunnels in the specimen of cable, though leading towards one another, never actually met or joined each other.

I do not know whether the white ants are able, like certain insects, to bore through lead and thus to penetrate to the interior of the cable. I am rather inclined to believe, with the Director of the Postal Department of Tonquin, that the insects find their way into the cable by the open ends, or by an accidental hole which may have existed in the lead covering. However that may be, care should be taken to guard against both these possible means of entry; and perhaps the best plan of doing this would be—

1. To accurately fit a metal cap over the two open ends of the cable.

2. To make the joints between the different lengths of the lead tube as perfect as possible.

3. To soak the tanned cords, the jute serving, and the cotton tapes to protect the three conductors of the cable in a solution of sulphate of copper.

This last method is neither complicated nor expensive; and perhaps it alone will suffice to limit or prevent the havoc caused in cables by white ants.

## APPLIED ELECTRO-CHEMISTRY.*

BY JAMES SWINBURNE.

There is probably no branch of industry which is developing so rapidly as electro-chemistry. It might have been thought that this development would have begun ten years ago, as the electrical engineer was then quite able to provide economical steam dynamos. As a matter of fact, inventors have been working at electrolysis and electro-chemical processes for more than half a century; but a large proportion of these were unpractical, as is sufficiently proved by their working out methods involving cheap electrical power when there was no prospect of such a thing. For the last ten years or so, the applications of electricity to chemical manufacture, and to metallurgy, have engaged the attention of a great many very able people, and a still greater number of the class the Americans expressively call "cranks." A considerable time-lag was to be expected, for it takes quite 10 years for people to realise that electrical power can be developed at high efficiency and low cost. Even now the average mechanical engineer does not appreciate the value of the electric motor; so it is hardly to be expected that chemical manufacturers can yet all fully realise exactly what electrical power will do. All the same, they have been by no means behindhand, and there are several large electro-chemical works already running in different parts of the world.

Some years ago the difficulty was that the average electrician knew no chemistry, and the chemist knew nothing about electricity; so that there was a sharp line between electricians and chemists. There is, however, a new state of things arising. During the last 15 years a new science may be said to have come into existence. This is chemistry on an engineering basis—that is to say, chemistry is now studied in its relation to the transformation of energy. This study demands almost a peculiar training. It requires a knowledge of mathematics and of thermo-dynamics, and mathematics is not generally a strong point among chemists. It also needs a knowledge of electricity and of general physics, and, of course, of chemistry. The result is that what I have called engineering chemistry, or chemical energetics, is not the work of the older chemists or physicists, but, with a very few eminent exceptions, is largely in the hands of a number of comparatively young men, who are not trammelled by older ideas, and who are specially fitted by their training in chemistry, physics, and mathematics to deal with this subject.

Splendid work has been recently done in physical chemistry and the theory of electrolysis in Germany, and that country has distinctly taken the lead in both theoretical and applied electro-chemistry. But the result is that there is a gradual development of two distinct classes of electro-chemist. One the purely scientific, who does not know the price of anything, and could not tell a buddle from a jigger; and the other who never heard of the Kupferferrocyanidniederschlagsmembranerscheinungen — I think that word is approximately correct. It is men of the last class that are doing the practical invention, and are getting capital and setting up factories. But the first class must not be regarded as useless. Like all purely scientific men they are providing the raw material for the practical technologist to work up into the finished article for the use of man. It is, however, a great misfortune that the two kinds of knowledge cannot be more often combined in the same man; and the present tendency is towards more complete separation, which is to be deplored.

Electricity is being gradually applied to many branches of metallurgy, and to various processes of chemical manufacture, chiefly inorganic; there are also signs of its development directly and indirectly in the manufacture of organic products. Electricity is also used as a means of getting very high temperature in the electric furnace, and though in such cases the reaction is generally a mere reduction by carbon, and not electrolysis at all, their description may be classed under electro-chemical work.

It would be clearly impossible to give any account of even the theory of electrolysis, or the practice of it alone in four short lectures. It was therefore very difficult to know how to give a short course on such a subject. As experiments are an important feature in the Cantor lectures, and as the only conceivable reason for anyone's coming to a lecture—unless he has to give it—is to see experiments which he cannot see elsewhere, and which cannot very well be described in print, it seemed best to show as many experiments as possible. The subject, however, does not lend itself very well to lecture demonstration, and therefore as many experiments as possible—especially new ones—were chosen, and the lectures were arranged and delivered very much to suit the experiments. As these would hardly read well the printed lectures are different, and include very little of the delivered matter, being practically independent. As just explained, it would be impossible to go over the whole ground, even very shortly; so I will merely touch on a few points that seem to me interesting, without attempting to follow the lectures delivered, or to give any sort of general survey of the subject. Up to now, the Cantor lectures have been not only exceedingly valuable in themselves, but the lecturer has frequently changed into an author, and the series of lectures grown into a book. If it is ever my fortune to develop these lectures into a book, I shall then at least have room to give a more general account of the subject.

### *Cost of Energy.*

In most electro-chemical manufactures the cost of energy is of cardinal importance. The cost and heating power of the coal is the most important factor. If coal is taken at 10s. a ton, and gives ½ I.H.P. hour per pound, and if the combined efficiency of the engines and dynamos is taken at 80 per cent., the coal comes out at 0·18d. per kilowatt hour. In many places coal is much cheaper than 10s. per ton, without being anything like proportionally worse, so that 0·18d. per Board of Trade "unit" may be taken as quite liberal enough, as far as coal goes. To the cost of coal must be added labour, superintendence, oil, and waste, and the interest and depreciation on the generating plant. These can be covered with a reasonable margin by taking the cost of power as ¼d. per kilowatt hour. A great deal depends, however, on precisely what is meant by cost; ¼d. per kilowatt hour covers outlay for coal, wages, and stores, and interest and depreciation at low rates on capital and plant. If, however, an engineer were to get out an estimate for the manufacture of some chemical, which was very simple, needing little more than electrolytic tanks and storage and packing; and if he found that the vats and electrolytic department cost (say) £16,000 to build and £4,000 as working capital; and that the profit after paying salaries, wages, rent, taxes, office expenses, and after paying for all energy used at the rate of a farthing a kilowatt hour, was £2,000 a year, he would be quite wrong in saying it would pay 10 per cent. The capital in engines and dynamos must be taken into account and added to the other, bringing it up to say £40,000. Then to the £2,000 must be added the interest on the £20,000 in generating plant, that is included in the farthing, say £1,000. The total profit is thus £3,000 on £40,000, not £2,000 on £20,000; or 7½ per cent. instead of 10.

This example is given to show that a good deal of care is necessary in working out even the roughest estimates. The great difficulty is to know what is meant by cost in each case. If the generating plant belonged to an independent proprietor he would

* Cantor Lecture—I.



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not be likely to supply energy at a farthing per kilowatt hour. He would reckon his prime cost as a little less than a farthing, and would then add on a considerable percentage to give his selling price. In central station work the cost of energy is enormously greater. This is because the generation does not go on continuously day and night, and because the expenses of distribution and collection, as well as the inconveniences of location, come in. The cost of energy produced by an electric-light station is thus no criterion, as the other expenses run up so enormously that the cost of coal burnt at full economical load is almost buried under a pile of incidental expenses.

Probably the greatest errors in estimating the costs of electrolytic processes are due, not to underrating or over-estimating the cost of electrical energy, but to not realising the expenses of handling, packing, finishing, or perhaps purifying the materials. Other things have to be considered, such as the dislike of the trade to anything new, or apparently new. The word "electric" acts like magic in increasing the sale of hairbrushes, quack medicines, and a thousand and one things which have nothing to do with electricity; but these articles are mostly sold to women, or to the more ignorant classes. In commerce, on the other hand, there is an equally ignorant prejudice against anything electric. Electrically tanned leather, for example, is regarded with considerable suspicion, especially as it is somewhat lighter in colour. Even the packing should be the same as that of the goods made in the old way. Some day people may realise that electrolytically-made chemicals are often more nearly pure than others. This is already commonly understood in the case of high conductivity copper; and then it is chiefly bought by electrical engineers.

In dealing with the cost of electrical energy, the price of coal has here been taken as the basis. There is abundance of water power, however, in many districts, and we must consider how far that may affect the question of cost of manufacture. It is only too frequently assumed that water power costs nothing, and must therefore give electro-chemical manufacture an enormous advantage over older processes. This is very far from the truth, however, and the economy to chemical workers of the use of water power has been enormously exaggerated. I say the economy to chemical workers advisedly, for I do not mean that it does not pay well to utilise water power, but that the advantage is to the owner of the waterfall—not to the manufacturer, except in special cases. An example will illustrate this best. Imagine a chemical district where coal is 10s. a ton, and where there is a large use of electrical power (say) for making caustic and bleach electrolytically. Imagine, also, that there is water power in the neighbourhood. If the owners of a chemical works want power, they will apply to the proprietor of the waterfalls. He will by no means make them a present of as much power as they want; on the contrary, he will charge rent; and he will charge as high a rent as he thinks he can get. The chemical makers, on the other hand, will not give a rent that will make the water power as costly as coal, but they will be guided by the least difference, so that the rent asked and obtained will be such that it costs the chemical company the same for water as for steam power. If the turbines and races which we suppose to be put down by the chemical manufacturers cost about the same as the engines and boilers, and take about the same labour and superintendence as the steam-generating plant, the rent for the water power, apart from the land for the turbines and dynamos, which is a different matter, will be approximately equal to the cost of coal for the same power. Assuming the plant to run continuously, day and night 1,000 kilowatts generated at 80 per cent. efficiency at 2lb. of coal per kilowatt hour, coal being 10s. a ton, comes to £6,500 a year in round numbers, or £6. 10s. per kilowatt year. A water power of (say) 10,000 kilowatts in such a place thus corresponds to a coal mine whose yearly output of coal is worth £65,000 before it is touched in the mine, and whose supply of coal is inexhaustible.

Suppose, however, that the water power is not in the chemical district at all, but in such a place as, for instance, Norway. The chemical manufacturer may be at some disadvantages there. The district may be inaccesible, and the establishment of works there may involve special difficulties and expenses. In such a case the proprietor of the water power will not ask £6. 10s. per kilowatt year, for he has no chance of getting that. He will eventually get some smaller rent, so that it will just pay a new concern to start in Norway rather than England. Still it is the owner of the water power that gets the advantage from it, not the chemical manufacturer.

Whether it will pay to use water power in a given place or not depends on how far the power is an important item in the cost of manufacture. In such cases as making aluminium, carborundum, or calcium carbide, the power is by far the heaviest part of the cost of manufacture; and as carriage is a small matter in these cases, such manufactures will be the first to grow in places which have water power, but which are otherwise inconvenient. In most cases, however, the actual cost of the power is a comparatively small matter, and the inconveniences of being away from supply of raw material and coal for heating purposes, and from the market and the supply of skilled labour, make it inadvisable to use water power, even when it can be obtained at a very low rent. Cases like that of Niagara are peculiar. It seems to be the idea that an industrial centre will spring up around the Falls merely to batten on cheap power. There are not very many industries, electrical or non-electrical, in which power plays a very important part, and in most cases it would not pay to start works in a new locality, even if the power were given, as the drawbacks are serious. Thus, for example, it would not pay a cotton-spinner to start a new works in Devonshire, even if power were given him there, as he could not get operatives there, and he would be completely out of touch with his markets, both for buying and selling. In other cases, the works must be near the raw material, if it is heavy, as in the case of gold mining, or near coal, or near both, as in the case of iron works. In the case of Niagara, it will undoubtedly pay users of electrical furnaces and makers of aluminium to take power from the supply company there rather than burn coal, as the supply company can always supply power more cheaply than it can be got from coal. Whether it would pay to go to Niagara, rather than to any other falls, depends on the terms offered.

The position of water power is a little anomalous just at present, because things have not settled down yet. At present the water powers are not fully utilised, or anything like it; and there are very few processes in which power is the factor of paramount importance in determining the cost. At first, therefore, power can be got for such processes at nominal rents, and it is almost correct in such cases to say the power costs nothing. The farthing per kilowatt hour, in the case of coal, however, included interest and depreciation on plant as well as labour and stores. In the case of the waterfall at a nominal rent, the interest on the capital sunk in flumes, races, turbines, and dynamos must also be taken into account. The cost of power will then come out a long way below a farthing, unless the fall of the water is very slight, and there are considerable engineering difficulties. In cases like aluminium or calcium carbide, carriage is of little importance. The bauxite, or other oxide of aluminium, has to be carried in any case, and if it has to go by sea or rail, it does not much matter how far it goes within reason, provided it has not to be handled on the way. The aluminium or the calcium carbide is so valuable in proportion to its weight, that the carriage of the produce to market is not worth considering. There are any number of waterfalls in the United States, Canada, Switzerland, and Norway which are available for processes of this nature, so it is probable that such processes will be able to obtain water power at very low rents for very many years to come.

Turning now to such cases as, for instance, making bleaching powder and caustic soda by the electrolysis of a solution of salt, the number of waterfalls available for this purpose is comparatively small. Suppose the electrolysis vats have a current efficiency of 80 per cent., and take (say) six volts per vat, the cost of energy comes out approximately £5 per ton of caustic. Of course this cost must be allocated as to the caustic and bleaching powder, as they are not independent products. We may say £2. 10s. per ton of caustic, and £2. 10s. for 2·3 tons of bleach, or, roughly, £2. 10s. for caustic and £1 a ton for bleaching powder. Even if the whole of this were saved, it would not pay to start a works in an out-of-the-way mountain pass, where the carriage of salt, lime, and coal for finishing, and that of the finished caustic and bleach, would come to far more than £5 for each ton of caustic made. In addition to carriage, superintendence and skilled labour are more expensive in out-of-the-way districts. The whole object of life is not to make an income; that is only a means to an end, and a man with anything in him will not exile himself except as a temporary way of making money comparatively rapidly.

The number of water powers at the coast or in other very accessible places is limited, and there will soon be enough taken up to raise the rent till the chemical manufacturers no longer profit appreciably by it. Theresult is that in the immediate future water power will not help the electro-chemist, except in such cases as the electrical furnace.

At present water powers are sometimes to be got cheap, as the owners, having so far got nothing for them, are glad to sell outright, or to give a concession for a number of years for a certain income, rather than await the chances of high rents later on, when electro-chemistry is more developed. In other cases proprietors have already very exaggerated ideas of the value of their property, and it is impossible to deal with them.

It is almost needless to remark that if an electro-chemical company owns a waterfall, it is not in any better position than if it rented it. It has merely sunk some of its capital in the waterfall, and the same rent that would otherwise have to be paid should be charged against the manufacturing account, and credited to the profit account of the waterfall ownership. If the waterfall was bought cheap, owning it may be profitable, but it does not cheapen the electrolysis, as the company might just as well have let their waterfall for a fair rent, and started their works in St. Helen's, or Kalk.

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It is needless to say all this is merely elementary economics. I do not carry books on economics with me on a holiday; but if I remember right, it is a simple application of Ricardo's theory of rent.

While on the subject of costs it may be as well to mention an apparent anomaly which often comes up in making estimates or designing new works. Suppose a process is to be worked, which needs a large steam-generating plant, and suppose that on paper the process is capable of yielding an enormous profit, say 50 per cent., on the capital. It may be safely said that such a process, in practice, will not yield such a large profit, as all sorts of things will go wrong, and troubles will arise in unexpected quarters. Let us assume, then, that in practice even a pessimist, who knows his subject, expects a profit of 25 per cent. to be earned. Then the question arises, what sort of machinery is to be put down? As the engines are to run day and night, the efficiency of the generating plant seems of the highest importance, and the first idea is to put down high-class boilers, with automatic stokers, and triple-expansion condensing engines of the best and most modern types, on the ground that, as the engines run continuously, the saving in coal is more than equal to the interest on the extra capital sunk. It must be remembered, however, that the available capital is limited, as, however good the process appears, it is of necessity a large experiment at first. Unless, therefore, the saving by coal will pay at least the same interest on the increased capital as the process will as a whole, it will be better to spend it so as to get a larger output at a lower efficiency. In extreme cases it may even pay to fit up second-hand marine or other engines at low cost and low efficiency. The same considerations apply to other kinds of plant. In such cases economical working is not so important as it appears at first sight, but freedom from breakdown is, of course, vital. Old machinery is often very safe from this point of view, if not overworked. When the process is satisfactorily started, and more capital is available, and the profits are falling towards the normal, it will pay to put in the best machinery, and to work at the highest economy, giving the plant a term of many years to repay its extra cost.

While on the subject of costs and estimates, it may be as well to point out another consideration that is frequently overlooked. An electro-chemical process is proposed which is to compete with a large existing chemical industry, and it is assumed that the price will not fall, because if it did fall a little the chemical manufacturers would fail. The existing steady price of a chemical is such that the badly-managed concerns just make it pay, and the well-managed works make good profits. The better makers can always lower prices considerably without loss, so that a new mode of manufacture cannot command the market by being able to produce a little cheaper; it can only oust a few of the existing manufacturers. It must be remembered that it will not pay to put down plant for a process that cannot pay interest and depreciation on that plant; but the old makers have already put down their plant, and rather than close as prices fall, it will pay them to write off the whole of their plant as worthless, or rather at its break-up value, and go on, if they make any profit on their working expenses alone, or even if they hope to do so soon. Before a new process can therefore drive an old one out of the market, its profits must at least be greater by the interest, and for some time by the depreciation of the plant engaged in the old manufacture in addition.

*Theory.*

But little can be said here on such a subject. For most practical purposes, electrolysis may be regarded as a convenient means of bringing about oxidation and reduction. The words oxidation and reduction are used very loosely by chemists, but the idea is generally clear enough. If we wanted to make it still clearer, we might go so far as to describe oxidation as what goes on at the anode and reduction as what takes place at the cathode. This would give a good idea of the changes meant, and the notion could then be extended to reactions which cannot be, or at any rate, are not produced by electrolysis.

When we examine the processes employed in commercial chemical manufacture, as well as in the laboratory, we are struck by the fact that by far the largest portion are processes of oxidation and reduction. Nearly all the processes for getting metals consist of reductions. Iron oxide is reduced to get iron. The carbon is then oxidised out in the converter or on the puddling hearth, to get steel or wrought iron. Zinc sulphide is oxidised first, merely to get it into a form to which reduction is easily applicable. The reduced zinc is then again oxidised, to make white paint. The Leblanc process for making soda crystals and bleach is a maze of oxidations and reductions, with a few substitutions thrown in. The pyrites is oxidised into oxide and sulphur dioxide. There are alternate reductions and oxidations of a complicated nature going on in the acid chambers. The sulphuric acid acting on the salt is a substitution process. Generating chlorine from the muriatic acid is an oxidation and reduction process, and the absorption of chlorine by lime may be considered another case. The bleach is then sold to oxidise paper pulp, and frequently to oxidise our linen to a regrettable extent. The salt cake is reduced in the black ash revolvers, a substitution going on also, this reaction being really very complicated, and after that there is only lixiviation and crystallisation. It would weary the reader, or we might include the Weldon process as part of the system, and enumerate more oxidations and reductions. We may, however, imagine the carbonate to be reduced by carbon, to give us sodium; and we now have a system, involving, without the Weldon process, no less than five separate oxidation and reduction processes to split salt into chlorine and sodium. Electrolysis splits fused salt into chlorine and sodium at once, without any other processes or chemicals being needed, and without any waste. The difficulties in electrolysing fused salt are so great, however, that at present the older and tremendously roundabout processes hold the field. The electrolysis of salt solution is more complicated, as sodium is not obtained, and there are a number of small secondary reactions.

For many purposes, all that the electro-chemist—if such a word could be applied to such a man—wants to know is, how much of a compound is decomposed by a coulomb or an ampere hour, and what pressure is needed. Faraday's law gives him one of the data; the other is a different matter, as the pressure needed depends not only on the back pressure of the decomposition vat, but also on the resistance of the circuit. The resistance often depends on the current density; for instance, if bubbles of gas are being evolved from an electrode, they insulate it, except for the thin films of liquid separating them. The result is a very high surface resistance. I have tried the effect of gradually increasing the pressure on lead plates in dilute acid. The pressure and current rise together until something like 3 volts is reached. The current then increases much more rapidly than the pressure, gases being given off in abundance, and between 3 and 4 volts there is a state of things in which a very small difference of pressure produces a given change of current density. The arrangement was used in connection with a resistance in a differential governor, and was very sensitive. As many processes, such as the electrolysis of salt solution, involve evolution of gases at the electrodes, it is important to get the most economical results. The mistake is often made in designing vats with the electrodes inconveniently close together with the idea that a substantial reduction of the reststance is thus secured. When there must be evolution of gas at an electrode the majority of the resistance is at the electrodes, and it generally makes little difference how far the electrodes are apart within reason.

## TELEPHONE LINE CONSTRUCTION IN THE ROCKIES.

Telephone construction in the Rocky Mountains is attended with a great deal of hardship. The line built from Leadville to Aspen several years ago is a case in point. It took two months, says the Denver *Field and Farm*, to cover the entire length, 48 miles. In ordinary construction the poles would be set 42 to the mile; but at certain points where sharp turns are necessary, the number sometimes increased to 75 to the mile. The members of the construction gang had to be expert as axemen as well as linemen; for when timber was encountered, a path of 200ft. on each side of the line had to be cleared in order that wires might not be broken when trees were blown over by the terrific blasts which at times prevail in that region.

A great deal of the comparative slowness of the installation was owing to the inability of the workmen to labour in such a rarefied atmosphere. At one point the wires were strung at an elevation of 12,000ft. above the level of the sea. In such an altitude the lineman soon became completely tired; after he had climbed two or three poles he had to take a rest to recuperate his energies. The preparation of the holes for poles, which would have been tedious in similar ground, even in an ordinary atmosphere, was an especially slow and fatiguing operation. It was often necessary to blast a hole for the pole by the use of giant powder, and an ex-miner who had had an extensive experience with explosives was assigned to the job.

The digging of one pole hole would sometimes occupy him a whole day. Over 300lb. of powder was used on the line for this purpose. When the Continental divide was reached the poles had to be abandoned, and the wires placed in a cable, which was buried in a two-foot trench for a distance of 7,000ft. The advisability of abandoning aerial construction at this point was demonstrated by the experience of the Company that maintains the Leadville and Denver line. At one point on that line, Mosquito Pass, the poles were originally set 70ft. apart. As soon as the wires were covered with sleet they snapped, and the line was useless. Double the number of poles were then used, with the same result. The space between the poles was then reduced to 25ft., but when the sleet came the line was swept down flat. Eventually an underground cable was laid for 2½ miles, and there has been no trouble since.



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## THE RELATION OF THE UNIVERSITIES TO APPLIED SCIENCE.

The discussion in *Nature* on the position of Science in Oxford, together with the letter of Prof. OSTWALD, communicated to *The Times* of August 25th by Prof. RAMSAY, raises the larger question of the relation of our English Universities to applied science, a question which Oxford especially has been reluctant to face. The particular form of mental training for which Oxford and Cambridge have so long been famous can only be properly understood and rightly defended in the light of the history of letters and of science in Europe. It is as natural that these ancient Universities should teach Greek and Latin as that a seed should grow up like the plant it came from. But it is also as reasonable that there should be changes in this time-honoured system of education as that a flower should improve under cultivation. When these old Colleges were founded Latin was the tongue in which students of all countries could converse, and nearly every book worth reading was written in Greek or Latin. The two races to whose military enterprise and intellectual activity the civilisation of Europe was due had not long ceased to be its dominant powers, and their place was taken by tribes that had but recently emerged from a condition of comparative barbarism. A similar sequence of events might cause English to become the classic language of a future age. We owe a debt to the great writers of the past which we are not likely to forget. But in view of the vast strides that Science has taken within the last hundred years, and the enormous extent to which it has been practically applied, it has become a question whether it is not possible for many of our countrymen to devote a larger portion of their time to it. Probably no one who has taken a degree in Science at Oxford or Cambridge would wish, if he

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could have his time over again and money enough to carry it through, to omit the classical part of his studies. Unfortunately, money is not very plentiful with many of those who desire, and are fitted to receive, a University education. Must such be content with reaching a lower standard?

The influence of Oxford is two-fold—intellectual and social. The College life creates a bond, even between those who were not up together, which goes far to break down the artificial barriers between man and man, and produces a freedom of intercourse of inestimable worth. The value of the intellectual influence of a great University also depends not merely on the course of study, but on the men with whom the student comes in contact and the opportunities he has of being influenced by them; and in this respect the possibilities of the Science course equal, if they do not surpass, those of the *Literæ Humaniores*. In Oxford, many of those who most strenuously advocate the retention of Greek and Latin as compulsory subjects seem not to realise that Science, when rightly taught and studied, has an educative value fully equal to that of the classic authors. And yet those very authors bristle with allusions to the science of their day, such as it was. If the departed Shades could recross the Styx, and visit Oxford in a body, what places would be most likely to attract them? It must be confessed that a majority of those best known in the Honours School might possibly prefer the Theatre. Lucretius would call upon the Professor of Chemistry and visit the works of the Electric Company. Plato and Aristotle would be taken over the Museum by the Radcliffe Librarian, and Socrates would ask awkward questions. Virgil would converse with the Hope Professor about the life-history of insects, while Galen and Hippocrates enjoyed themselves in the Physiological Laboratory; and among the comparative strangers there would be Empedocles studying the Glacial Period for a change, and Pliny fraternising with Prof. Ray Lankester. Men of such mental power could not possibly desire that the youth of the present day should concentrate their whole attention upon so remote a past. In their own teaching they dealt with all that was newest and most practically important, and they would expect us to do the same.

If we contrast scientific with classical studies we find that each has certain educative properties analogous to those of the other. Thus mathematics is to Science what logic is to philosophy, and a man familiar with applied mathematics is seldom to be caught napping in his logic. But in studying ancient philosophies through the medium of a dead language there is a farther element of discipline, namely, the intricate way in which the inflections depend upon each other, and on the form of the sentence. It is the submission of the imagination to a mode of expression bound by rigid rules that makes the writing of Greek and Latin verses useful as a mental gymnastic. All this we have in a far more perfect form in physics and chemistry directly the student enters the laboratory. He soon finds that it is easier to read the description of an experiment than to repeat it. He learns the need of patience and the importance of accuracy; and by degrees realises that what seems at first a confused multitude of phenomena is in reality the orderly result of a few simple laws. And if he does not by-and-by experience the elevating influence of contemplating laws, the foundation of which is in the infinite past and upon which the eternal future rests, it is probable that he would be equally likely to miss what is ennobling in the teaching of classic authors. Add to this that there is in laboratory training an element not found in literary work, namely, that the student tests his own work by a standard absolutely free from prejudice or fashion. Opinions that satisfy one critic may be rejected by another; and who can keep pace with the ever changing literary modes? But if the results of experiment fail to agree with theory, there are but two alternatives—either the student is at fault, or he is on the track of a new discovery. Most men reach this point shortly before taking their degree, and it is then they grudge the time spent on the classics. The amount done is so small that they get no benefit from it as a literary study, and an hour a week for the first term would suffice to teach all the vocabulary they require in order to understand scientific nomenclature. Twenty years ago things were different. Science was a smaller subject then.

Lord Playfair, in the debate on the second reading of the London University Commission Bill, stated that "France since the war had spent nearly 100 millions of francs in equipping her higher Colleges, so that they might suffice for modern scientific requirements. Germany had spent upon Strasburg no less than £711,000 in the building of a new University and its scientific laboratories, and annually voted above £50,000 for their maintenance. The future competitions of the world would not be determined by armies and navies alone, but would be mainly governed by the intellectual development of the people." Prof. Ostwald, in the letter published in *The Times*, contrasts the German with the English system. He states that as the result of a suggestion from some leading practical scientific men, a considerable sum of money has been spent by the Prussian Government in endowing electrochemical chairs and laboratories—that at Göttingen, an institute for physical chemistry has just been completed; and that the Saxon Landtag has unanimously voted £25,000 for the erection of a splendid laboratory for physical chemistry at Leipzig. These nations have realised that the real work of science begins where the English University course leaves off. Our discoveries and inventions are made amidst the labour and anxieties of other work, and by the time they filter back to our Alma Mater they are out of date. What wonder, then, that our young men are being left behind by those who have such opportunities of systematically studying the living problems of the day?

## ON THE MAGNETIC BEHAVIOUR OF ELECTROLYTIC IRON, NICKEL AND COBALT.*

BY W. LEICK.

It is well known that specimens of iron only slightly differing in chemical composition may sometimes show a totally different magnetic behaviour. But while the most various kinds of iron and steel have been magnetically tested (I need only recall the detailed investigations of Hopkinson), little attention has been paid to electrolytic iron, and the published results often differ widely. It seems to be tolerably certain that iron differs according to the solution from which it has been deposited. Most experimenters, especially Holtz† and Beetz, attribute to galvanic iron a great coercive force and great hardness. The last-named also states that iron deposited from solutions containing sal-ammoniac may hold a large amount of permanent magnetism, but that this is not the case when the solution contains no sal-ammoniac. But other workers report differently. Thus Krämer‡ maintains that iron deposited from ferrous chloride solutions is so soft that its edges may be cut with a knife. Further, Klein§ says that iron deposited from a mixed solution of ferrous sulphate and ammonium sulphate appears to be incapable of permanent magnetisation; and V. Jacobi‖ believes that galvanic iron behaves like soft iron, and may be used for induction coils, &c.

In view of these different and somewhat confusing opinions it appeared to me of interest to subject the magnetic behaviour of iron deposits to a detailed scrutiny, and especially to express their

* *Wied. Ann.*, Vol. LVIII., No. 4, pp. 691-715. Abstract.
† *Pogg. Ann.*, CLI., p. 69, 1874.
‡ Dingl. *Polyt. Journ.*, CXI., 1861.
§ *Bull. de l'Acad. de St. Petersbourg*, XIII., 1868.
‖ *Pogg. Ann.*, CXLIX. p. 341, 1872.

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susceptibility and intensity of magnetisation in absolute measure, which has, as far as I know, not yet been done. It was natural that the investigation should be extended to other metals capable of ferro-magnetism, such as nickel and cobalt.

*Preparation of the Deposits.*

Many precautions are necessary in order to obtain really brilliant metallic deposits, as otherwise black, non-homogeneous deposits may be formed. I obtained my deposits from the following three solutions:—1. Ferrous sulphate, $FeSO_4+7H_2O$, with or without sal-ammoniac in various concentrations. 2. Ferrous chloride, $FeCl_2+4H_2O$, also with or without sal-ammoniac. 3. Iron-ammonium sulphate. For the nickel deposits I used nickel-ammonium sulphate, and for the cobalt deposits, cobalt sulphate. I soon found it to be essential that the crystals should be chemically pure in order to obtain smooth deposits. I may state at once that no independent rods of galvanic iron were examined, but only layers deposited in various thicknesses upon the cathode. The latter usually consisted of cylindrical brass or copper rods about 12cm. long and 2mm. to 4mm. thick. The anodes consisted of pure iron, nickel and cobalt respectively. The cathode must be cleaned with the greatest care.

The iron deposits were obtained as follows: Two glasses filled with the solution chosen were joined by a bent glass tube full of the same liquid and closed at both ends with parchment paper. The anode dipped into the one glass and the cathode into the other. Sometimes a simple U-tube was used; but then the electrolysis could only be carried on for a short time without leading to the formation of a muddy deposit. Most of my rods, however, only required an hour for their formation, and the simpler method could be safely used for them. The current was always derived from Daniell or Bunsen cells, and a galvanometer and rheostat were introduced into the circuit. The deposits were usually obtained at ordinary temperatures. Cooling down to 0deg. seemed to give smoother deposits; but the advantage is uncertain.

As regards concentration, I usually took 13 grammes of ferrous sulphate to 6 of sal-ammoniac dissolved in 500 cubic cm. of water. But the concentration seems to be of very slight importance.

The current, on the other hand, requires careful regulating. When the current is very small the deposits are formed very slowly, and are often black and muddy, owing probably to the increasing impurity of the liquid. The best current is from 0·1 to 0·2 ampere. With larger currents the metal was bright and clean enough, but little coherent, and of a granular or pulverulent structure, which eventually led to the detachment of small pieces or strips from the cathode. Such pieces were very brittle, and hard enough to scratch ordinary glass. For nickel and cobalt larger currents had to be employed.

I also prepared a nickel-iron alloy from the mixed nickel-ammonium and iron sulphates, using nickel and iron anodes coupled together. Cobalt-iron was similarly obtained from cobaltous and ferrous sulphates.

*Experimental Method.*

The method was essentially that of J. Müller (see *Lehrbuch*, 1889). Two coils of known dimensions, as similar as possible, were placed on each side of a Wiedemann dead-beat mirror galvanometer, and the magnetising current, derived from several Bunsen cells, was sent through these coils. Thus the deflection due to the magnetising coil alone was reduced to a minimum. The copper or brass rod bearing the iron deposit was introduced into the centre of one of the coils, and the deflection noted. That this method is unobjectionable I verified by determining the temporary magnetic moments of soft iron at various distances from the galvanometer and obtaining consistent results.

In the following all measurements are expressed in absolute C.G.S. units.

Some test experiments were also made to find whether the material of the cathode had any influence on the deposits. But cathodes of brass, copper, and carbon gave identical results. With very strong fields it was found that the rod bearing the deposit produced a deflection by itself. A correction had to be applied in such a case, but as a rule this deflection was negligible.

*Deposits from Ferrous Sulphate.*

Deposits from ferrous sulphate showed at once considerable permanent magnetism. Taken out of the electrolyte and introduced into the magnetising coil, they produced, without being magnetised, a deflection of the needle which was nearly proportional to their weight. Thus a rod with 11 milligrammes of iron gave an original deflection of seven scale divisions, and two others from the same solution, with 41 and 60 milligrammes respectively, gave deflections of 24 and 36 divisions. I found the same behaviour in all other rods to a greater or less extent. *It is evident that the earth's magnetic force is sufficient to impart a permanent magnetic moment to the deposits during their formation.* For the further experiments I prepared three iron deposits from a solution containing sal-ammoniac. All the deposits were about 4cm. long, had an even metallic lustre, and were so coherent that no irregularities could be discovered in their structure with a lens. All the three were deposited on brass rods, and weighed 4, 16 and 60 milligrammes respectively. In the following tables these rods are designated by I., II. and III. respectively.

**Table I.**—*(Rod I.)*

| *i.* | H. | *p.* | I. |
|---|---|---|---|
| 0 | 0 | −1·0 | −94 |
| 0·2 | 3·6 | 0·0 | 0 |
| 0·4 | 7·2 | 1·0 | +94 |
| 0·6 | 10·8 | 2·0 | 188 |
| 0·8 | 14·4 | 3·0 | 282 |
| 1·0 | 18·0 | 3·9 | 366 |
| 1·2 | 21·6 | 5·0 | 469 |
| 1·4 | 25·2 | 6·0 | 562 |
| 1·6 | 28·8 | 7·2 | 677 |
| 1·8 | 32·4 | 8·1 | 761 |
| 2·0 | 36·0 | 9·0 | 846 |
| 2·2 | 39·6 | 9·7 | 912 |
| 2·6 | 46·8 | 11·1 | 1,043 |
| 3·0 | 54·0 | 12·4 | 1,156 |
| 4·0 | 72·0 | 14·5 | 1,363 |
| 5·0 | 90·0 | 16·0 | 1,500 |

The first column shows under *i* the values of the current, the second under H the values of the field, the third under *p* the galvanometer deflections, and the fourth the intensity of magnetisation I of the iron. It will be seen that up to a field intensity of about 80 units the magnetisation of the iron increases nearly in proportion to the current intensity. After that it increases more slowly, but without sensibly approaching an asymptotic limit. Even with a field of 90 units the point of saturation is not attained; whereas in soft iron, as used for induction apparatus, saturation is closely approached in fields of 10 units. In this respect, therefore, electrolytic iron behaves more like hard steel than like soft iron. The values of the magnetic susceptibility *k* for the field intensities used are the following:—

| | | | | | | |
|---|---|---|---|---|---|---|
| H = 7·2 | 10·8 | 14·4 | 18·0 | 21·6 | 25·2 | 28·2 |
| *k* = 13·0 | 17·4 | 19·6 | 20·3 | 21·7 | 22·3 | 23·5 |
| H = 32·4 | 36·0 | 39·6 | 46·8 | 54·0 | 72·0 | 90·0 |
| *k* = 23·5 | 23·5 | 23·0 | 22·3 | 21·4 | 18·9 | 16·7 |

These values are in general somewhat higher than the corresponding ones for cast iron. But in weak fields the susceptibility of soft iron is much greater, and in strong fields about the same, as that of electrolytic iron; and the maximum, which in soft iron occurs at a field intensity of about 5 units, is only attained at 35 units, and it is not as decided as in the case of soft iron. In strong fields, on the other hand, the magnetisation of electrolytic iron attains nearly as high values as that of wrought iron.

The magnetic behaviour of Rods II. and III. was quite similar to that of Rod I., as may be seen from the following tables:—

**Table II.**—*(Rod II.)*

| *i.* | H. | *p.* | I. | *k.* |
|---|---|---|---|---|
| 0·5 | 9·0 | 24 | 149 | 16·6 |
| 0·8 | 14·4 | 54 | 335 | 23·3 |
| 1·3 | 23·4 | 102 | 623 | 27·0 |
| 2·0 | 36·0 | 130 | 806 | 22·3 |
| 3·0 | 54·0 | 171 | 1,060 | 19·6 |
| 3·5 | 63·0 | 190 | 1,190 | 17·3 |
| 4·2 | 75·6 | 214 | 1,320 | 17·5 |

**Table III.**—*(Rod III.)*

| *i.* | H. | *p.* | I. | *k.* |
|---|---|---|---|---|
| 0·5 | 9·0 | 109 | 223 | 24·8 |
| 0·8 | 14·4 | 226 | 351 | 25·2 |
| 1·3 | 23·4 | 421 | 670 | 28·6 |
| 2·0 | 36·0 | 498 | 797 | 22·1 |
| 3·0 | 54·0 | 650 | 1,040 | 19·3 |

In both rods the permanent magnetic moment was also determined, and it was found that electrolytic iron possesses an extraordinarily high coercive power. Rods II. and III. having been magnetised with a field of 54 units, they had—

| | II. | III. |
|---|---|---|
| Temporary moment ..... | 171 | 650 |
| Permanent do. ..... | 111 | 407 |

Hence the ratio of temporary to permanent magnetisation is 1·54 in Rod II. and 1·58 in Rod III. After repeated strong concussion of the rods the deflections for the permanent magnetic moment of Rod II. were in succession 110, 109, 109, 109; and for Rod III., 403, 402, 400, 400. After 21 days a repetition of the measurements gave 109 and 399 respectively. *Hence it is seen that the permanent magnetisation of electrolytic iron is hardly influenced at all by concussion or time.*

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Another circumstance also brings out the high coercive power of electrolytic iron. With a somewhat large current passing through a solution containing sal-ammoniac, a loose layer of iron had been formed, small pieces of which could be detached with a knife. In this manner I obtained a lustrous iron plate 17mm. long, 2mm. broad, and weighing nearly 7 milligrammes. Magnetised with an electromagnet, this iron gave an intensity of magnetisation of 48·5; whereas according to F. Kohlrausch the moment of ordinary steel magnets is about 40, that of the best long magnets about 100 absolute units.

In all these experiments the magnetising current was not suddenly made or broken, but it was quite gradually increased or reduced to zero. But this precaution, which must never be omitted in magnetising thick iron rods, was found to be superfluous with these deposits with a maximum thickness of 0·02mm., since the deflection of the galvanometer needle remained the same, whether the current was altered gradually or suddenly.

The deposits obtained from ferrous sulphate solutions without sal-ammoniac showed a somewhat lesser temporary and permanent moment than Rods I. to III. But this fact, partly described by Beetz, I am inclined to attribute solely to the less favourable structure of the deposits obtained from such solutions. For they are less homogeneous and lustrous, and are also apt to show consequent poles. This view has been confirmed by the observation that very thin deposits from solutions free from sal-ammoniac, which were obtained in a smooth and uniform state, showed the same behaviour with regard to temporary and permanent magnetism as the deposits obtained with sal-ammoniac. But in all rods I noticed a phenomenon to which I should like to call attention. The thinner the metallic deposits were—and the thickness deduced from the other dimensions and the weight was in some cases not more than 0·001 to 0·01mm.—the closer did the ratio of the permanent to the temporary magnetisation approach unity. Thus a very thin deposit weighing less than 1·5 milligrammes gave a temporary maximum deflection of 7·5, and a permanent deflection of 7·3 scale divisions. The same phenomenon was noticed by Beetz* in his Paper "On the Internal Processes Underlying Magnetisation," and was explained on the assumption of molecular magnets capable of rotation.

*Deposits from Ferrous Chloride.*—The preparation of metallic deposits from ferrous chloride solution offered somewhat greater difficulties, probably because it is not so easy to obtain the crystals fresh. They easily disintegrate, make the solution turbid, and produce a black, muddy precipitate, especially on the side of the cathode facing the anode. The following three rods, being fairly smooth and homogeneous, were examined in detail:—Rod IV. 10 milligrammes iron from $FeCl_2$ solution with sal-ammoniac, Rod V. 13·9 milligrammes, and Rod VI. 40·1 milligrammes without sal-ammoniac. Their magnetic behaviour will be seen from Tables IV., V. and VI.

**Table IV.**—*(Rod IV.)*

| *i.* | H. | *p.* | I. | *k.* |
|---|---|---|---|---|
| 0·2 | 3·6 | 3 | 22 | 6·1 |
| 0·4 | 7·2 | 12 | 89 | 12·4 |
| 0·6 | 10 8 | 20 | 148 | 13·8 |
| 0·8 | 14·4 | 31 | 229 | 15·9 |
| 1·0 | 18·0 | 50 | 370 | 20·5 |
| 1·2 | 21·6 | 65 | 481 | ... |
| 1·4 | 25·2 | 75 | 555 | 22·0 |
| 1·6 | 28·8 | 86 | 636 | 22·1 |
| 1·8 | 32·4 | 99 | 733 | ... |
| 2·0 | 36·0 | 110 | 814 | 22·6 |
| 2·2 | 39·6 | 120 | 888 | 22·4 |
| 2·6 | 46·8 | 134 | 992 | 21·2 |
| 3·0 | 54·0 | 151 | 1,120 | 20·9 |
| 0 | 0 | 84 | 622 | ... |

**Table V.**—*(Rod V.)*

| *i.* | H. | *p.* | I. | *k.* |
|---|---|---|---|---|
| 0·2 | 3·6 | 5 | 25 | 7·2 |
| 0·4 | 7·2 | 20 | 143 | 14·7 |
| 1·0 | 18·0 | 53 | 281 | 15·6 |
| 1·4 | 25·2 | 80 | 424 | 16·8 |
| 2·0 | 36·0 | 114 | 604 | 16·8 |
| 2·6 | 46·8 | 145 | 769 | 16·3 |
| 3·0 | 54·0 | 156 | 827 | 15·3 |
| 3·5 | 63·0 | 185 | 981 | 15·5 |
| 4·0 | 72·0 | 220 | 1,166 | 16·2 |
| 5·0 | 90·0 | 250 | 1,325 | 14·7 |

**Table VI.**—*(Rod VI.)*

| *i.* | H. | *p.* | I. | *k.* |
|---|---|---|---|---|
| 0·2 | 3·6 | 10 | 19 | 5·3 |
| 0·4 | 7·2 | 45 | 83 | 11·5 |
| 0·6 | 10·8 | 69 | 128 | 11·9 |
| 0·8 | 14·4 | 110 | 205 | 14·7 |
| 1·0 | 18·0 | 150 | 279 | 15·5 |
| 1·4 | 25·2 | 210 | 391 | 15·6 |
| 2·0 | 36·0 | 330 | 614 | 17·0 |
| 2·2 | 39·6 | 365 | 679 | 17·1 |
| 3·0 | 54·0 | 448 | 833 | 15·4 |
| 0 | 0 | 230 | 428 | ... |

* Beetz. *Pogg. Ann.*, CXI., p. 365, 1860, and CLII., p. 484, 1874.

It is evident from these tables that in this case also do the deflections increase in proportion to the magnetising force after a certain current intensity. The point of saturation is sensibly approached, but is not quite attained. Rods V. and VI. have about the same intensity of magnetisation, but that of Rod IV. is greater. It seems to be a general rule that the magnetisation increases with the thinness of the deposits. The deflections for Rods IV., V. and VI. refer to the same distance from the galvanometer needle, and can therefore be directly compared. A comparison with Rods I. to III. further shows that the deposits from ferrous sulphate possess a somewhat higher temporary magnetic moment than those from ferrous chloride. Hence the susceptibilities and permeabilities are smaller in the latter, as is also the permanent magnetisation. But this is still very considerable, and is very little affected by concussion. It may be surprising that all the preceding tables begin with a comparatively high field intensity, in which soft iron would already have attained one-third or half its highest magnetisation. This is due to the fact that the electrolytic rods, as already mentioned, show an initial permanent magnetisation, which can only be neutralised by a field of several units.

In order to observe the influence of very slight magnetising forces, I removed the magnetism of some rods by heating. This was a little difficult, since the different expansions of the iron and the copper rod made the deposit crack or detach itself in small bits, so that no comparison with a fresh deposit could be made. But eventually I succeeded in depriving Rod IV. of its permanent magnetism by very gradual heating in chalk powder, without spoiling its uniformity. Its magnetic behaviour is shown in the following table, which may be directly compared with Table IV., showing the properties as they were before heating.

**Table VII.**—*(Rod IV., heated.)*

| *i.* | H. | *p.* | I. | *k.* |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | ... |
| 0·05 | 0·9 | 21 | 155 | 172·0 |
| 0·1 | 1·8 | 35 | 259 | 144·0 |
| 0·2 | 3·6 | 60 | 444 | 123·0 |
| 0·6 | 10·8 | 77 | 570 | 53·0 |
| 0·9 | 16·2 | 91 | 673 | 41·5 |
| 1·2 | 21·6 | 109 | 807 | 37·4 |
| 1·5 | 27·0 | 120 | 888 | 32·9 |
| 2·0 | 36·0 | 143 | 1,058 | 29·3 |
| 3·0 | 54·0 | 180 | 1,332 | 24·9 |
| 3·5 | 63·0 | 185 | 1,369 | 21·7 |
| 4·0 | 72·0 | 190 | 1,406 | 19·5 |
| 5·0 | 90·0 | 195 | 1,443 | 16·0 |
| 0 | 0 | 118 | 873 | ... |

It will be noticed that for weak magnetic fields the magnetisation increases more rapidly than the field, and attains much higher values than for the un-heated rod, the deposit now giving the same deflection with 0·2 ampere, as it did before with 1·1 ampere. The magnetic moments of the heated rod remain uniformly above those of the other, although with increasing currents the differences decrease. The susceptibility is also much higher than that of the other deposits, and reaches about the same value as for soft iron. The approach to the point of saturation is distinctly traceable. The high permanent magnetism is still striking. It seems not to suffer at all under the heating process, but to increase, if anything.

*Deposits from Iron-Ammonium Sulphate.*

The third kind of deposits examined were those from a solution of iron-ammonium sulphate. They showed strong metallic lustre, and weighed 4 and 21 milligrammes respectively. Their magnetic properties were quite similar to those of the other deposits already described. Their temporary and permanent magnetisations were only little smaller than in the case of the ferrous sulphate deposits. The permanent magnetism is only a third of the temporary; but the difficulty experienced in neutralising the original magnetisation by a reverse current is very remarkable. Thus in Rod VII. it is only a current of one ampere, *i.e.*, a field intensity of over 15 units, which is capable of annulling the original permanent magnetisation. The rest will be seen from Tables VIII. and IX.

As regards Rod VII., it should be added that the magnetisation was contrary to the original magnetism. This will explain the very slow increase of magnetisation for field intensities below 30 units. The susceptibility is low and shows many irregularities, especially in the case of Rod VIII.

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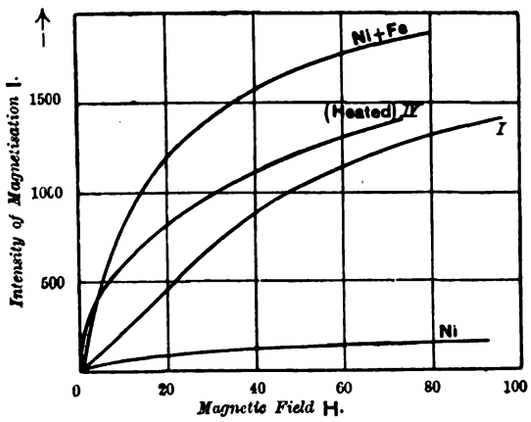
**Table VIII.**—*(Rod VII.)*

| *i.* | H. | *p.* | I. | *k.* |
|---|---|---|---|---|
| 0 | 0 | -1·2 | -258 | ... |
| 0·2 | 3·6 | -1·0 | -215 | ... |
| 0·5 | 9·0 | -0·4 | - 92 | ... |
| 0·8 | 14·4 | -0·2 | - 46 | ... |
| 1·0 | 18·0 | +0·1 | + 23 | 1·3 |
| 1·2 | 21·6 | +0·2 | 46 | ... |
| 1·4 | 25·2 | 0·6 | 139 | 5·5 |
| 2·0 | 36·0 | 2·0 | 430 | 11·9 |
| 2·5 | 45·0 | 2·3 | 495 | 11·0 |
| 3·0 | 54·0 | 3·1 | 667 | 12·4 |
| 3·5 | 63·0 | 5·0 | 1,078 | 17·0 |
| 4·48 | 80·0 | 6·0 | 1,289 | 16·1 |
| 0 | 0 | 2·0 | 430 | ... |

**Table IX.**—*(Rod VIII.)*

| *i.* | H. | *p.* | I. | *k.* |
|---|---|---|---|---|
| 0 | 0 | 4·1 | 168 | ... |
| 0·2 | 3·6 | 4·2 | 172 | 47·9 |
| 0·5 | 9·0 | 4·5 | 184 | 20·4 |
| 0·8 | 14·4 | 4·8 | 197 | 13·8 |
| 1·0 | 18·0 | 5·3 | 217 | 12·1 |
| 1·2 | 21·6 | 6·0 | 245 | 11·9 |
| 1·4 | 25·2 | 9·9 | 406 | 16·1 |
| 2·0 | 36·0 | 13·0 | 533 | 14·8 |
| 2·5 | 45·0 | 17·5 | 717 | 15·9 |
| 3·0 | 54·0 | 20·0 | 845 | 15·6 |
| 3·5 | 63·0 | 26·0 | 1,066 | 16·9 |
| 4·48 | 80·0 | 32·5 | 1,330 | 16·6 |
| 0 | 0 | 11·0 | 451 | ... |

We may take it as the result of the investigation that with equally good iron deposits their magnetic properties depend upon the nature of the solution, but only to a small extent. All the iron specimens, without exception, turned out to be hard and brittle, and of great coercive power. The latter is, of course, measured by the field intensity necessary to remove the remanent magnetism.




While in soft iron this intensity is about 2·3 units, all the electrolytic specimens required 20 to 30 units for their demagnetisation. But in spite of the high permanent moment the temporary magnetism in strong fields attained nearly the same values as in soft iron.

*Nickel Deposits.*

Previous results obtained with ordinary nickel and cobalt would lead one to expect that the magnetic moments of equal iron, nickel, and cobalt rods under the same conditions would be in the proportion of 4:1:3. I was therefore surprised to find that the maximum of I for nickel was only one-tenth of the corresponding value for iron. The permanent magnetism is from one-seventh to one-fifth of the temporary, and is therefore smaller than that of electrolytic iron. But the coercive force is very considerable, since the remanent magnetism can only be removed by a contrary field of 35 units. While I in electrolytic nickel has a maximum value of 132, Ewing's curves give as much as 500 for a lesser field intensity.

*Cobalt Deposits.*

Electrolytic cobalt shows even less magnetisation than nickel. This may, however, be due to the imperfect uniformity of the deposits tested. They showed considerable original magnetisation, amounting to about half the total permanent magnetism. The susceptibility of cobalt, like that of nickel, is very small, and is, curiously enough, nearly constant for fields of 1 to 4 units.

I have come to the conclusion that the peculiar behaviour of nickel above referred to is characteristic of the electrolytic variety.

*Deposits of Nickel-iron and Cobalt-iron Alloys.*

Since meteorites, composed esentially of iron and nickel, show peculiar magnetic properties, it was interesting to test iron-nickel alloys with regard to their magnetic behaviour. Prof. Oberbeck suggested obtaining such alloys by electrolysis. It was difficult by the method here employed to determine the exact constitution of the alloy obtained; but one specimen obtained from a concentrated solution of nickel-ammonium and ferrous sulphates and detached from the supporting rod was found to contain 4·7 per cent. of nickel.

A deposit weighing 2 milligrammes attained the extraordinary intensity of magnetisation of 1,830 units in a field of 4 units. As far as I know, this is the highest value on record, that for soft iron being between 1,700 and 1,750. This may be due to the nickel molecules facilitating the orientation of the iron molecules in some way. The alloys also show a high permanent moment, which may exceed that of iron deposits.

Cobalt-iron alloys, which I also attempted to prepare, seemed to behave similarly to the nickel alloys. But I am still working at both, and must reserve further particulars.

The accompanying curves represent graphically some of the results obtained.

## TRANSMISSION AND PHOTOMETRY OF X-RAYS.*

BY PROF. ANTONIO RÓITI.

*Comparison of Two Tubes.*—I worked with two tubes of the kind described some time ago,† in which the aluminium is at the same time the anode and the anticathode, and also constitutes a wall separating the vacuum from the external air. But instead of

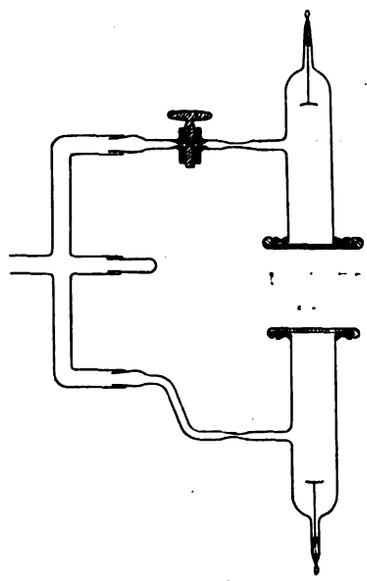


FIG. 1.

embracing the glass tube, the aluminium took the shape of a flat plate resting upon the mouth of the glass tube by polished contact only. The plate was burnished on both sides, and had a thickness of a little over 2mm. The cathode was also of aluminium, and had the shape of a spherical cap, with its centre of curvature about 1cm. on the other side of the plate, so that the free portion of the plate was nearly uniformly covered by the cathode rays.

The two tubes are represented at one-fifth of their natural size in Fig. 1, attached to the Geissler pump, with the two plates facing each other at a distance of 5cm.

They were arranged in parallel, the plates being connected with the positive terminal of a large Ruhmkorff coil and the caps with the negative terminal. The discharge produced a green fluorescence all over the walls of the tube, but with greater intensity in the neighbourhood of the plates, probably owing to reflection by the plates themselves.

The tubes were as much alike as they could be made, but to make their luminosities equal, I found it necessary to put the anodes to earth. The luminosity took the shape of the third stage, *i.e.*, that at which the fine brush from the centre of the cap just disappears. The tubes leading to the pump were also invaded by

* "Cryptochrosis, and other Researches upon X-Rays." *Atti dei Lincei*, Vol. CCXCII., July, 1896, and "An X-Ray Actinometer," *Elettricista*, No. 9, 1896. Abstract.

† See *The Electrician*, July 31, p. 450.

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the third stratum of the cathode rays, and showed a whitish flash of light.

I also arranged the tubes in series, by connecting the first to the negative terminal of the coil, the plate of the second to the positive terminal, and joining the other two electrodes with a wire. Under these circumstances, the tube attached to the negative terminal presented the usual fluorescence. The other was not green at all, but contained a whitish cloud projecting from the luminous pump tube. This cloud formed an anode in conjunction with the aluminium plate. It protected that plate from the cathode rays and prevented its sending out X-rays. The cloud consisted of a residue of gas. The energy of the cathode rays impinging upon it, instead of producing X-rays, performed the work of dissociation, and thus gave rise to the luminescence observed.

*X-Rays from Liquids, but not from Gases.*—I have two reasons for thinking that cathode rays do not give rise to X-rays when they impinge upon gases. The first is the absence of photographic action across a small hole in a tube having two coaxial rings for electrodes, and presenting between the two rings a bright conical discharge. No impression was obtained even after several hours. The second reason is, that when a sensitive plate is attached to the tube connected with the positive terminal the plate receives no impression in spite of the transparency of the aluminium.

On the other hand, the rays may proceed from liquids, or at least from mercury. Using a small quantity of mercury as an anode and anti-cathode, photographic impressions were obtained on a protected plate on the other side of the cathode. The rays appeared to proceed from the centre of the mercury surface.

*Dissociation of Sulphuric Acid.*—A small quantity of sulphuric acid was introduced into a tube provided with a ring anode and a concave cathode, arranged so that the cathode rays proceeded

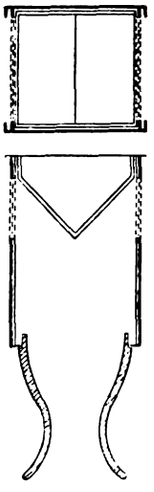

FIG. 2.

through the ring to the surface of the liquid. The tube was attached to the pump, and provided with an auxiliary condensing tube immersed in a freezing mixture. The discharge at first produced a vivid green on the walls as usual, which was soon replaced by a blue glow of increasing brightness. A gas was evolved which could not be condensed. After an hour's working of the pump 6·7 cubic cm. of the gas was obtained. An analysis gave 3·6 cubic cm. of sulphuric anhydride and 0·7 cubic cm. oxygen. The rest was probably nitrogen, due to the presence of some air in the collecting vessel. No X-rays were produced at the surface of the sulphuric acid.

*An X-Ray Actinometer.*—The instrument is constructed on the principle of Ritchie's photometer. As seen in Fig. 2 a rectangular prism is placed at the bottom of a square box. Two windows with guides are to the right and left of the prism, in which screens of various kinds may be inserted, and an eye piece is attached in front of the box, provided with a diaphragm. Both the prism and the box are made of brass lined with lead. The two faces of the prism are covered with a fluorescent layer of crystalline potassium platino-cyanide. When in use, the windows are closed by means of cardboard screens. The actinometer is best mounted on a vertical bar, along which it can be shifted. The tubes are fixed above and below it, or, if one tube is to be referred to a constant source of light, an incandescent lamp fed by a regulated current is placed on the lower shelf, and is partly screened off with cobalt glass. All observations should be made in a darkened room. The eyes should not regard the prism fixedly, but should be closed and intermittently opened for a short time. This avoids subjective images, and gives uniform and precise results.

*Cryptochrosis.*—The behaviour of the various forms of X-rays with regard to transmission and absorption may be termed *cryptochrosis*, after Melloni, who termed the corresponding properties of the obscure heat rays *thermochrosis*. We know that ordinary glass transmits a greater proportion of the rays of an oil lamp than those of an alcohol lamp. For placing a thermo-electric pile between the two sources and adjusting the distance so that the galvanometer shows no deflection, and then covering both the faces of the pile with equal plates of glass, the galvanometer shows that the side next the oil lamp receives more energy than that turned towards the alcohol lamp. Similarly, the penetrating power of the X-rays proceeding from two tubes is in general different, and I have always found that the rays of one tube, which were more penetrative for one substance, were also better able to penetrate all other substances, such as copper of 0·1mm., tinned iron of 0·3mm., aluminium in thickness up to 8mm., ebonite of 8mm., glass of 2·3mm., mica of 1·8mm., ox-bone of 2·5mm., buffalo horn of 2·4mm., deal boards of 75mm. aggregate thickness, and paraffin of 18mm. thickness. I have not so far observed a case corresponding to that of thermochrosis, in which black glass, in opposition to ordinary glass, is more transparent for the alcohol flame than for the oil flame.

When a series of tubes is arranged according to the penetrating powers of their rays, the order remains the same even if different coils are used, or different E.M.F.'s, and the penetrating power is not in direct proportion to the power of exciting fluorescence. Using two tubes giving rays of equal penetrating power, I found, on the other hand, that the introduction of a spark gap between the coil and the anode of the tube increased the penetration, even while it diminished the phosphogenic power. When the field was made uniform by bringing the actinometer closer up to the sparking tube, the interposition of equal screens led to a brightening of the face turned in that direction.

With the same tubes I found that when X-rays have traversed any given body they acquire a different penetrative power. Up to the present, I have always found *that they penetrate more easily not only the substance traversed, but any other substance.* Placing a screen in one window, and finding the position of equal brightness, this position was always disturbed by the interposition of two further screens, one on each side, and in every case that side appeared the brighter which was illuminated by rays which had penetrated the two screens in succession.

I will add some quantitative measurements executed on July 31st. The actinometer was fixed at a distance of 10cm. from the platinum anti-cathode of a Jena glass tube, and to produce uniformity of the field I used a lamp of 2 c.p. fed by 0·92 ampere at 5 volts. I noted the distances $d_0$ at which it then stood from the edge of the prism. Then I introduced between the tube and the actinometer a piece of tinfoil 0·02mm. thick stretched in a frame, and noted the new distance $d_1$ between the lamp and the prism when the field was uniform. I again measured $d_0$ and $d_1$, and then $d_0$ a third time. I proceeded in the same way, adding three other sheets in succession, getting in each case three values for $d_0$, and two each for $d_2$, $d_3$, and $d_4$. I then returned to three, two, and one thickness in the same manner. In the following Table $n$ is the number of layers, $d_n$ the distance of the lamp necessary to obtain equal brightness when $n$ layers are interposed on the other side, $K_n$ the amount of energy penetrating the $n$ layers (deduced on the assumption of the law of inverse squares). $K_{n-1} - K_n$ represents the energy absorbed by the $n$th layer, and the ratio of this quantity to $K_{n-1}$ represents the absorptive power of the $n$th layer. This is seen to diminish to a limit, just as in thermochrosis. The rays are eventually reduced to those for which the coefficient of extinction is a minimum.

| $n$ | $d_n$ | $K_n$ | $K_{n-1} - K_n$ | $\frac{K_{n-1} - K_n}{K_{n-1}}$ |
|---|---|---|---|---|
| 0 | 16·75 | 1 | | |
| 1 | 21·75 | 0·593 | 0·407 | 0·407 |
| 2 | 28·00 | 0·358 | 0·235 | 0·395 |
| 3 | 35·80 | 0·219 | 0·139 | 0·388 |
| 4 | 45·75 | 0·134 | 0·085 | 0·388 |

These and further experiments have shown that it is impossible to set up a scale of transparency of bodies for X-rays without specifying the source whence the rays have been derived, and the path they have to traverse before reaching the body.

It has also been found that the brightness of fluorescence depends much upon the material of the screen. Experiments were made with barium platino-cyanide, ammonium fluo-uranate, and calcium tungstate. The platino-cyanide is the brightest both under the lamp and under X-rays. The tungstate is the feeblest under the lamp, but stronger than the uranium salt under X-rays. An actinometer containing strips of all three salts could never be made quite uniformly bright or brought to a position of equilibrium. It becomes therefore also necessary to specify the fluorescent body used in the actinometric measurements.



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## OFFICIAL VOCABULARY FOR CODE TELEGRAMS.

The following is a translation of a Circular issued by the Internation Bureau at Berne to Chambers of Commerce, code compilers, &c., regarding the second edition of the Official Vocabulary for use in code telegrams :—

"The International Telegraph Conference, which assembled at Buda-Pesth from June 16 to July 22, 1896, has given to Regulation VIII.. which treats of code language and of the Official Vocabulary, the following form :—

REGULATION VIII.

1. Code language is that which is composed of words each having an intrinsic meaning, but not forming intelligible phrases, in one or more of the languages authorised for telegraphic correspondence in plain language.

2. The words used in code language must not exceed ten letters, according to the Morse alphabet. They must be taken from one or more of the following languages: German, English, Spanish, French, Dutch, Italian, Portuguese, and Latin.

3. Proper names can only be used in telegrams composed wholly or in part in code language, with their signification in clear language. Proper names, however, which appear in the Official Vocabulary shall be admitted if used as code words.

4. The office of origin may demand of the sender the production of his code, in order to ascertain if the rules fixed in the three preceding paragraphs have been duly observed.

5. From a date to be fixed by the next Conference all the words used in private telegrams drawn up in code language shall be extracted from the augmented Official Vocabulary, to be prepared by the International Bureau of the Telegraphic Administrations.

"As a result of this regulation the International Bureau is instructed to prepare and publish a new and enlarged edition of the 'Official Vocabulary.' In the discussion of the subject preceding these decisions the views of the Conference were clearly indicated. The essential points are as follows :—

"The second edition must contain many more words than the first in order to meet all the requirements of commerce. It must in every respect be a *vocabulary* pure and simple, *i.e.*, a list of the words in the eight languages admitted, from which code-compilers may select such as are most suitable for their purpose. Any special selection or any special arrangement of words which might lead the purchaser of the second edition to confound it with a *code* must be avoided. Further, there will be no necessity to pay attention to typographic, telegraphic or phonetic similarity between one word and another. It will consequently contain words differing from each other by only one letter, and between which the telegraphic dissimilarity may be *nil*.

"It is contemplated that sooner or later this new Vocabulary will be declared obligatory for the European and extra-European telegraphic services. With a view to meeting the case of possessors of private codes already existing, the International Bureau considers it desirable to insert in the new edition, as far as circumstances permit, all the words of these codes, provided that they are legitimate and not made-up words, containing not less than five or more than ten letters, extracted from the eight admitted languages. To attain this object it is necessary that the International Bureau should be in possession of codes the validity of which the compiler or proprietor wishes to assure after the definitive adoption of the Official Vocabulary. The International Bureau therefore begs Chambers of Commerce, compilers of codes, and all who desire to have the words of their codes inserted in the second edition of the Vocabulary, to forward, *before the end of the present year*, one copy to the address given below. It must be understood that the codes are to be sent gratuitously, and that the words appearing therein may be so used without infringement of authorial rights.

The International Bureau of the Telegraphic Administrations, Berne, Switzerland.

"September 1, 1896."

## PROF. J. J. THOMSON'S ADDRESS TO SECTION A.

There is a melancholy reminiscence connected with this meeting of our Section, for when the British Association last met in Liverpool the chair in Section A was occupied by Clerk-Maxwell. In the quarter of a century which has elapsed since that meeting one of the most important advances made in our science has been the research which, inspired by Maxwell's view of electrical action, confirmed that view and revolutionised our conception of the processes occurring in the electro-magnetic field. When the Association last met in Liverpool, Maxwell's view was almost without supporters ; to-day its opponents are fewer than its supporters then. Maxwell's theory, which is the development and extension of Faraday's, has not only affected our way of regarding the older phenomena of electricity ; it has, in the hands of Hertz and others, led to the discovery of whole regions of phenomena previously undreamt of. It is sad to think that his premature death prevented him from reaping the harvest he had sown. His writings are, however, with us, and are a storehouse to which we continually turn, and never, I think, without finding something valuable and suggestive.

"Thus ye teach us day by day,
Wisdom, though now far away."

The past year has been rich in matters of interest to physicists. In it has occurred the jubilee of Lord Kelvin's tenure of the Professorship of Natural Philosophy at the University of Glasgow. Some of us were privileged to see this year at Glasgow an event unprecedented in the history of physical science in England, when congratulations to Lord Kelvin on the jubilee of his professorship were offered by people of every condition and country. Every scientific society and every scientific man is Lord Kelvin's debtor ; but no society and no body of men owe him a greater debt than Section A of the British Association ; he has done more for this Section than any one else, he has rarely missed its meetings, he has contributed to the Section papers which will make its proceedings imperishable, and by his enthusiasm he has year by year inspired the workers in this Section to renew with increased vigour their struggles to penetrate the secrets of nature. Long may we continue to receive from him the encouragement and assistance which have been so freely given for the past half century.

By the death of Sir W. R. Grove, the inventor of Grove's cell, we have lost a physicist whose name is a familiar one in every laboratory in the world. Besides the Grove cell, we owe to him the discovery of the gas battery, and a series of researches on the electrical behaviour of gases, whose importance is only now beginning to be appreciated. His essay on the correlation of the physical forces had great influence in promoting that belief in the unity of the various branches of physics which is one of the characteristic features of modern natural philosophy.

In the late Prof. Stoletow, of Moscow, we have lost the author of a series of most interesting researches on the electrical properties of gases illuminated by ultra-violet light, researches which, from their place of publication, are, I am afraid, not so well known in this country as they deserve to be.

As one who unfortunately of late years has had only too many opportunities of judging of the teaching of science in our public and secondary schools, I should like to bear testimony to the great improvement which has taken place in the teaching of physics in these schools during the past ten years. The standard attained in physics by the pupils of these schools is increasing year by year, and great credit is due to those by whose labours this improvement has been accomplished. I hope I may not be considered ungrateful if I express the opinion that in the zeal and energy which is now spent in the teaching of physics in school there may lurk a temptation to make the pupils cover too much ground. You may by careful organisation and arrangement ensure that boys shall be taken over many branches of physics in the course of a short time. It is indeed not uncommon to find boys of 17 or 18 who have compassed almost the whole range of physical subjects. But although you may increase the rate at which information is acquired, you cannot increase in anything like the same proportion the rate at which the subject is assimilated, so as to become a means of strengthening the mind and a permanent mental endowment when the facts have long been forgotten. Physics can be taught so as to be a subject of the greatest possible educational value ; but when it is so it is not so much because the student acquires a knowledge of a number of interesting and important facts, as by the mental training the study affords in, as Maxwell said, "bringing our theoretical knowledge to bear on the objects and the objects on our theoretical knowledge." I think this training can be got better by going very slowly through such a subject as mechanics, making the students try innumerable experiments of the simplest, and, what is a matter of importance in school teaching, of the most inexpensive kind, but always endeavouring to arrive at numerical results, rather than by attempting to cover the whole range of mechanics, light, heat, sound, electricity, and magnetism. I confess I regret the presence in examinations intended for school boys of many of these subjects. I think, too, that in the teaching of physics at our universities there is perhaps a tendency to make the course too complex and too complete. I refer especially to the training of those students who intend to become physicists. I think that after a student has been trained to take accurate observations, to be alive to those pitfalls and errors to which all experiments are liable, mischief may in some cases be done if, with the view of learning a knowledge of methods, he is kept performing elaborate experiments, the results of which are well known. It is not given to many to wear a load of learning lightly as a flower. With many students a load of learning, especially if it takes a long time to acquire, is apt to crush

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enthusiasm. Now, there is, I think, hardly any quality more essential to success in physical investigations than enthusiasm. Any investigation in experimental physics requires a large expenditure of both time and patience; the apparatus seldom, if ever, begins by behaving as it ought; there are times when all the forces of nature, all the properties of matter, seem to be fighting against us; the instruments behave in the most capricious way, and we appreciate Coutts Trotter's saying, that the doctrine of the constancy of Nature could never have been discovered in a laboratory. These difficulties have to be overcome, but it may take weeks or months to do so, and, unless the student is enthusiastic, he is apt to retire disheartened from the contest. I think, therefore, that the preservation of youthful enthusiasm is one of the most important points for consideration in the training of physicists. In my opinion this can best be done by allowing the student, even before he is supposed to be acquainted with the whole of physics, to begin some original research of a simple kind under the guidance of a teacher who will encourage him and assist in the removal of difficulties. If the student once tastes the delights of the successful completion of an investigation, he is not likely to go back, and will be better equipped for investigating the secrets of Nature than if, like the White Knight of "Alice in Wonderland," he commences his career knowing how to measure or weigh every physical quantity under the sun, but with little desire or enthusiasm to have anything to do with any of them. Even for those students who intend to devote themselves to other pursuits than physical investigation, the benefits derived from original investigation as a means of general education can hardly be over-estimated, the necessity it entails of independent thought, perseverance in overcoming difficulties, and the weighing of evidence gives it an educational value which can hardly be rivalled. We have to congratulate ourselves that through the munificence of Mr. Ludwig Mond, in providing and endowing a laboratory for research, the opportunities for pursuing original investigations in this country have been greatly increased.

The discovery at the end of last year by Prof. Röntgen of a new kind of radiation from a highly exhausted tube through which an electric discharge is passing, has aroused an amount of interest unprecedented in the history of physical science. The effects produced *inside* such a tube by the cathode rays, the bright phosphorescence of the glass, the shadows thrown by opaque objects, the deflection of the rays by a magnet, have, thanks to the researches of Crookes and Goldstein, long been familiar to us; but it is only recently that the remarkable effects which occur outside such a tube have been discovered. In 1893, Lenard, using a tube provided with a window made of a very thin plate of aluminium, found that a screen impregnated with a solution of a phosphorescent substance became luminous if placed outside the tube in the prolongation of the line from the cathode through the aluminium window. He also found that photographic plates placed outside the tube in this line were affected, and electrified bodies were discharged; he also obtained by these rays photographs through plates of aluminium or quartz. He found that the rays were affected by a magnet, and regarded them as the prolongations of the cathode rays. This discovery was at the end of last year followed by that of Röntgen, who found that the region round the discharge tube is traversed by rays which affect a photographic plate after passing through substances such as aluminium or cardboard, which are opaque to ordinary light; which pass from one substance to another, without any refraction, and with but little regular reflection, and which are not affected by a magnet. We may, I think, for the purposes of discussion, conveniently divide the rays occurring in or near a vacuum tube traversed by an electric current into three classes, without thereby implying that they are necessarily distinctly different in physical character. We have (1) the cathode rays inside the tube, which are deflected by a magnet; (2) the Lenard rays outside the tube, which are also deflected by a magnet; and (3) the Röntgen rays, which are not, as far as is known, deflected by a magnet. Two views are held as to the nature of the cathode rays; one view is, that they are particles of gas carrying charges of negative electricity, and moving with great velocities which they have acquired as they travelled through the intense electric field which exists in the neighbourhood of the negative electrode. The phosphorescence of the glass is on this view produced by the impact of these rapidly-moving charged particles; though whether it is produced by the mechanical violence of the impact, or whether it is due to an electro-magnetic impulse produced by the sudden reversal of the velocity of the negatively-charged particle—whether, in fact, it is due to mechanical or electrical causes—is an open question. This view of the constitution of the cathode rays explains in a simple way the deflection of those rays in a magnetic field, and it has lately received strong confirmation from the results of an experiment made by Perrin. Perrin* placed inside the exhausted tube a cylindrical metal vessel with a small hole in it, and connected this cylinder with the leaves of a gold-leaf electroscope. The cathode rays could, by means of a magnet, be guided so as either to pass into the cylinder through the aperture or turned quite away from it. Perrin found that when the cathode rays passed into the cylinder the gold leaf of the electroscope diverged, and had a negative charge, showing that the bundle of cathode rays enclosed by the cylinder had a charge of negative electricity. Crookes had many years ago exposed a disc connected with a gold-leaf electroscope to the bombardment of the cathode rays, and found that the disc received a slight *positive* charge; with this arrangement, however, the charged particles had to give up their charges to the disc if the gold leaves of the electroscope were to be affected, and we know that it is extremely difficult, if not impossible, to get electricity out of a charged gas merely by bringing the gas in contact with a metal. Lord Kelvin's electric strainers are an example of this. It is a feature of Perrin's experiment that, since it only acts by induction, the indications of the electroscope are independent of the communication of the charges of electricity from the gas to the cylinder, and since the cathode rays fall on the inside of the cylinder, the electroscope would not be affected, even if there were such an effect as is produced when ultra-violet light falls upon the surface of an electro-negative metal, when the metal acquires a positive charge. Since any such process cannot affect the total amount of electricity inside the cylinder, it will not affect the gold leaves of the electroscope; in fact, Perrin's experiments prove that the cathode rays carry a charge of negative electricity.

The other view held as to the constitution of the cathode rays is that they are waves in the ether. It would seem difficult to account for the result of Perrin's experiment on this view, and also, I think, very difficult to account for the magnetic deflection of the rays. Let us take the case of a uniform magnetic field: the experiments which have been made on the magnetic deflection of these rays seem to make it clear that in a magnetic field which is sensibly uniform the path of these rays is curved; now if these rays were due to ether waves, the curvature of the path would show that the velocity of propagation of these waves varied from point to point of the path—that is, the velocity of propagation of these waves is not only affected by the magnetic field, it is affected differently at different parts of the field. But in a uniform field what is there to differentiate one part from another, so as to account for the variability of the velocity of wave propagation in such a field? The curvature of the path in a uniform field could not be accounted for by supposing that the velocity of this wave motion depended on the strength of the magnetic field, or that the magnetic field, by distorting the shape of the boundary of the negative dark space, changed the direction of the wave front, and so produced a deflection of the rays. The chief reason for supposing that the cathode rays are a species of wave motion is afforded by Lenard's discovery, that when the cathode rays in a vacuum tube fall on a thin aluminium window in the tube, rays having similar properties are observed on the side of the window outside the tube; this is readily explained on the hypothesis that the rays are a species of wave motion to which the window is partially transparent, while it is not very likely that particles of the gas in the tube could force their way through a piece of metal. This discovery of Lenard's does not, however, seem to me incompatible with the view that the cathode rays are due to negatively charged particles moving with high velocities. The space outside Lenard's tube must have been traversed by Röntgen rays, these would put the surrounding gas in a state in which a current would be readily started in the gas if any electromotive force acted upon it. Now, though the metal window in Lenard's experiments was connected with the earth, and would therefore screen off from the outside of the tube any effect arising from slow electrostatic changes in the tube, it does not follow that it would be able to screen off the electrostatic effect of charged particles moving to and from the tube with very great rapidity. For, in order to screen off electrostatic effects, there must be a definite distribution of electrification over the screen; changes in this distribution, however, take a finite time, which depends upon the dimensions of the screen and the electrical conductivity of the material of which it is made. If the electrical changes in the tube take place at above a certain rate, the distribution of electricity on the screen will not have time to adjust itself, and the screen will cease to shield off all electrostatic effects. Thus the very rapid electrical changes which would take place if rapidly-moving charged bodies were striking against the window might give rise to electromotive forces in the region outside the window, and produce convection currents in the gas which has been made a conductor by the Röntgen rays. The Lenard rays would thus be analogous in character to the cathode rays, both being convective currents of electricity. Though there are some points in the behaviour of these Lenard rays which do not admit of a very ready explanation from this point of view, yet the difficulties in its way seem to me considerably less than that of supposing that a wave in the ether can change its velocity when moving from point to point in a uniform magnetic field.

I now pass on to the consideration of the Röntgen rays. We are not yet acquainted with any crucial experiment which shows unmis-

* See *The Electrician*, Vol. XXXVI., February 14, 1896, p. 523.



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takably that these rays are waves of transverse vibration in the ether, or that they are waves of normal vibration, or, indeed, that they are vibrations at all. As a working hypothesis, however, it may be worth while considering the question whether there is any property known to be possessed by these rays which is not possessed by some form or other of light. The many forms of light have in the last few months received a noteworthy addition by the discovery by M. Becquerel of an invisible radiation, possessing many of the properties of the Röntgen rays, which is emitted by many fluorescent substances, and to an especially marked extent by the uranium salts. By means of this radiation, which, since it can be polarised, is unquestionably light, photographs through opaque substances similar to, though not so beautiful as, those obtained by means of Röntgen rays, can be taken, and, like the Röntgen rays, they cause an electrified body on which they shine to lose its charge, whether this be positive or negative.

The two respects in which the Röntgen rays differ from light is in the absence of refraction and perhaps of polarisation. Let us consider the absence of refraction first. We know cases in which special rays of the spectrum pass from one substance to another without refraction; for example, Kundt showed that gold, silver, copper allow some rays to pass through them without bending, while other rays are bent in the wrong direction. Pflüger has lately found that the same is true for some of the aniline dyes when in a solid form. In addition to this the theory of dispersion of light shows that there will be no bending when the frequency of the vibration is very great. I have here a curve taken from a Paper by Helmholtz,* which shows the relation between the refractive index and the frequency of vibration for a substance whose molecules have a natural period of vibration, and one only; the frequency of this vibration is represented by OK in the diagram. The refractive index increases with the frequency of the light until the latter is equal to the frequency of the natural vibration of the substance; the refractive index then diminishes, becomes less than unity, and finally approaches unity, and is practically equal to it when the frequency of the light greatly exceeds that of the natural vibration of the molecule. Helmholtz's results are obtained on the supposition that a molecule of the refracting substance consists of a pair of oppositely electrified atoms, and that the specific inductive capacity of the medium consists of two parts, one due to the ether, the other to the setting of the molecules along the lines of electric force.

Starting from this supposition, we can easily see without mathematical analysis that the relation between the refractive index and the frequency must be of the kind indicated by the curve. Let us suppose that an electromotive force of given amplitude acts on this mixture of molecules and ether, and let us start with the frequency of the external electromotive force less than that of the free vibrations of the molecules; as the period of the force approaches that of the molecules, the effect of the force in pulling the molecules into line will increase; thus the specific inductive capacity, and therefore the refractive index, increases with the frequency of the external force; the effect of this force on the orientation of the molecules will be greatest when the period of the force coincides with that of the molecules. As long as the frequency of the force is less than that of the molecules, the external field tends to make the molecules set so as to increase the specific inductive capacity of the mixture; as soon, however, as the frequency of the force exceeds that of the molecules, the molecules, if there are no viscous forces, will all topple over and point so as to make the part of the specific inductive capacity due to the molecules of opposite sign to that due to the ether. Thus, for frequencies greater than that of the molecules, the specific inductive capacity will be less than unity. When the frequency of the force only slightly exceeds that of the molecules, the effect of the external field on the molecules is very great, so that if there are a considerable number of molecules, the negative part of the specific inductive capacity due to the molecules may be greater than the positive part due to the ether, so that the specific inductive capacity of the mixture of molecules and ether would be negative; no waves of this period could then travel through the medium; they would be totally reflected from the surface. As the frequency of the force gets greater and greater, its effect in making the molecules set will get less and less, but the waves will continue to be totally reflected until the negative part of the specific inductive capacity due to the molecules is just equal to the positive parts due to the ether. Here the refractive index of the mixture is zero. As the frequency of the force increases, its effect on the molecules gets less and less, so that the specific inductive capacity continually approaches that due to the ether alone, and practically coincides with it as soon as the frequency of the force is a considerable multiple of that of the molecules. In this case both the specific inductive capacity and the refractive index of the medium are the same as that of the ether, and there is consequently no refraction. Thus the absence of refraction, instead of being in contradiction to the Röntgen rays, being a kind of light, is exactly what we should expect if the wave-length of the light were exceedingly small.

The other objection to these rays being a kind of light is that there is no very conclusive evidence of the existence of polarisation. Numerous experiments have been made on the difference between the absorption of these rays by a pair of tourmaline plates when their axes are crossed or parallel. Many observers have failed to observe any difference at all between the absorption in the two cases. Prince Galitzine and M. de Karnojitsky, by a kind of cumulative method, have obtained photographs which seem to show that there is a slightly greater absorption when the axes are crossed than there is when the axes are parallel. There can, however, be no question that the effect, if it exists at all, is exceedingly small compared with the corresponding effect for visible light. Analogy, however, leads us to expect that to get polarisation effects we must use, in the case of short waves, polarisers of a much finer structure than would be necessary for long ones. Thus a wire bird-cage will polarise long electrical waves, but will have no effect on visible light. Rubens and Du Bois made an instrument which would polarise the infra red rays by winding very fine wires very close together on a framework; this arrangement, however, was too coarse to polarise visible light. Thus, though the structure of the tourmaline is fine enough to polarise the visible rays, it may be much too coarse to polarise the Röntgen rays if these have exceedingly small wave lengths. As far as our knowledge of these rays extend, I think we may say that though there is no direct evidence that they are a kind of light, there are no properties of the rays which are not possessed by some variety of light.

It is clear that if the Röntgen rays are light rays, their wave-lengths are of an entirely different order to those of visible light. It is perhaps worth notice that on the electro-magnetic theory of light we might expect two different types of vibration if we suppose that the atoms in the molecule of the vibrating substance carried electrical charges. One set of vibrations would be due to the oscillations of the bodies carrying the charges, the other set to the oscillation of the charges on these bodies. The wave-length of the second set of vibrations would be commensurate with molecular dimensions; can these vibrations be the Röntgen rays? If so, we should expect them to be damped with such rapidity as to resemble electrical impulses rather than sustained vibrations.

If we turn from the rays themselves to the effects they produce, we find that the rays alter the properties of the substances through which they are passing. This change is most apparent in the effects produced on the electrical properties of the substances. A gas, for example, while transmitting these rays is a conductor of electricity. It retains its conducting properties for some little time after the rays have ceased to pass through it, but Mr. Rutherford and I have lately found that the conductivity is destroyed if a current of electricity is sent through the Röntgenised gas. The gas in this state behaves in this respect like a very dilute solution of an electrolyte. Such a solution would cease to conduct after enough electricity had been sent through it to electrolyse all the molecules of the electrolyte. When a current is passing through a gas exposed to the rays, the current destroys and the rays produce the structure which gives conductivity to the gas; when things have reached a steady state the rate of destruction by the current must equal the rate of production by the rays. The current can thus not exceed a definite value, otherwise more of the conducting gas would be destroyed than is produced. This explains the very characteristic feature that in the passage of electricity through gases exposed to Röntgen rays the current, though at first proportional to the electromotive force, soon reaches a value where it is almost constant and independent of the electromotive force, and we get to a state when a tenfold increase in the electromotive force only increases the current by a few per cent. The conductivity under the Röntgen rays varies greatly from one gas to another; the halogens and their gaseous compounds, the compounds of sulphur and mercury vapour are among the best conductors. It is worthy of note that those gases which are the best conductors when exposed to the rays are either elements, or compounds of elements, which have in comparison with their valency very high refractive indices. The conductivity conferred by the rays on a gas is not destoyed by a considerable rise in temperature; it is, for example, not destroyed if it be sucked through metal tubing raised to a red heat. The conductivity is, however, destroyed if the gas is made to bubble through water; it is also destroyed if the gas is forced through a plug of glass wool. This last effect seems to indicate that the structure which confers conductivity on the gas is of a very coarse kind, and we get confirmation of this from the fact that a very thin layer of gas exposed to the Röntgen rays does not conduct nearly so well as a thicker one. I think we have evidence from other sources that electrical conduction is a process that requires a considerable space—a space large enough to enclose a very large number of molecules. Thus Koller found that the specific resistances of petroleum, turpentine, and distilled water, when determined from experiments made with very thin layers of

* See *The Electrician*, July 24, p. 404.

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these substances, was very much larger than when determined from experiments with thicker layers. Even in the case of metals there is evidence that the metal has to be of appreciable size if it is to conduct electricity. The theory of the scattering of light by small particles shows that if we assume the truth of the electro-magnetic theory of light, the effects should be different according as the small particles are insulators or conductors. When the small particles are non-conductors, theory and experiment concur in showing that the direction of the complete polarisation for the scattered light is at right angles to the direction of the incident light; while, if the small particles are conductors, theory indicates that the direction of complete polarisation makes an angle of 60deg. with the incident light. This result is not, however, confirmed by the experiments made by Prof. Threlfall on the scattering of light by very small particles of gold. He found that the gold scattered the light in just the same way as a non-conductor, giving complete polarisation at right angles to the incident light. This would seem to indicate that those very finely divided metallic particles no longer acted as conductors. Thus there seems evidence that in the case of conduction through gases, through badly-conducting liquids, and through metals, electric conduction is a process which requires a very considerable space and aggregations of large numbers of molecules. I have not been able to find any direct experimental evidence as to whether the same is true for electrolytes. Experiments on the resistance of thin layers of electrolytes would be of considerable interest, as according to one widely-accepted view of electrolysis conduction through electrolytes, so far from being affected by aggregations of molecules, takes place by means of the ion, a structure simpler than that of the molecule, so that if this represents the process of electrolytic conduction there would not seem room for the occurrence of an effect which occurs with every other kind of conduction.

In this building it is only fitting that some reference should be made to the question of the movement of ether. You are all doubtless acquainted with the heroic attempts made by Prof. Lodge to set the ether in motion, and how successfully the ether resisted them. It seems to be conclusively proved that a solid body in motion does not set in motion the ether at an appreciable distance outside it; so that if the ether is disturbed at all in such a case the disturbance is not comparable with that produced by a solid moving through an incompressible fluid, but must be more analogous to that which would be produced by the motion through the liquid of a body of a very open structure, such as a piece of wire netting, where the motion of the fluid only extends to a distance comparable with the diameter of the wire, and not with that of the piece of netting.

There is another class of phenomena relating to the movement of the ether, which is, I think, deserving of consideration, and that is the effect of a varying electro-magnetic field in setting the ether in motion. I do not remember to have seen it pointed out that the electro-magnetic theory of light implicitly assumes that the ether is not set in motion even when acted on by mechanical forces. On the electro-magnetic theory of light such forces do exist, and the equations used are only applicable when the ether is at rest. Consider, for example, the case of a plane electric wave travelling through the ether. We have parallel to the wave-front a varying electric polarisation, which on the theory is equivalent to a current; at right angles to this, and also in the wave-front, we have a magnetic force. Now, when a current flows through a medium in a magnetic field there is a force acting on the medium at right angles to the plane, which is parallel both to the current and to the magnetic force; there will thus be a mechanical force acting on each unit volume of the ether when transmitting an electric wave; and since this force is at right angles to the current and to the magnetic force, it will be in the direction in which the wave is propagated. In the electro-magnetic theory of light, however, we assume that this force does not set the ether in motion, as, unless we made this assumption, we should have to modify our equations, as the electro-magnetic equations are not the same in a moving field as in a field at rest. In fact, a complete discussion of the transmission of electro-magnetic disturbances requires a knowledge of the constitution of the ether which we do not possess. We now assume that the ether is not set in motion by an electro-magnetic wave. If we do not make this assumption we must introduce into our equation quantities representing the components of the velocity of the ether; and unless we know the constitution of the ether, so as to be able to deduce these velocities from the forces acting on it, there will be in the equations of the electro-magnetic field more unknown quantities than we have equations to determine. It is, therefore, a very essential point in electro-magnetic theory to investigate whether or not there is any motion of the ether in a varying electro-magnetic field. We have at the Cavendish Laboratory, using Prof. Lodge's arrangement of interference fringes, made some experiments to see if we could detect any movement of the ether in the neighbourhood of an electric vibrator, using the spark which starts the vibrations as the source of light. The movement of the ether, if it exists, will be oscillatory, and with an undamped vibrator the average velocity would be zero; we used, therefore, a heavily damped vibrator, with which the average velocity might be expected to be finite. The experiments are not complete, but so far the results are entirely negative. We also tried by the same method to see if we could detect any movement of the ether in the neighbourhood of a vacuum tube emitting Röntgen rays, but could not find any trace of such a movement. Prof. Threlfall, who independently tried the same experiment, has, I believe, arrived at the same conclusion.

Unless the ether is immovable under the mechanical forces in a varying electro-magnetic field there are a multitude of phenomena awaiting discovery. If the ether does move, then the velocity of transmission of electrical vibrations, and therefore of light, will be affected by a steady magnetic field. Such a field, even if containing nothing but ether, will behave towards light like a crystal, and the velocity of propagation will depend upon the direction of the rays. A similar result would also hold in a steady electric field. We may hope that experiments on these and similar points may throw some light on the properties of that medium which is universal, which plays so large a part in our explanation of physical phenomena, and of which we know so little.

## ON TUBES FOR PRODUCING X-RAYS.

BY PROF. AUGUSTO RIGHI.

I believe it will be advantageous to experimenters to make known a very easy and speedy method of constructing tubes for X-rays, with which, as I shall explain further, very remarkable effects may be obtained. One of these tubes, whilst costing almost nothing, may be constructed in a few minutes, after which a small mercury pump can rarify the air inside to the proper degree in less than a quarter of an hour.

I take a piece of glass tube with thick walls (for example, length 15cm., internal diameter 0·8cm., external diameter 1·6cm.) and introduce one end of it into a kind of aluminium thimble, sufficiently wide to allow the tube to go almost to the bottom of it.

Generally I use one of those aluminium sewing thimbles which are now to be found in commerce. With good sealing-wax I now close up the space which remains between the glass and the rim of the thimble, taking care that it does not go down to the bottom. Through the other extremity of the tube I introduce the cathode and a little tube of glass intended to form the communication with the pump, closing well every crack with sealing-wax. The cathode is merely a little disc of aluminium 1mm. to 2mm. thick and 7mm. in diameter, situated at about 8cm. from the bottom of the thimble, and fixed merely to a stem of aluminium which comes out of the tube.

I keep the thimble immersed in water while the pump is working, so as to prevent the melting of the sealing-wax which joins it to the glass. For example, if the tube must stand vertical with the thimble below it, I plunge this latter into a receptacle full of water having an aluminium bottom. It is well that the thimble should touch the bottom of the receptacle.

The effects obtained with tubes so constructed are sufficiently noteworthy. For example, using a coil which, with a current of 15 amperes and a mercury-break producing 10 or 12 interruptions per second, gave sparks of 8cm. length between brass balls of 4cm. diameter. I have obtained, with an exposure of 120 seconds on a plate 12cm. distant from the tube, a very good shadow of the bones of my hand. The shadow of a fœtus of four mouths was so good that, examining it with a lens, the most minute particulars were seen. Increasing the current to 24 amperes, I have obtained fine photographs of bones of the hand with 10 to 20 seconds of exposure, keeping the photographic plate 10cm. from the tube.

Then placing the plate at 7cm. only, I obtained a distinct shadow of the bones of the hand *by a single break of the current*, or by *one single discharge*. This photograph deserves to be called *instantaneous*. Augmenting slightly the current induced in the coil, the instantaneous photograph becomes perfect with regard to intensity: but it is necessary to slightly increase the thickness of the walls of the tube, so that they may be able to resist.

These tubes of simple construction cannot be separated from the pump, otherwise the internal pressure increases with time, and especially with use, which, however, occurs also, though more slowly, with the ordinary tubes, so that the effects which they give rise to are not constant. With the tube united to the pump, there is the advantage of being able, at the beginning of every experiment, to carry the exhaustion to its highest degree, and thus to have always and with certainty the greatest effect.*

* [The style of tube described is very similar to that adopted by Prof. A. Rotti, and referred to on p. 450 of our issue of July 31st. Prof. Righi, however, would appear to have obtained the better results.—ED. *E.*]

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## LENARD'S RAYS.

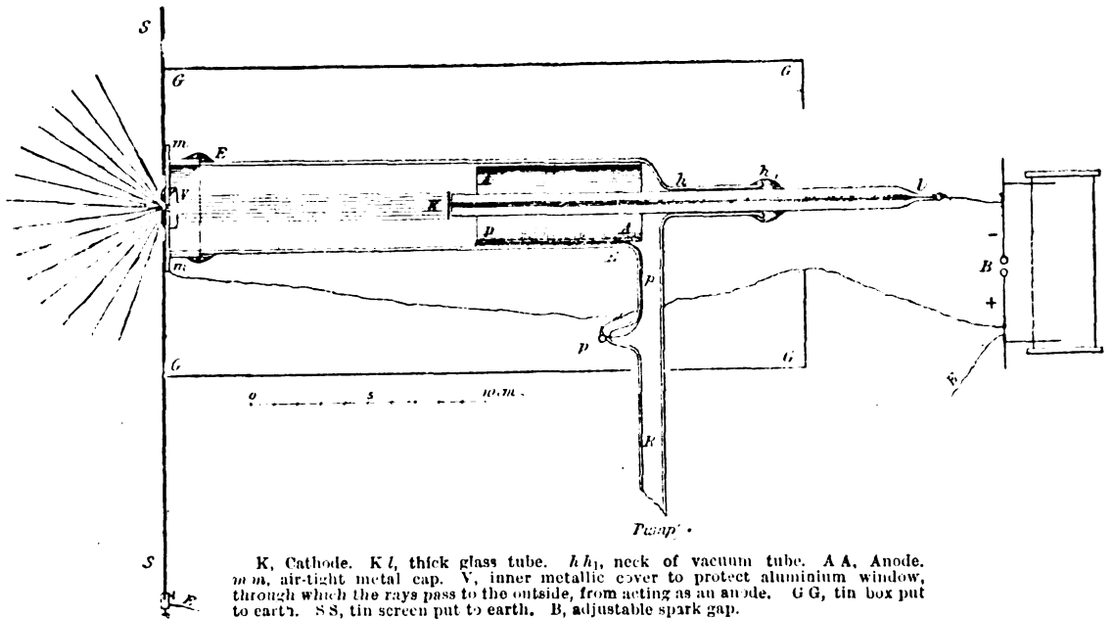
(FROM A CORRESPONDENT.)

In view of the discussion on Röntgen rays and allied phenomena, to take place to-day, at the British Association meeting, a few words on Lenard's rays (which are to be shown at Liverpool) may be appropriate from one who has seen the experiments.

Lenard, as our readers* will remember, was using a Crookes tube with a small flat cathode, K, opposite which he placed a small window of aluminium foil, about $\frac{1}{100}$mm. thick, mounted in a metal cap *mm*. On making a high vacuum in the tube, and passing sparks from an induction coil, cathode rays were created inside the tube. Some of these, impinging on the window, passed through it and emerged in the air outside. To investigate these rays Lenard used a fluorescent screen, consisting of thin paper impregnated with pentadecyl-paratolyl-ketone, a substance which physically resembles paraffin wax, and is much less highly fluorescent than the platino-cyanides of barium or potassium. Using this screen he found that a brilliant fluorescent light was produced close to the window, and spread out at wide angles by diffusion, but rapidly died away in intensity, owing to the great opacity of air. At a distance of 2in. from the window (which was only about $\frac{1}{10}$in. in diameter) scarcely anything was visible. On affixing beyond the window a second tube filled with hydrogen, especially with rarefied hydrogen, he found these rays to be much less absorbed; they could be traced to a distance of 2ft. or 3ft.

Using this little screen he made the well-known investigations upon the opacity of metals and other substances, and found the opacity to be nearly proportional to density. He also investigated the effect of the magnet in deflecting the rays, and found them to be of various qualities, some more deflectable than others, and observed also that their deflectibility depended on the state of the internal vacuum in which they were created. But he missed observing any rays that possessed the property of not being deflected at all. These were Röntgen's subsequent discovery. Those rays which Lenard observed he photographed through sheets of aluminium, and he noted their property of causing the discharge of an electroscope, whether the latter were positively or negatively electrified. By using an air blast to drive away from the neighbourhood of the electroscope the air that had been acted upon by his rays, he is able to show that the action on the electroscope is two-fold. It is actively discharged by air that has been subjected to the operation of the deflectable rays, it is less actively discharged by the non-deflectable rays. But as the deflectable rays are precisely those to which air is very opaque, it is found that while the air blast greatly affects the rate of discharge when the electroscope is at a distance of say five inches from the window, it hardly affects the rate of discharge at all when the electroscope is within an inch or so of the window. The opacity of air to these rays presents the most striking *differentia* between Lenard's rays and Röntgen's rays.

Prof. Lenard was invited in 1894 to show the then newly discovered phenomena to the British Association at Oxford. It is greatly to be regretted that he was not able at that time to do so, as his deeply interesting research—which was the starting point of Röntgen's—has been, though not in these columns, overshadowed by the immense popularity of Röntgen's recent discovery.




K, Cathode. K *l*, thick glass tube. *h h*$_1$, neck of vacuum tube. A A, Anode. *m m*, air-tight metal cap. V, inner metallic cover to protect aluminium window, through which the rays pass to the outside, from acting as an anode. G G, tin box put to earth. S S, tin screen put to earth. B, adjustable spark gap.

Lenard Tube.

* *The Electrician*, Vol. XXXII., March 23, March 30, and April 6, 1894.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September 4, 1896.*

**Failure of the King's County Elevated Railroad.**—The extensive introduction of the trolley system in Brooklyn has materially decreased the income of the "L" roads, with the result that the King's County Elevated Railroad went in the hands of a receiver on August 31st, the receiver being the President himself, General James Jourdan. Of course, this makes the suit in one sense simply an opportunity to adjust the difficulties, rather than a petition at law. The property has been so highly taxed that this, together with the competition brought about by the trolley systems, has made the company unable to meet its obligations. The company is capitalised for $4,757,000, though the road cost over $10,000,000 to build and equip. The yearly operating expenses are about $700,000, and the receipts, which were the result of transporting 30,000,000 passengers per year, have lately been cut down 50 per cent. In 1895 the assets were $15,600,000, the funded debt $9,700,000, current liabilities $700,000, real estate and mortgages $38,500, second mortgage bonds $364,000. In the same year the profit and loss deficiency was $817,000, gross earnings $804,000, which was an increase of $62,000. There is a coal bill now due of $35,000, together with other obligations, to meet which there is but $51,000 in the treasury. The bondholders have expressed a willingness to extend the time; but the coal dealers are not going to supply more coal without substantial credit. It is believed the receivership will lead to a reorganisation of the entire system. While the road is in the hands of the

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receiver it is compelled by its franchise to operate every day whether paying or not.

**Annual Meeting of the American Association for the Advancement of Science.**—This was held from August 24th to 28th, in Buffalo. It was one of the smallest meetings of recent years, but the number and quality of the Papers present were considered as up to the standard. The number of electric topics treated was unusually large, amongst the most important of which may be mentioned those "On Electrolysis and Some Outstanding Problems in Electro-Dynamics," "The Polarisation and Internal Resistance of a Galvanic Cell and Visible Electric Waves," "The Counter-Electromotive Force of an Electric Arc," "Some Points in the Mechanical Conception of the Electromagnetic Field," "The Theory of Galvanic Polarisation," "The Photographic Study of Röntgen Rays and the Duration of X-Ray Discharge in Crookes Tubes," "The Distribution of High-Frequency Alternating Currents throughout the Cross-Section of a Wire," "The Graphical Treatment of Alternating Currents in Branching Circuits," "Mechanical Models of an Electric Circuit," "A Rule for the Dynamo and Motor," "Electrical Waves in Long Parallel Wires," "The Influence of a Static Charge of Electricity on the Surface Tension of Water," "A New Alternating-Current Curve-Tracer," "A Description and Exhibition of Portable Apparatus for Recording Curves of Alternating Currents of Electromotive Force." The officers elected for 1896-97 are, Prof. Wolcott Gibbs, Newport, R.I., president. The vice-presidents, also performing the functions of chairmen of the various sections, are W. W. Beman (Mathematics and Astronomy); Carl Barus, Providence, R.I. (Physics); John Galbraith, Toronto, Canada (Mechanical Science and Engineering); W. P. Mason, Troy, N.Y. (Chemistry); Richard T. Colburn, Elizabeth, N.J. (Social and Economic Science); F. W. Putnam, Cambridge, Mass., Permanent Secretary; Asaph Hall, Ann Arbor, Mich., General Secretary; E. S. Kellicott, Columbus, Ohio, Secretary of the Council; R. S. Woodward, New York, Treasurer. The place of meeting for next year will be decided upon by the Council. The proposition to hold only a formal meeting at Toronto, August 17, 1897, and then adjourn to assist in welcoming the British Association, met with considerable opposition of the Committee, although passed, and was reversed in general session, the place of meeting for next year being left to the Council. It was then decided that the meeting should be held on August 9, 1897, at Detroit, and then adjourn to Toronto, when the British Association will meet there on August 18th. The time after the meeting was pleasantly spent in excursions made to Niagara and other points.

## CORRESPONDENCE.

### THE "UNIVERSAL" ENGINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been much interested in reading your intelligent criticism of the "Universal" engine.

In constructing the first engine of this class I was troubled by the fact that the high-pressure cylinder was surrounded by receiver steam. Reference to the early sectional drawings, which were published last February, will show that I endeavoured to minimise condensation by interposing a steam jacket between the cylinder and the receiver. The effect of the jacket was thoroughly tested by careful experiments, and no trace of any beneficial effect could be discovered; I therefore decided to abandon the jacket as a useless complication. Your readers will probably remember that Mr. Willans passed through a nearly identical experience, for he tried steam-jacketing to his high-pressure cylinder, and later he put a jacket round all his cylinders; but in neither instance did he find any considerable improvement. I hope shortly to be able to give you particulars of the exact percentage of initial condensation in the "Universal" engine; but I need scarcely remark that when the percentage is very low, as it undoubtedly is in this case, the experiments to determine it must be conducted with very great care, for any error in the calculation of clearance might seriously affect the result.

The combination of automatic cut-off and throttled expansion at low loads is no discovery of mine, but arises naturally out of the use of a shaft expansion governor; and I am indebted to Captain Sankey for his able but unintentional exposition of the theory of its action in his Paper read before the Institution of Mechanical Engineers last year. In that Paper he made it quite clear that a perfect cut-off gear such as the Corliss is only perfect mechanically, and that at low loads the high initial pressure, which it allows, is so detrimental to economy as to raise the steam consumption much above that which suffices with the despised throttle valve.—Yours, &c.,

JOHN S. RAWORTH.

49, Queen Victoria-street, E.C., September 14, 1896.

### COMBINED ELECTRIC LIGHTING AND TRACTION PLANTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I regret that Mr. Hesketh is not able to join me in a reply to the remarks of Prof. D. C. Jackson with reference to our Paper on "Combined Electric Lighting and Traction Plants." As you point out, our arguments as to the value of such a combined plant depend principally upon the assumption that we are not bound to use separate and special machinery for the two circuits. I altogether decline to allow that "we are forced . . . . to use separate machinery (excepting boilers) for the two classes of service." That we *may* do so is no reason why we should.

We came to practically the same conclusions regarding separate machinery as does Prof. Jackson, as the following extract from our Paper will show:—

"We may have (*a*) a separate and distinct tramway plant within the same station buildings as our lighting plant, and under the same management and control; or (*b*) we may utilise the existing lighting machinery by various methods.

"If we adopt the former . . . . we shall require nearly as much extra plant as though the tramways were being worked from a distinct station. The only advantages will be that the existing buildings (enlarged) and the existing lighting staff and management will be available."

The work which Prof. Mengarini has done at Rome is one example of the possibility to use, not only the same machinery, but also the same mains, for both lighting and traction purposes. The station which I am about to lay down here will, I hope, be another. It should be borne in mind that our Paper dealt with the subject from the point of view of the lighting engineer, who would be able to largely reduce his working expenses by the addition of a traction load. That a tramway station could reduce its expenses to the same degree by the addition of a lighting load, we did not intend to suggest.—Yours, &c.,

JOHN H. RIDER.

Corporation Electricity Department, East-street,
Plymouth, September 8, 1896.

### NEW MEN AND OLD PLANT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I hesitate somewhat to make any comments on the subject of Mr. Quin's Report for two very cogent reasons. I was an unsuccessful candidate for the post Mr. Quin now holds, and I have recently joined the staff of the consulting engineer whose work he impugns. Whatever, therefore, I may say will possibly in the minds of some be attributed to pique or spite; but, at the risk of being misjudged, I feel constrained, out of loyalty to my late chief, Mr. John Hesketh, to defend him from the innuendos of his successor; the former, in his position as electrical engineer to the Queensland Government, being at too great a distance to be able to defend himself.

At the commencement of his picturesque report* Mr. Quin points out, with his very "English straightforwardness," that he is "not concerned as to the personality of the party or parties responsible" for what he so dictatorially terms the "blunders which have been made" at the Blackpool works. I sincerely hope that the parties referred to will consider Mr. Quin's youth, and gently overlook this; but they will, no doubt, consider that he must be endowed with a most egotis-

* See *The Electrician*, September 4, p. 608.

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tical personality to condemn, on the strength of a low-tension mains experience, the high-tension work of older and—with all possible deference—more capable engineers.

As regards the efficiency of the plant in work at Blackpool, at the lowness of which Mr. Quin exhibits such lively indignation, in making his valuation he forgets, I think, that the $\frac{\text{E.H.P.}}{\text{I.H.P.}}$ value is not the only factor by which the plant should be judged. The "working efficiency" of a central-station plant is surely the product of this value, and, what might almost be termed its "knockabout" efficiency—in other words, its percentage of reliability under all emergencies. When the Blackpool station was laid down the "working efficiency" of the plant installed was the highest obtainable at the time, and, in consideration of the remarkable absence of engine-room breakdowns and repairs, it must be owned that the choice has been fully justified.

Then as to the condition of the cables. Mr. Quin makes a direct and insulting indictment of Mr. Hesketh's management in the following sentence :—"I find that the general rule in force here seems to have been to *ram* and *jamb* as many cables into one iron pipe as could be got by sheer force." To Mr. Quin's reasoning the exception evidently proves the rule; for the "instance" he gives is the one solitary exception which at all approaches his harrowing description; and this, as he well knows, but does not own, was but arrived at as a temporary measure, rendered necessary by the sudden increase in the demand at the beginning of the present season. Before Mr. Quin arrived on the scene, extra conduits had been laid, and nothing but the season's close was wanting to reduce this section of the mains to its normal condition.

Then, again, "the high-tension cables have perished on all sides." Perhaps as having been on the station staff since the commencement of supply, I may be allowed to know as much about this as does the "Man on the Spot" of the last few weeks; and, considering that, with the exception of the 3,000 volt arc circuits (composed of small-sized cables) only one absolute *cable fault* has occurred on the high-tension mains since supply was started, I think that this sweeping statement must have been written on the strength of some very highly imaginative data.

Another matter which has fallen under the ban of Mr. Quin's displeasure is the method of charging at Blackpool; and without consideration of the fact that the majority of the consumers are short-hour users (and likely to kick), he, ignoring the experience of his predecessor, proposes to raise the price per unit from 6d. to 8d., and to adopt the maximum demand method, a most excellent system in its way, but totally unsuited with a *raised* price to the town in question.

Mr. Quin's action in this matter, and also in the quite needless forcing of 200-volt supply on the central districts, will, I venture to believe (even at the risk of being reduced by him to a vulgar fraction or to the unknown quantity of an equation), cripple the Blackpool demand almost to as great a degree as the writing of his verbose report must have sapped his imagination.—Yours, &c.,

ARTHUR T. COOPER (late Chief Assistant Blackpool Corporation Electricity Works).

Hampden Club, N.W., September 15, 1896.

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TO THE EDITOR OF THE ELECTRICIAN.

SIR: The publication of Mr. Quin's report, setting forth his opinion on the electrical work and plant belonging to the Blackpool Corporation, makes it, in the opinion of some of my townsmen, incumbent on me, as the Chairman of the Committee responsible for our original works, to explain the reasons that guided us in laying them down.

The question is, I think, of interest to the members of the electrical industry generally; for electric light works are, I observe, being extensively laid down by other Corporations; and if Mr. Quin's example is followed, and the new comer into the management of the works condemns wholesale the plans of his predecessors, there will be few men of sufficient intrepidity to risk the odium of initiating the electric lighting of their towns.

In the calm scientific region in which you shine, Sir, I suppose there are no petty jealousies to distract you, and you may therefore be surprised to know that they play a very important part in provincial towns; and it is the blight that such petty jealousies have cast upon the Blackpool undertaking which is the real ground of the present *impasse*. That a scientific gentleman should be found to truckle to this state of things is to be regretted, and can, I think, only be explained by his want of experience in the ways of the world.

What, Sir, are the real facts? Go back a few years! Then Blackpool, the most frequented seaside place in the world, had a few arc lamps fixed on hideous masts, erected along the magnificent Sea Front. Then a few of us urged that it would greatly assist Blackpool in keeping ahead of its rivals to lay down proper electric light works, by means of which the Promenade could be properly and elegantly lighted, and the commercial residents of the town given the opportunity of making their places of business more attractive. It is amusing to turn back over the files of the newspapers to see the abuse with which the few bold ones were assailed. They were accused of endeavouring to introduce the electric light simply to get their own premises lighted, and were told by the wiseacres that no one else would take it, &c. However, we managed to defeat the opposition, and got the works started. Lord Kelvin opened them, and, after carefully inspecting them, pronounced them excellent, and told us that in our Mr. Hammond we had the right man in the right place. Lord Kelvin prophesied to us great success, and his prophecy came too true. When once the business settled down we quickly found that our plant was too small to keep pace with the demand. So we had to get additional plant in a hurry, without giving the scientific manufacturers of 84 per cent. plant time to develop their ideas and to carry them into execution. We were inundated with applications from new customers; and in order to supply them in the short summer season we drew in fresh mains as fast as we could, and overburdened the plant of 75 per cent. efficiency, so despised by Mr. Quin, in a manner that would make his hair stand on end. I remember Mr. Hesketh, our late manager, telling me one morning that he had been compelled to run the 100 ampere plant up to 135 amperes. Of course, we had most anxious "quarters of hours," but we pulled through last summer without grave mishap. Then, said Mr. Hammond, this sort of thing is altogether foolish and criminal. The Committee must take time by the forelock and lay down a 300-kilowatt plant of the flywheel alternator type before next Easter, and transfer the generating plant for the tramway to the electric light works. The Committee were convinced of the soundness of this advice, and went even one better, for they determined to make assurance doubly sure, and recommended that two 300-kilowatt plants with the necessary additional mains should be laid down. Now, Sir, came in the foolishness of the irresponsible ones. Extend the electric light works six months before the plant was wanted! Absurd! Utter waste of ratepayers' money! Works constructed on grossly extravagant lines, &c.! Led by the nose of the clever consulting engineer, &c.! In vain we pointed out that in electric lighting timely extensions of plant were the only means of attaining success. In vain we showed in black and white that the capital expenditure had been most moderate—*i.e.*, £69 per kilowatt, against the Brighton Works £131. Well, Sir, we were defeated. I did not seek re election, and the Electric Lighting Committee became the football of the Council. What has been the result? Just six months after the deplorable resolution of the Council stopping all extensions *for twelve months*, the Council eats humble pie, and endows the new Electric Lighting Committee with the sum of £30,000 to carry out the very extensions with identically the type of plant pleaded for by our adviser. Too late! Though they got Mr. Ferranti to undertake to deliver one set of plant for use this season, the season is over and the plant is not there. You can easily guess the effect on the working. Extinction after extinction, the service brought into disrepute, and all because petty jealousies against me personally were considered of more importance than the good of the town and the safety of its enterprise.

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You will perhaps, Sir, wonder what all this has to do with Mr. Quin's report. I think I can show a close connection. Mr. Hesketh, you are doubtless aware, came to us from the Newcastle-on-Tyne Works, where the slow-speed plant has done so well that their extensions have all been carried out on the same lines. He, being well aware of the *other side* of the case for slow-speed plant, thoroughly acquiesced in our system and in the extensions with the same class of plant. He was with us from the beginning, appreciated the difficulties of the situation, and avoided as much as possible taking sides. Securing an honourable post under the Queensland Government his place had to be filled up. Do the Committee appoint a gentleman who had gained his experience in working similar plant to theirs? No! Do they make an offer to Mr. Jackson, of Newcastle, or to Mr. Dickinson, of Leeds, who, with similar plant to that at Blackpool, had scored the record lowest coal bill in the country? No! They choose a gentleman who had never had the handling of slow-speed plant or apparently seen a ring main. His answer to the Committee's question, "What do you think of the works?" showed at once that if appointed he was prepared to condemn them "hip and thigh," thus enabling the Committee to make a big score over the late management.

"This is our man,"
The courtier cried,
"I am sure we've judged aright;
I'll give you
A hundred ducats, friend,
For the loan of your shirt to-night."

We started on a voyage of discovery in 1891 with absolutely open minds, and saw all that the leading manufacturers and contractors could show us. We then invited propositions, and reported carefully on the same to our Council. Eventually we chose the scheme of Mr. Robert Hammond, which provided for 3 Galloway boilers, ring steam main, 6 Fowler slow-speed engines, 3 Electric Construction alternators, 3 Brush arc machines, 14 miles highest class Silvertown cables, Brockie-Pell arc lamps for the Promenade; and we had the great gratification of seeing the contract of £18,691 scrupulously carried out by Mr. Hammond *without one penny of extras*. Having had experience of Mr. Hammond's careful methods and untiring energy in the Corporation's interests we naturally appointed him our consulting engineer for the extensions, and I am confident that the purse of the ratepayers was safeguarded by his appointment.

Finally, Sir, though I hesitate to step out of my *rôle* and refer to technical matters, I would like to say a word of explanation of how we came to give the preference to slow-speed plant. The Committee, you must remember, was a Blackpool committee, most of us born in the place or the county. The visitors to Blackpool are largely comprised of Lancashire mill hands and mill proprietors. The favourite talk of the wealthy mill proprietor is his grand mill engine. At neighbouring Bolton we are proud to possess two great works of world-wide reputation for slow-speed plant. What was good enough for the great mills of our county was good enough for us. Proud of our county's position in the world as the cheapest power producer, we would have been "nawt but fules" if we had not kept to the good old slow-speed plan.

I said that we started on our travels with open minds; we had no consulting engineer to guide us, for we only made Mr. Hammond's acquaintance after our journey was completed and our report presented; but we came home unanimous as to the plans that we should adopt; and I challenge anyone to show that with the experience available in 1891-2, we did not fulfil completely the trust imposed upon us by our fellow ratepayers.—Yours, &c., JAS. PEARSON.

50, Bank-Hey-street, Blackpool, Sept. 15, 1896.

## LOCK-ARMOURED ELECTRIC LIGHT CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Our attention has been called to a circular issued by Messrs. W. T. Glover and Co., descriptive of "Glover's Patent High Conductivity Lock Armour," which is claimed by that firm to be their invention, and to the article in your last week's issue dealing with this cable.

We give you notice that this is an infringement of the lock-coil patents which were issued to Messrs. Latch and Batchelor in 1884, which patents are the property of Messrs. George Elliot and Co., the well-known colliery owners and wire-rope makers of Westminster, Cardiff, and Newcastle-on-Tyne, who have granted us the exclusive right to use this invention in connection with electric cable work in this country.

Very large quantities of this lock-cable have been made during the past ten years for haulage and other purposes by Messrs. Elliot, and its advantages are fully appreciated by mining engineers. We have already manufactured many miles of cable under our licence with lock-coil armour, in some cases the steel segments serving merely as a mechanical protection, in others the armouring being used as the return conductor, and we have no intention to allow our rights under these patents to be infringed. Our solicitors are taking the necessary steps for our protection, and we desire to give public notice that we shall take proceedings against any firm manufacturing, or against any person, company, or corporation using, cables any part of which is formed of segments which, when put together, interlock, so as to form a complete locked ring or shield on the cable, or otherwise infringing the patents in question.

We shall be obliged by your giving to this letter equal publicity to that given to the notice of Messrs. Glover in your last week's issue.—Yours, &c.,

T. O. CALLENDER, Managing Director.

90, Cannon-street, London, E.C., Sept. 17, 1896.

## PHOTO-PRINTING OF TRACINGS BY ARC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall be much obliged if any of the readers of *The Electrician* will give me particulars as to the photo-printing of tracings by arc light. The chief points are:—

1. The size of lamp necessary for a double-elephant sheet.
2. The best arrangement of the arc above the frame.
3. The time it takes to print, blue or white prints.
4. Whether the Jandus arc lamp is suitable.

The supply is at 100 volts.—Yours, &c., B. M. J.

Sept. 9, 1896.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

TENDERS INVITED.—The Electric Lighting Committee of the Borough of Morley invites tenders for the supply and erection of (*a*) Lancashire boilers and fittings, feed pump, &c.; (*b*) steam alternators and exciters, motor-alternator, accumulators, steam and exhaust pipes, valves, &c.; (*c*) switchboard and instruments; (*d*) overhead crane; (*e*) underground work, cables and stoneware culverts; (*f*) transformers and switchboards; (*g*) arc lamps, posts and accessories, and (*h*) meters. Plans, specification, &c., may be obtained of the consulting engineer, Mr. Robert Hammond, Ormond House, Great Trinity-lane, London, E.C., and tenders must be addressed to the Town Clerk (Mr. R. Borrough Hopkins), Town Hall, Morley, by October 14th. Further particulars are given in our advertisement columns.

——— Messrs. Murphy and Stevenson (Limited), linen manufacturers, of Belfast, invite tenders for the supply and erection of an electric light installation in their new factory at Dromore, Co. Down. Plans and specifications, which have been prepared by Mr. J. H. Greenhill, M.I E.E., may be obtained at their office, Ormeau-avenue, Belfast. Tenders should be sent in to the firm by 24th inst. Further information appears in our advertisement columns.

——— The Lord Provost, Magistrates and Council of Edinburgh invite tenders for the wiring of the Burgh Assessments Office, High-street. Tenders must be sent to the Town Clerk, City Chambers, Edinburgh, by the 22nd inst.

——— Tenders are invited until 18th October by the French Post and Telegraph authorities for the supply of 257,500 porcelain insulators and 594 tons of copper wire.——Tenders are invited until the 24th inst. for the supply of a quantity of gutta-percha insulated telegraph cables in two lots, and until the 17th inst. for the supply in 12 lots of 137·7 kilometers of paper insulated cables.

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——Tenders are also invited until the 26th inst. for the supply and fitting of pneumatic pipe lines in the city of Paris. Tenders in all cases to be sent to the Sous-Secretariat d'Etat des Postes et des Telegraphes, Rue de Grenelle 103, Paris.

TENDERS INVITED.—The Corporation of Swansea invites tenders for (*a*) the supply and fixing of cables, casings, switch and fuse boards and all sundry fittings and materials for installing the electric light in the Swansea Market; and (*b*) the supply and erection of a temporary generating plant, including gas engine, generator, and main switch-boards, together with the maintenance of the same, for twelve months. Tenders to be sent to the Town Clerk, the Guildhall, Swansea, by 4 p.m. on Thursday next.

——— The Société Nationale des Chemins de Fer Vicinaux invites tenders for the electrical equipment of about 14 miles of suburban railway at Charleroi and elsewhere, on the overhead trolley system. Particulars from the Company, Rue de la Science, 26, Brussels. Tenders to be in by October 28th.

——— The Belgian State Railway authorities invite tenders for the supply and erection of a complete electric lighting plant at Arlon, for the lighting of the railway station and offices, waggon shops, &c. Tenders to be sent to the Bourse, Brussels.

ESTIMATES REQUIRED.—The Vestry of St. Mary Magdalen, Bermondsey, invites estimates for preparing a report as to the advisability of establishing electricity supply works, the best system of distribution to be employed, &c. Estimates to be in by 4 p.m. 23rd inst.

TENDERS ACCEPTED.—The Electric Lighting Committee of the Bath Town Council met on Monday afternoon to consider Mr. Robert Hammond's report on the tenders recently received for the extension of the electricity works about to be acquired by the Corporation. Mr. Hammond's recommendations were as follows:—

| | |
|---|---|
| *Boiler House Plant* (Babcock boilers):— | |
| Electric Construction Company ..... | £2,462 |
| *Engine House Plant* (Flywheel alternators):— | |
| Electric Construction Company ..... | 8,364 |
| *Underground Works*:— | |
| Callender's Cable & Construction Company (cables) | 7,985 |
| Electric Construction Company (converters) ..... | 470 |
| *Overhead Travelling Crane*:— | |
| Stothert and Pitt ..... ..... | 350 |
| | £19,631 |

With regard to arc lamps and posts, the eight tenders received varied from £2,224 to £3,545, and Mr. Hammond recommended that each tenderer should erect a sample lamp at Bath, which, working for two months, would give the Committee an excellent opportunity of deciding for themselves which maker should secure the order. It was unanimously decided to adopt Mr. Hammond's report in its entirety for recommendation to the Council.

——— At the last meeting of the Metropolitan Asylums Board the "Exmouth" Training Ship Committee reported that tenders had been obtained from four firms for supplying a pair of electric light cables for the ship. The tenders were as follows:—

| | | | |
|---|---|---|---|
| Callender Co. (*accepted*) ... | £197 0 | Silvertown Company ..... | £199 10 |
| Johnson and Phillips ..... | 206 10 | Siemens Bros. and Co..... | 198 10 |

As the estimate of the Callender Company was the lowest, and the existing cables were supplied by them, and had been found quite satisfactory until accidentally injured by passing barges, &c., the Committee decided to obtain from that Company the new cables required. The Committee's action was approved.

——— The tender of Messrs. W. A. Baker and Co. has been accepted by the Newport Harbour Commissioners for installing the electric light on the pontoon landing-stages at a cost of £75.

——— The Electrical Committee of the Bristol Corporation has accepted the tender of Mr. F. Martin for making additions and alterations to the electricity station building at £16,725. Twelve tenders, varying from £16,725 to £23,561, were sent in.

——— The tender of Messrs. Simpson Bros., of Hapton, Burnley, has been accepted for wiring the Blackpool Primitive Methodist Chapel for the electric light.

——— The Harrogate Town Council are stated to have accepted the tender of the Edison and Swan Company at £297. 17s. (or alternately at £275. 15s. 5d.) for supplying and fixing electric light fittings at the new baths.

——— The tender of the Prescot Company has been accepted by the Blackpool Corporation for the supply, laying, and maintenance of high and low-tension cables, &c., recently advertised. It is a standing rule of the Corporation that the amount of tenders are not given. Tenders were also received from the Fowler-Waring Company, Messrs. Siemens, Bros., and Co., and Messrs. W. T. Glover and Co.

——— The Electric Light Committee of the Dewsbury and District Technical School has decided to accept the tender of Mr. A. R. Turner, of Dewsbury, for installing the electric light at the School.

TENDERS RECEIVED.—The Cork City Council has only received two tenders for the transfer of the Cork Provisional Order. These proposals have been referred to the Electric Lighting Committee for consideration and report.

APPOINTMENT.—Mr. O. Hansom has been appointed assistant engineer at the Bedford electricity supply station at £135 per annum. Mr. Hansom was until recently assistant engineer at the Hampstead electricity station.

APPOINTMENTS VACANT.—The Vestry of St. John, Hampstead, are about to appoint an assistant electrical engineer at a salary of £2. 5s. Some further particulars are given in our advertisement columns, and applications for the post must be sent in to Mr. Arthur P. Johnson, Vestry Clerk, by 10 a.m. of the 27th inst.

——— The Electric Lighting Committee of the County Borough of Huddersfield invites applications for the post of working mechanical engineer at the municipal electric supply station. Salary £2. 10s. per week. Applications to be in by Monday next.

DISSOLUTION OF PARTNERSHIP.—Messrs. Walter John Curtis and Frederick Shakespeare Hanning, electrical engineers, 6, King-street, Wolverhampton, have dissolved partnership.

PERSONAL.—We are asked to state that Mr. R. F. Barrett Lennard has taken over Mr. J. A. Russell's share in the business of Russell and Lennard, and all existing contracts. Pending amalgamation with the Electrical Installation Company, Mr. Barrett Lennard will carry on business in his own name at 135, Victoria-street, S.W. Reference was made to the dissolution of partnership between Messrs. Russell and Barrett Lennard in our last issue, page 647.

REMOVAL.—Messrs. L. Darlow and Co., metal stampers, have removed from Ludgate-hill to 4, Clerkenwell-green, E.C.

AGENCY.—Messrs. Connolly Brothers (Limited), of Vale Mills, Blackley, Manchester, have appointed the United Asbestos Company, of 93, Bothwell-street, Glasgow, their agents in Scotland for the sale of insulated wires, cables, &c. A stock will be kept at the new agency to meet urgent orders.

RE GEORGE SCHULTZ AND CO.—In our issues for September 4th and 11th we have reported the bankruptcy proceedings taken against Mr. George Schultz, lately trading as George Schultz and Co., at 90, Cannon-street, E.C. Mr. Schultz writes to inform us that he has no trade creditors, and that his late business connection is not in any way affected by the proceedings which were taken against him by Messrs. Fossick and Co. (Limited). Mr. Schultz's business has been continued without interruption by Messrs. Charles Jennings and Co. at the same address, Mr. Schultz remaining as manager with that firm, whose specialities, as our readers are aware, include "isotropic iron" for dynamo magnets and armatures, transformer and disc stampings, steel dynamo castings, &c. In a circular, dated August 31st, Mr. Schultz explains that the bankruptcy proceedings are the sequel to an action brought against him by the liquidator of Fossick and Co. (Limited) for the recovery of a very large sum of money for unpaid capital on one-third of the shares of that Company, which he was required to purchase and hold as a guarantee of careful management. Mr. Schultz is one of the numerous band who, notwithstanding their success in an action at law, find themselves mulct in heavy costs, and considers himself the victim of circumstances for which the state of the law of limited liability is partly responsible.

LIQUIDATIONS.—A meeting will be held at 103, Queen Victoria-street, E.C., on October 16th, to receive an account of the voluntary winding-up of the Improved Electric Glow Lamp Syndicate, Limited.

——— A meeting will be held at 145, Cannon-street, E.C., on October 13th, to receive an account of the winding up of Fossick and Co., Limited, steel and iron merchants.

BENNETT AND DRUCE (IN CHANCERY).—At the meeting of creditors in this matter, held at the office of Mr. James Todd, 3, Winckley-square, Preston, on Thursday last, creditors representing £1,007 out of £1,304 were present. It was explained by Mr. Todd that the assets were being realised and the business carried on by him under the direction and supervision of the Court, and that no unnecessary delay would be incurred in the realisation of the assets. We learn that it was unanimously agreed that no action should be taken by any creditor.

NOVEL ELECTRIC ADVERTISING.—*Pearson's Weekly*, a journal which on electrical subjects frequently has something amusing if not instructive to tell, has become a patron of the electric light in the form of a bold advertisement on the gigantic wheel at the India and Ceylon Exhibition, Earl's Court. The letters constituting the name of the paper are formed by groups of clear incandescent electric lamps placed on the western side of the wheel, and when the portion of the wheel upon which the letters are affixed reaches the highest point, the lamps are switched on, and a prominent advertisement is the result. The advertisement forms a conspicuous

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addition to the attractions of the gardens, and on a clear night can be seen for miles.

HUNGARIAN MILLENNIUM EXHIBITION.—We have been favoured with copies of the German translation of the official catalogues of the following groups at this Exhibition, which is being held at Budapest:—1B, music; 2, cultural institutions; 3, public schools; 5, trade and finance; 6, farming; 7A, mining; 8, iron and metal trades; 9, machinery; 10, shipbuilding and navigation; 12, wood and furniture; 14, leather, textile, &c.; 15, paper, &c.; 16, jewellery; 17, military: 18, chemistry; and 19, food. The catalogues have been translated under the superintendence of the officials of the Budapest Chamber of Commerce.

POCKET ACCUMULATORS.—The Standard Accumulator Company forward us an advance copy of their list of portable hand lamps, pocket and bicycle accumulators, and accumulators for Röntgen ray apparatus, in which special attention is called to the non-corrodible terminals and a new design of expansion valve used. It is claimed for the valve that it entirely prevents the escape of acid.

MEACOCKS SYSTEM FOR STREET TRAMWAYS AND LIGHT RAILWAYS.—We have received from Messrs. Meacock Bros., of Birmingham, a pamphlet describing their system of electrically driving a cable tramway. This system consists in forming the cable in single continuous loops of about 1½ miles in length, and driving the loops by means of electric motors placed at various points along the line. By means of this device the speed of the cars may be varied at different points in a district to suit the requirements of the traffic. The grooves in the rails of existing tramways are dispensed with, the car being guided by a central disc wheel. The Meacock system of electric traction for light railways is of the closed conduit form, and it is proposed to use "pneumatic driving wheels in place of tooth gearing."

PRICE LIST.—A price list is to hand of the "Still" incandescent electric lamps, made by Messrs. W. M. Still and Co. The list gives full particulars of lamps of all the usual candle powers, and of a variety of reflectors for use in incandescent lighting.

"ANNUAIRE DE L'ASSOCIATION SUISSE DES ELECTRICIENS."—We have received a copy of the 1896-97 issue of this "Annuaire," which gives a complete list of the members and the transactions of the Association for the past year. Useful tables and statistics relating to electric lighting and tramway undertakings, and a list of persons engaged in the electrical and allied trades in Switzerland are also given. The work, which has been edited by Dr. A. Denzler, of Zurich (one of the secretaries), is nicely got up, and should prove of assistance to Swiss electrical engineers.

RAILWAY DIRECTORY.—A useful reference book reaches us from the Directory Publishing Company, Catherine-street, London, W.C. "The Directory of Railway Officials for 1896" is compiled by Mr. S. Richardson Blundstone, editor of the *Railway Engineer*, and is in its second year of publication. The contents are claimed to be compiled entirely from official sources. The railways of which particulars are given include British, Irish, Colonial and Foreign lines, and the particulars regarding each line will be found of service to all desirous of communicating with the officials of these undertakings. The book is well printed, and is published at 10s.

ELECTRO-HARMONIC SOCIETY.—The opening smoking concert of the season takes place on Friday, 25th inst., at the St. James's Hall Restaurant, at eight o'clock. An excellent programme is provided under the musical direction of Mr. T. E. Gatehouse and Mr. Alfred E. Izard.

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ALDERLEY EDGE.—The Board of Trade has notified the District Council that it is prepared to consider the question of the transfer of the Provisional Order to the Alderley and Wilmslow Electric Supply Company as soon as it is satisfied with the financial position of the transferees. Mr. S. V. Clivehugh, the engineer to the Company, has forwarded a cheque for £300 to the Council in payment of the cost of obtaining the Order.

BANGOR.—At a special meeting of the City Council on Wednesday, a formal resolution in favour of at once applying for a Provisional Order was passed.

BANTRY (CORK).—The lighting of this little seaport town is in a deplorable state, and the Town Commissioners are making inquiries as to the relative cost of electric and gas lighting with a view to improving same.

BEDFORD.—The Electric Lighting Committee reported at the last meeting of the Urban Council that the demands for electric current for private lighting continue to be satisfactory. These additional applications represent an equivalent of about 1,000 8 c.p. incandescents. Owing to the number of applications received from residents in the Crescent and Lurke-street it has been decided to at once commence the work of laying electric light mains in these districts.

BOLTON.—The Gas and Electricity Committee has decided to adopt the "Brighton" method of charging for electric current.

BRADFORD.—The Town Council has decided to promote a Bill in the next Session of Parliament authorising the construction of additions to the present tramway system. The Council also wish to reserve powers to itself to work the tramways, and to introduce mechanical traction.

BRISTOL.—The Local Government Board has sanctioned the application of the Town Council for power to borrow £75,000 for electric light extension purposes. The period of the loan is 25 years.

BURGLARY.—At Douglas, Isle of Man, the offices of the Douglas Southern Electric Tramways Company have been broken into, and a considerable amount of money and cheques stolen. A safe weighing 3cwt. was removed and thrown into the sea.

CARDIFF.—The Town Council proposes to extend the electric light mains to Leckwith, Cowbridge and Cathedral roads, at a cost of £1,600. The borough electrical engineer (Mr. N. Applebee) has submitted a report recommending the further extension of the mains to Tudor-road and Clare-street, at a cost of £640, and from Castle-street to Cathedral-road, at a cost of £600.

CLUB LIGHTING.—It has been decided to introduce the electric light into the Liberal Club, Buchanan-street, Glasgow. The contract has been let to a local firm, Messrs. Wm. Ramsay and Co.

COVENTRY.—The Coventry and District Electric Tramways Company have decided to apply to Parliament for powers to enable them to make important extensions to their line. At present the Company run a successful service from Coventry to Bedworth, a distance of six miles, and the proposed extensions will open up traffic in two other directions to the outskirts of the city.

DOUGLAS (ISLE OF MAN).—As the result of a long discussion on the lighting question at the last meeting of the Town Council it was decided to renew the contract with the gas company for 12 months, and "to expend the sum of £5 in obtaining the opinion of an electrical engineer on the question of the advisability of establishing electricity supply works."

ELECTRICAL TRADES' UNION.—Meetings of members of this Union are announced to be held on Monday and Friday next—on Monday at the Club Union-buildings, Clerkenwell-road, E.C., and on Friday at Woolwich-road, Charlton, S.E. The chair is to be taken on each occasion at 8:30 p.m.

ELECTRICITY IN SHIPBUILDING.—Messrs. Short Bros. and Co., of Pallion, Sunderland, have decided to employ electric motors for driving the machinery at their shipbuilding yard. It is anticipated that this step will effect a minimum saving of 30 per cent. The change is in its initial stage, and at present only a section of the machinery, including the punching, shearing, and levelling machines, and a circular saw, is being driven electrically. Should the experiment prove successful, as the promoters of it are quite sanguine it will, it is intended to adopt electricity for driving the whole of the yard machinery.

ELECTRIC OMNIBUSES.—We find it stated in several London newspapers that Mr. William Marshall, a Director of the London Electric Omnibus Company, invited a select party on Wednesday to witness a demonstration of the progress made by the Company in the vehicles it is proposed to place on the streets after the Locomotives on Highways Act has come into force in November next. The demonstration took place at the works at Whitehall, under Mr. Radcliffe Ward's guidance. From a daily contemporary we learn that vibration has been reduced to a minimum, and that accumulators are charged to enable a 20-mile run being made without re-charging becoming necessary. The financial papers contain particulars of other advantages which are claimed for the vehicles, but these are not of an electrical character.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from September 9th to September 15th, with the ports of destination:—

*Argentina*—Buenos Ayres, £383 (telegraph material). *Australasia*—Brisbane, £105 (including £70 telephones); Fremantle, £1,096 (including £20 telephones); Melbourne, £386 (including £283 telegraph material); Perth, £85; Sydney, £596; Wellington, £420 (including £80 telegraph material). *Belgium*—Antwerp, £20; Ghent, £10. *Brazil*—Rio de Janeiro, £449. *Ceylon*—Colombo, £40 (including £27 telegraph material). *China*—Shanghai, £59 (telephone stores). *Egypt*—Alexandria, £161 (including £132 telegraph material and £29 telephone material). *Germany*—Hamburgh, £321 (telegraph material). *Holland*—Amsterdam, £115. *Hong Kong*—£12. *India*—Bombay, £135; Calcutta, £848; Kurrachee, £75; Madras, £40; Rangoon, £15 (telephone stores). *Japan*—Yokohama, £10. *Panama*—Santos, £32 (telephone apparatus). *Portugal*—Lisbon, £43. *South Africa*—Cape Town, £542; Durban, £198; East London, £585. *Straits Settlements*—Penang, £29; Singapore, £139 (telephone stores). *Sweden*—Gothenburg, £48 (telegraph wire); Stockholm, £65. *West Indies*—Antigua, £10. Total, £6,987.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows:—

*Australasia*—Melbourne, £8. *Sweden*—Stockholm, £8 (telephone apparatus). Total, £16.

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FERMOY (CORK).—In reply to a letter from Mr. F. Warden Stevens, who is acting as consulting engineer for the proposed electric lighting scheme, the Town Commissioners have decided to allow the present lamp-posts to be adopted for electric lighting purposes. The Commissioners also intimate that they are willing to provide or pay for the electric lamps and standards, and will only require the Company to provide the electric current for the public lighting.

FULHAM (LONDON).—Mr. F. H. Medhurst has submitted his report on the advisability of erecting joint electricity and refuse destructor works to the Electric Lighting Committee, but the consideration of the matter has been deferred for the present. A resolution in favour of applying to the Board of Trade for a Provisional Order has been passed by the Committee.

GERMANY.—By a new law which has recently come into operation in Germany, it is a penal offence to compare prices in public advertisements with those of a competitor, or to use a device of a competitor in a misleading manner. A severe penalty is attached to the inducing of an employé of a competitor to disclose any information which may have been confided to him by his employer, and it has also become penal to retail certain goods contrary to agreement with the manufacturer. Editors, publishers and printers of newspapers, circulars, &c., become liable, as well as the authors of the offences against the new law.

GLASGOW.—At a special meeting of the City Council on Wednesday it was decided to adopt the Tramways Committee's recommendation to send a deputation, consisting of the general manager of the tramways (Mr. Young) and the engineer (Mr. Clark), to America, for the purpose of making full inquiries into the practice and working cost of the various forms of mechanical traction in operation in typical American cities and reporting thereon. Mr. Nelson objected to this proposal on the ground that the deputation had already visited the Continent, and there were no systems of haulage in use in America that were not employed on the Continent, and had already been seen in operation. The proposal was ultimately agreed to by 37 votes to 11.

HUDDERSFIELD.—The Electric Lighting Committee recommends the Town Council to supply electric light fittings to any person requiring a supply of electric current, provided such person undertakes to repay the cost of same (with interest) by annual payments. This proposal was discussed at Wednesday's meeting of the Council, when it was decided to refer the matter back in order that the Committee might again consider the law relating to the borrowing of the necessary money. The deficiency in the accounts of the electricity department for the first six months of the year only amounted to £116. 11s. 9d., as against £624. 0s. 11d. in the corresponding period of last year.

JOHANNESBURG.—It is stated that the proposal for the construction of an electric tramway in the Rand district involves the building of no less than 100 miles of tramway. The promoters guarantee the completion of the work within a period of nine months from the commencement of operations.

LEGAL.—In the matter of the Callender Company against the National Telephone Company, in which the plaintiffs move for an order to restrain defendants from interfering with certain telephonic apparatus, an interim injunction was granted on Wednesday. The parties have agreed that the motion shall stand over until the second motion days next Sittings, the defendants giving an undertaking in the terms of the interim order.

MELBOURNE.—At a recent meeting of the City Council it was decided to apply for an order authorising the Council to supply electric current within the area of the municipal district. In the course of the discussion Alderman Bayles said he thought the Council should have been supplied with a report setting out the result of the working of the present electric lighting plant and the cost. He had ascertained that the original loan for electric lighting purposes was £150,000, which realised, less cost of flotation, £118,750. Of that sum £104,480. 11s. 10d. had been expended, leaving a balance of £14,250. 8s. 2d. He found that the cost of lighting last year, including both electricity and gas, was £25,720, electricity costing £23,440. 6s. 8d., and gas £2,776. 5s. 9d. In the year previous to the establishment of the electric light the cost of the gas was only £20,942. 3s. 5d.

MORECAMBE.—The District Council has decided to make application to the Local Government Board for sanction to borrow £26,000 for the purposes of the purchase of the undertaking of the Morecambe Electric Light and Power Company, and for making certain additions and extensions to the plant and mains.

MUMBLES (SWANSEA).—It is probable that this village will shortly be in a position to boast of the advantages of the electric light. Mr. Weaver, who is an influential resident, has decided to introduce the electric light at his residence, and he finds that by a slight addition to the plant a considerable portion of the district could also be lighted electrically. He has very generously offered to supply current for lighting the main road by means of arc lamps. Though the District Council has not formally accepted the offer, there is very little doubt as to its ultimate decision in the matter.

RUSSIA.—The British Consul-General in Russia points out that the old prejudice against Russian laws and customs continues to prevail amongst British firms who refrain from undertaking Russian contracts. This prejudice does not exist amongst Belgians and Germans, and it is stated that £20,000,000 of Belgian capital has been put into Russian industries, chiefly metallurgical. But of nearly 50 of the various industrial undertakings started in Southern Russia during the past 18 months, only two were started with British capital.

SOUTHPORT.—A scheme is being promoted for the purpose of constructing an electric tramway between Southport and Lytham, a distance of about eight miles. The proposed line, which would be carried across the Ribble, should be convenient to residents in these towns, as it would obviate the present objectionable railway journey which necessitates travelling round Preston to and from Southport and Lytham.

ST. GEORGE'S, HANOVER-SQUARE (LONDON).—At the last meeting of the Vestry some time was devoted to the consideration of the question of the introduction of the electric light at the stables, at a cost of some £20 to £25. Mr. G. BEST thought they should start by lighting Piccadilly electrically, as that beautiful street was disgracefully lighted. Ultimately it was decided to adopt the electric light at the stables.

TELEPHONES IN JAPAN.—The *Japan Weekly Mail* states that the Japanese Government, with the consent of the Diet, is to appropriate a sum of above 12,800,000 yen, spread over seven years, for the expansion of the telephone service. The work of construction is being actively carried on at various important places, the present intention being to complete, by March, 1898, the extension to Tokyo, Osaka, Yokohama, and Kobe, as well as the new constructive work in Nagoya, Nagasaki, Shimonoseki, &c., and to establish connection between Tokyo and Kobe. According to estimates for the current fiscal year, the number of new subscribers in the four cities of Tokyo, Yokohama, Osaka, and Kobe, under the expanded system, will be 13,333, and of those in Kyoto and 35 other places where the service is to be newly established, there will be 6,800. Along with the erection of new telephone exchanges the authorities will, it is stated, also connect up with exchanges already established. Thus are a portion of the funds provided by China to be used in the service of peace.

THEFT.—A young man named Ernest Otter, described as an electrician, of Cambridge-road, Hammersmith, was charged at Marylebone (London) Police Court last week with stealing various articles the property of a merchant in whose house he had been employed to fit up the electric light. The charge against the prisoner was that from almost every house where he had been sent by his employers to work, articles of value had been stolen under suspicious circumstances. In several cases servants had been dismissed on suspicion of being the thieves. Prisoner was committed for trial.

TRANSVAAL TELEGRAPHS.—The statistics of the Telegraph Department of the South African Republic for the second quarter of 1896, which have been recently issued, show a satisfactory increase. The total income for the quarter is given as £20,688, against the first quarter's total of £19,363. The total for the half-year is £40,052, compared with £33,176 for the corresponding period in 1895. Telephones have yielded £5,030 for the half-year, against £3,884 in 1895. The cablegrams despatched in the second quarter for 1896 numbered 10,234, of the value of £28,133. 18s. 8d., compared with, for the first quarter, 9,300, of the value of £17,777. Total for the half-year, 19,534, value £55,911.—*African Review.*

VICTORIA (AUSTRALIA).—The new Customs tariff imposes a duty upon lamp ware and lanterns of 30 per cent. *ad valorem*. Arc lamps without globes, incandescent lamps, and miners' safety lamps are admitted free.

WITHINGTON (LANCS.).—The electric lighting question has been before the District Council for some time, and recently circulars were sent out to occupiers of houses of the rateable value of £30 and upwards so as to ascertain the amount of support likely to be accorded to an electric lighting scheme. Upwards of 70 per cent. of the replies received were favourable to the introduction of the electric light, and the question was to be again discussed at the meeting of the Council yesterday (Thursday). Letters have been received from one or two private companies for sanction to their applications for a Provisional Order, and the Gas Committee of the Manchester Corporation has also offered to extend its electric mains to the district.

YORK.—At the last meeting of the City Council one or two of the members endeavoured to postpone the issue of advertisements inviting tenders for the supply of electric light plant and machinery till after the November elections. After some discussion the action of the Streets and Buildings Committee, which has the matter in hand, was approved.

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# COMPANIES' MEETINGS AND REPORTS.

## London Electric Omnibus Company (Limited).

The first ordinary general (statutory) meeting of this Company was held yesterday at Winchester House, Major Flood Page presiding.

The SECRETARY (Mr. A. Caillat) read the notice calling the meeting.

The CHAIRMAN, after referring to recent legislation affecting auto-cars, said they had an electrical omnibus almost ready to place on the streets. The delay which had taken place in completing it was due to the many improvements which had been introduced since the formation of the Company. The omnibus, as compared with its original design, had been entirely reconstructed. When finished it would be the best, the easiest running and the most comfortable omnibus that had ever been seen in the world. There would be practically no vibration, and hardly any noise. In these vehicles the passengers would be able to read the newspapers as well as they could in an electrically-lighted room. They would be able to run their omnibuses at a cost of about 2½d. per mile. In the opinion of experts this Company possessed a battery superior to any other now in use, and they believed that if they were able to provide a service of electrical omnibuses which would go along easily, and which were comfortable and as cheap, for cheaper, than the present omnibus service of London, there was no need for the people who were promoting electrical omnibus companies to have any fear as to success. It had been asked how could a small company like theirs compete with the large omnibus companies already in the field? The best way was by not remaining a small Company. In the event of their being able to show that they could run their omnibuses at the cost he had stated, he thought they would have no difficulty in extending their business. Theirs was a pioneer Company, and they did not intend to launch out into building factories, and otherwise expending large sums of money. Their financial resources had so far been carefully husbanded, and every penny would be well looked after in the future. He hoped the shareholders would not allow themselves to be led away by people who, through ignorance, or from other causes, threw doubt on the probable success of this and similar undertakings. So soon as he believed —which he did not think would happen—that the Company would not succeed, the shareholders should be informed of the fact. He had supreme confidence that the electric omnibus would hold its own, and that this Company had a fair chance of taking a lead in the electrical industry in regard to omnibuses and other vehicles. They had already had several applications from provincial towns respecting the formation of local companies, and it seemed to him extremely probable that they would have an additional source of revenue in those quarters.

After a few remarks from Mr. C. E. SPAGNOLLETI (consulting engineer), who spoke hopefully of the Company's prospects, the proceedings terminated with a vote of thanks to the Chairman.

# NEW COMPANIES, STATUTORY RETURNS, &c.

**BULLIVANT AND CO. (LIMITED).**—This Company was registered on September 8th, with a capital of £150,000, in £10 shares (of which 5,000 are Preference), to acquire the business of manufacturers of wire ropes and telegraph cables, lately carried on by Bullivant and Co., and to carry on the business of manufacturers of and dealers in wire rope and netting, wire tramways, mining and hauling plant, and telegraph cables.

**JAMES HINKS AND SON (LIMITED).**—This Company was registered on September 8th, with a capital of £80,000, in £1 shares, to acquire the business of lamp manufacturers carried on by a Company of the same name (now in liquidation) at Birmingham, and to carry on the business of manufacturers of and dealers in all kinds of electric light fittings, lamps, brackets, candelabra, &c. The first Directors are: James Hinks, Joseph Hinks, Alfred Ludlow, Henry Rollason, Joseph Glover, and Harry Hinks.

**STEWART ELECTRICAL SYNDICATE (LIMITED).**—This Company was registered on September 10th with a capital of £1,200, in £1 shares, to enter into an agreement with Willis N. Stewart, to manufacture, sell, and supply arc lamps and incandescent lamps, and electrical apparatus generally, and to carry on the business of suppliers of electricity, electricians, electrical and mechanical engineers, &c. The subscribers, with one share each, are E. Hulbert, W. N. Stewart, H. H. Wells, E. W. Rogers, W. J. Heath, engineer, T. Dott, and C. G. Hayman.

**WARRINGTON RUBBER WORKS (LIMITED).**—This Company has been registered with a capital of £100,000, in 50,000 Preference and 50,000 Ordinary shares of £1 each, to carry on business as manufacturers of and dealers in indiarubber goods of all kinds, mechanical and electrical engineers, machinists, wire-drawers, metallurgists, electro-platers, &c.

**CROMPTON AND COMPANY (LIMITED).**—The annual return of this Company to August 10th has been filed. The nominal capital is £280,000, divided into 26,000 Ordinary and 30,000 Preference shares of £5 each; 5,928 of the former and 28,180 of the latter have been taken up, and 4,000 of the Ordinary have been issued as fully paid. The full amount has been called on the Preference, and £1 per share on the Ordinary, resulting in the receipt of £142,852.

**NORTHWICH ELECTRIC SUPPLY COMPANY (LIMITED).**—The annual return of this Company to July 2nd has been filed. The nominal capital is £10,000, in £5 shares; seven shares have been taken up, but no calls have as yet been made.

**OMNIBUS AND TRAMCAR ELECTRIC LIGHTING COMPANY (LIMITED).** The annual return of this Company to May 16th has just been filed. The nominal capital is £60,000, in £5 shares, and seven of these have been subscribed for. The full amount per share has been called and paid.

# CITY NOTES.

**MEMORANDA.**—Bank rate, 2½ per cent. (Sept. 10, 1896). Price of silver, 30⅞d. per oz. (Sept. 17th). Consols (2¾ per cent.) 109⅞—110⅛ for money, 109⅞—110⅛ for account; 2½ per cent. 104½—105 (Sept. 17th). Stock Exchange Settling Days: Consols, Oct. 1st; Stocks and Shares Continuation Day, Sept. 28th; Ticket Day, Sept. 29th; Pay Day, Sept. 30th; Mining Share Carry-over Day, Sept. 26th.

**ARMSTRONG (SIR W. G.) AND CO. (LIMITED).**—The report of the Directors of this Company states that, after deducting depreciation and adding last year's balance, there remains a profit of £358,689 upon the year's operations. The Directors propose the payment of a dividend of 2s. 3d. per share on the Ordinary shares and 4 per cent. per annum on the Preference shares of the Company (less tax), of which 6d. per share and 2 per cent. respectively have already been paid as interim dividends, leaving 1s. 9d. per share on the Ordinary shares and 2 per cent. on the Preference shares now payable, and a balance of £5,709. 0s. 1d. to be carried forward. Every department of the works has been fully occupied. The Directors add that the year should be regarded as one of more than ordinary prosperity.

**BABCOCK AND WILCOX (LIMITED).**—The fifth ordinary general meeting of this Company was held on Friday last at the Cannon-street Hotel, E.C., Mr. Andrew Stewart (the Chairman) presiding. The Chairman said that during the financial year the Directors had been able to pay an interim dividend for the half-year ended December 31, 1895, at the rate of 6 per cent. on the Preference shares, and a dividend of 5 per cent. on the Ordinary shares, amounting to £10,000. They now propose to pay for the half-year ended June 30, 1896, a dividend, at the rate of 6 per cent. on the Preference shares, and a dividend of 10 per cent. on the Ordinary shares, amounting in all to £17,000, making 15 per cent. on the Ordinary shares for the year. They had placed to the reserve fund the sum of £25,000, and had carried forward a balance of £5,276. 14s. 3d. They had during the past year exploited new markets, increased the sales considerably in the older markets, and had fairly-assured evidence of prosperity in the present year. They had acquired ground and buildings at Renfrew, not far from the present works, on which they had built new works and extended the old ones. The report and accounts were then adopted.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended September 13th were £835, against £808 in the corresponding week of 1895, an increase of £27. The total receipts for the half-year amount to £10,016, against £9,316 in the corresponding period of 1895, an increase of £700.

**DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company announce the payment (in addition to the dividend at the rate of 10 per cent. per annum on the Preference shares) of an interim dividend at the rate of 4 per cent., free of income tax, on the Ordinary shares for the half-year ended June 30th last.

**DUBLIN AND LUCAN STEAM TRAMWAY COMPANY (LIMITED).**—An extraordinary general meeting of the proprietors of this Company was held last week at Dublin for the purpose of considering a resolution relative to the adoption of a system of electric traction instead of steam. Mr. Wm. Mooney, who presided, proposed: "That an application be made to the grand jury of the county of Dublin, and subsequently to the Privy Council, for an order to amend the Orders in Council, 1880 and 1896, to authorise the Company to work the line thereby sanctioned (and which is now in course of construction) by electricity, by the overhead trolley system or otherwise, or by other mechanical power, at the discretion of the Directors; and for that purpose to erect the necessary poles and wires, or other appliances, on the public road, and to purchase land for the erection of the power house. And further to authorise the Company, in order to provide funds for execution of such electric or other works, to create and issue, if and whenever they deem it advisable to do so, new Preference Stock not exceeding £12,000, at such cumulative rate of interest as might hereafter be fixed by the Directors. Also to authorise the Company, if the Directors shall think it desirable to do so, to contract for the execution of said electric works, without issuing such extra Preference Stock in the first instance, on the terms of paying the expense thereof, with interest, by instalments out of the annual receipts of the Company, or to authorise the Directors to issue a part of the Preference Stock, paying the balance out of revenue." The Chairman said the Directors were authorised by an Order in Council to have the line any gauge they wished, but not less than three feet. The matter had been under discussion frequently, and it was likely it would be increased, possibly to the same gauge as the Dublin United Tramways. The resolution having been seconded, was duly carried

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 13th inst. amounted to £1,262. The amount for the corresponding week last year was £1,278. Decrease, £16.

**METROPOLITAN DISTRICT RAILWAY.**—A mere rumour at the end of last week that electric traction would be introduced on this line was one of the chief factors in causing a rise of three points in the price of the Ordinary shares, which showed an improvement on the week of 4½ points, from 26¼ to 30¾. The Metropolitan District was one of the few Home Railway lines which showed an improvement on the week's quotations.

**ROYAL ELECTRIC COMPANY OF MONTREAL.**—The coupons due October 1st on this Company's Four-and-a-half per Cent. Debenture Loan for £150,000 will be paid on and after that date by the Bank of Montreal, 22, Abchurch-lane, London, E.C. Coupons must be left three clear days for examination.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts of this Company for the half-month ended Sept. 15th were £1,767, against £1,455 in the corresponding period of 1895.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Divi-dend. | Name. | Previous Week's Price September 9. | Price Wednesday, September 16. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Sept. 12. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 52 54 | 50 53 | 4 14 4 | Jan., Apr., July, Oct. | 53 | 52 |
| £3,993,560 | Stock | 24/0 | Do. Preferred | 97½ 98½ | 97 98 | 5 7 0 | " " | 98½ | 97½ |
| £3,993,560 | Stock | 5/0 | Do. Deferred | 9¼ 9½ | 8¾ 9¼ | .. | .. | 9½ | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 6 | January and July .. | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8¼ 9¼ | 8¼ 9¼ | .. | .. | .. | .. |
| 180,000 | £10 | 3/0 | Brazilian Submarine | 15¼ 15¾ | 15¼ 15¾ | 4 8 11 | Mar., June, Oct., Dec. | 15⅝ | 15⅜ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | 160 170 | .. | ... | Jan., Apr., July, Oct. | 150 | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ 13½ | 12½ 13½ | 5 13 6 | February and August | 12⅝ | 12½ |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20½ 21½ | 20½ 21½ | 4 13 | " " | 21 | 20½ |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) xd | 3½ 4½ | 3½ 4½ | 4 8 11 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. xd | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% 110% | 107% 110% | 4 2 7 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10½ | 9½ 10½ | 4 3 0 | Jan., Apr., July, Oct. | 9¾ | 9½ |
| 400,000 | 10 | 5/6 | Eastern | 18 18⅜ | 18 18½ | 3 10 3 | " " | 18⅝ | 18½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 19½ | 19 20 | 3 0 0 | " " | 19⅜ | .. |
| £1,297,857 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 3 0 6 | May and November | 134 | 132½ |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 104 107 | 4 13 11 | February & August | 106 | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 18½ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18 7/16 | 18 5/16 |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 5 | February & August | 131½ | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 4 17 1 | January and July .. | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 16 2 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 109 | 106 109 | 3 13 9 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% 114% | 111% 114% | 3 10 11 | May and November | 111⅜ | .. |
| 180,227 | 10 | 3/9 | Globe Telegraph and Trust | 11¼ 11⅜ | 11¼ 11⅜ | 3 15 7 | Jan., Apr., July, Oct. | 11⅜ | 11⅜ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 18 18½ | 18 18½ | 3 5 9 | " " | 18 7/16 | 18 |
| 150,000 | 10 | 5/0 | Great Northern | 24 25 | 24½ 25½ | 3 18 6 | Jan., April, and July | .. | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 13 8 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 53 56 | 53 56 | 4 9 3 | May and November | 55¼ | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 109 112 | 5 7 5 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 7 | " " | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | .. | .. |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 140 145 | 140 146 | 4 2 2 | " " | 144 | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 6 | 5 6 | 5 0 0 | January and July .. | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 105 | 102 105 | 4 15 6 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | 1 2 | .. | January and July .. | 1 | .. |
| £150,000 | 100 | 8% | * Do. 8 per Cent. Debentures, 1902 | 99 104 | 99 104 | 7 16 1 | June and December | 99 | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1½ 1½ | 1½ 1½ | .. | .. | 1⅜ | 1½ |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 13 | 5 0 0 | May and November | 11⅝ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £30,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 10 11 | June and December | .. | .. |
| 61,248 | 15 | 5/3 | Western and Brazilian | 8¾ 9½ | 8¼ 9¼ | 4 17 4 | May and November | 8¾ | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 7 7½ | 7 7½ | 5 0 0 | — | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 2¾ | 2½ 2¾ | .. | — | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 107 | 103 107 | 5 12 8 | February & August | — | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 107 | 103 107 | 5 12 8 | " " | — | .. |
| $1,177,000 | $1,000 | 7% | * Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 4 2 | May and November | — | .. |
| £164,300 | £100 | 6% | * Do. 6 per Cent. Sterling Bonds (red.) | 100 105 | 100 105 | 5 14 6 | March & September | — | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chili Telephone (fully paid) | 3½ 4 | 3½ 3¾ | 5 6 8 | — | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/16 1/16 | 1/16 1/16 | .. | .. | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ¾ ¾ | ¾ ¾ | 5 14 3 | Yearly | 13/16 | .. |
| 484,597 | 5 | 2/6 | National | 7½ 7¾ | 7½ 7¾ | 3 11 0 | June and December | 7¾ | 7 7/16 |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | .. | .. | — |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 19 | 17 19 | 3 3 2 | " " | 18½ | — |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6¾ 7¼ | 6¾ 7¼ | 3 8 7 | " " | 6 13/16 | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 17 2 | — | 109¼ | 103½ |
| 58,000 | 5 | 4/0 | United River Plate | 3¾ 4¼ | 3½ 4 | 3 4 1 | January and July .. | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 101 106 | 101 103 | 5 0 0 | July .. .. .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | 4 15 3 | January and July .. | .. | .. |
| — | 5 | .. | Birmingham Electric Supply (fully paid) | 8 | 9 | .. | .. | .. | .. |
| .. | 5 | .. | Do. (£4 paid) | 6 | 6 | .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 16 17 | 16 17 | 2 18 10 | February & August | 17 | 16¾ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17½ 18½ | 17½ 18½ | 3 4 10 | January and July ... | 18½ | 18 5/16 |
| £140,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 132 136 | 132 136 | 3 14 1 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | — | .. | — |
| £30,000 | £5 | 2/6 | Charing Cross & Strand Electricity Supply Corp. | 9½ 9¾ | 9½ 9¾ | 2 15 5 | — | 9¾ | 9½ |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — — | — — | .. | — | .. | — |
| 24,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. | — | .. | .. |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 13¾ 14¼ | 13¾ 14¼ | 4 4 3 | — | 13¾ | .. |
| 8,322 | £5 | — | House-to-House Electric | .. — | — .. | .. | — | — | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. | — | — | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | — — | — — | .. | — | — | .. |
| 111,000 | 5 | .. | London Electric Supply | 1 1½ | 1 1¼ | .. | January and July .. | — | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13 14 | 13 14 | 2 17 2 | — | 13⅜ | 13 |
| £1[illegible],000 | Stock | 4½% | * Do. 4½% Debs. | 120 123 | 120 124 | 3 13 9 | — | — | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 12 13 | 12 13 | .. | June and December | .. | .. |
| .. | .. | .. | Rand Electric | 1 1/16 1 1/16 | 1 1/16 1 1/16 | .. | — | — | .. |
| 19,980 | £5 | 2/6 | St. James and Pall Mall | 12 13 | 11½ 12½ | 3 2 0 | — | .. | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 11 | 3 6 8 | — | — | — |
| 59,900 | 5 | 2/0 | Westminster Electric Supply (fully paid) | 11 12 | 11 12 | 2 18 4 | — | .. | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | 11 11/16 | 11½ |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1⅜ 1⅝ | 1 1½ | .. | — | — | — |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1¾ 2 | 1½ 1¾ | .. | — | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 110 113 | 110 113 | 3 19 8 | March & September | 1½ | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July .. | 112½ | .. |
| 59,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1⅞ 2⅛ | 1⅞ 2⅛ | 6 13 4 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 5 9 | January and July .. | 2⅛ | 2 |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | — — | — — | .. | .. | .. | .. |
| 110,000 | 2 | 1/0 | Electric Construction | 1⅜ 1⅝ | 1½ 1¾ | 2 17 2 | — | — | — |
| 12,845 | 2 | 2 9/2 | Do. 7 per Cent. Cumulative Pref. | 2⅞ 3¼ | 2⅛ 3 | 4 13 4 | — | 1⅝ | 1½ |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ¾ 1 | ¾ 1 | .. | September | 3⅛ | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | — — | — — | — | — | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 21½ 23½ | 21½ 22½ | 4 8 11 | February & August | .. | .. |
| £300,000 | 100 | — | * Do. 4 per Cent. Debentures | 107 110 | 107 110 | 3 12 9 | March & September | 22 1/16 | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ¾ ⅞ | ¾ ⅞ | .. | .. | 109¾ | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 40 43 | 40 43 | 4 3 10 | March and July | .. | .. |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 104 107 | 104 107 | 4 14 4 | January and July | 42⅜ | 41½ |
| £100,000 | 10 | 6/0 | W. T. Henley's Telegraph Works Ordinary | 18 19 | 18 19 | 4 10 1 | March & September | .. | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 11 10 | " " | 18⅝ | 18½ |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 1 0 115 | 110 115 | 3 18 3 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1⅜% | City and South London Railway Con. Ordy. | 51 53 | 51 53 | 2 16 7 | January and July .. | 53 | 51 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14½ 15 | 14½ 15½ | 3 5 7 | " " | 15½ | 14½ |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 138 | 136 138 | 2 18 0 | May and November | .. | .. |
| 37,500 | £10 | 2½% | Liverpool Overhead Railway | 13½ 13⅝ | 13 7/16 13 7/16 | 2 4 9 | — | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 16⅝ 17⅛ | 16⅝ 17⅜ | 2 17 9 | — | .. | .. |
| 125,000 | Stock | 4% | Do. 4% Debenture | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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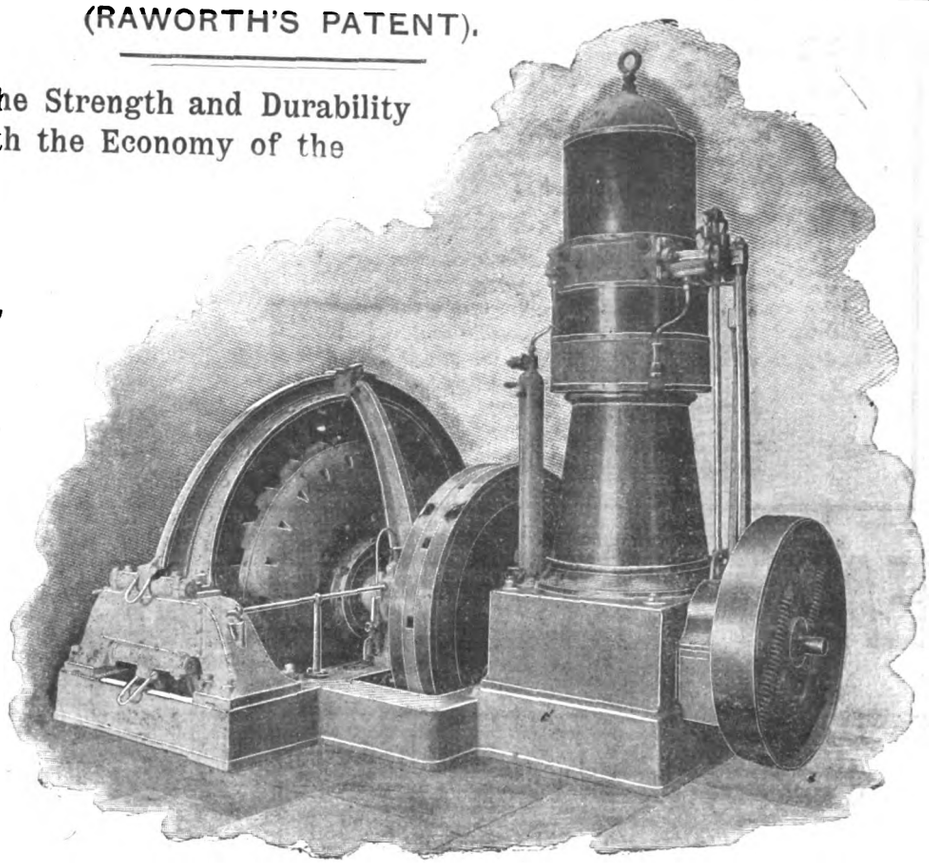

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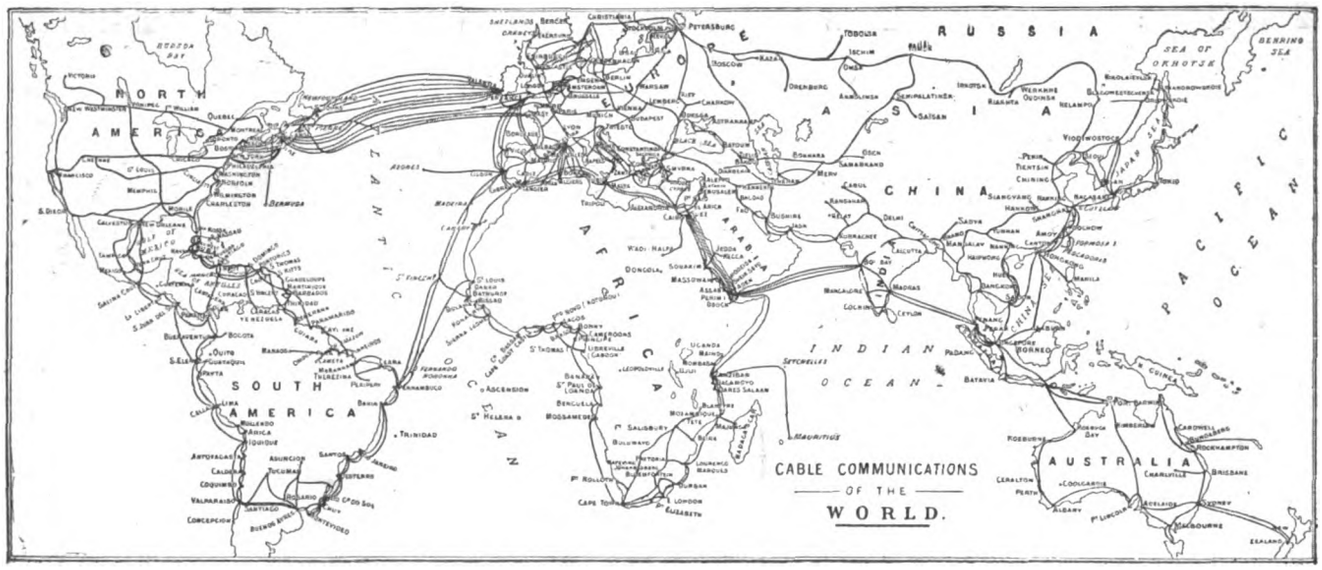
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.

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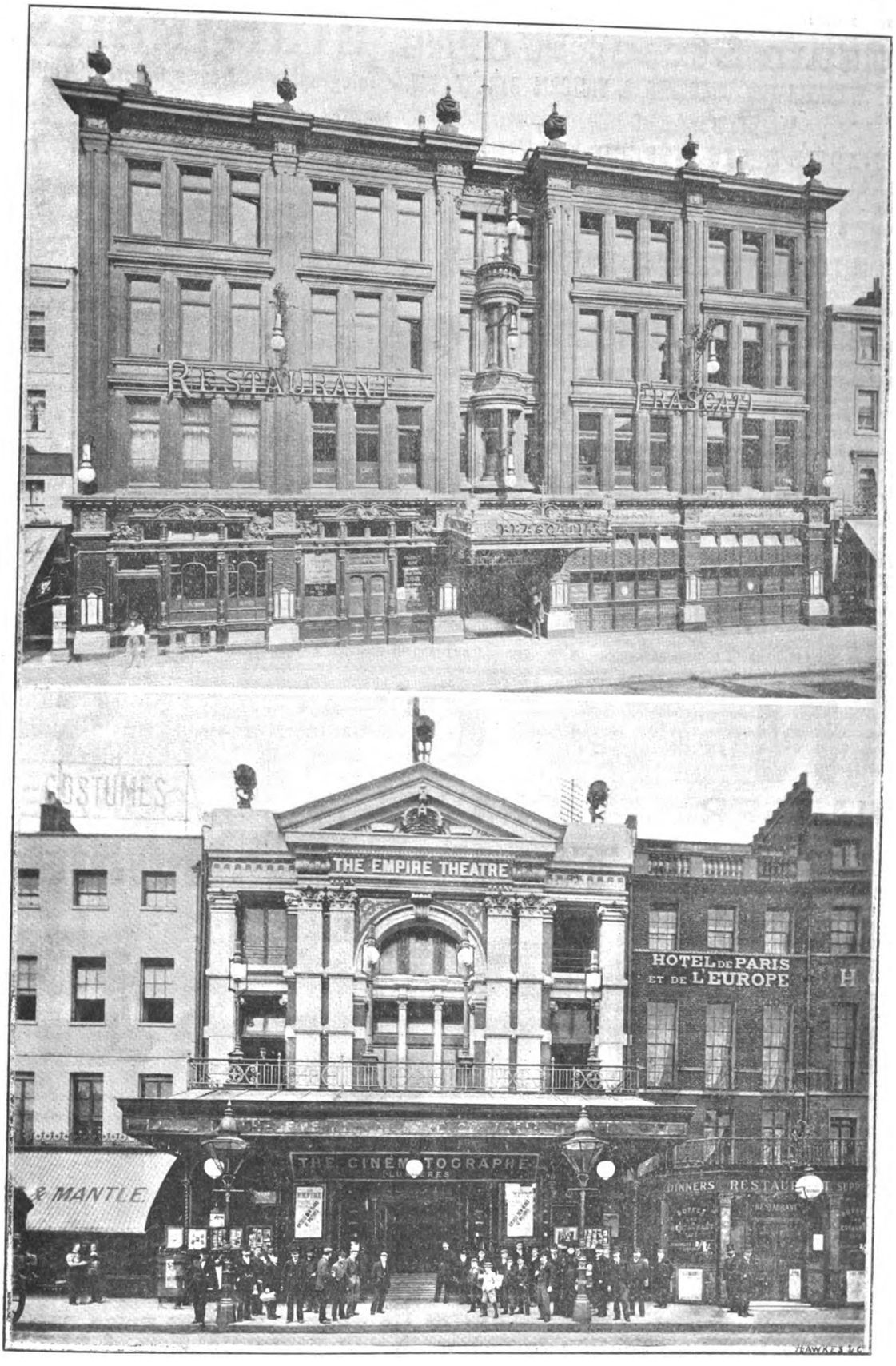


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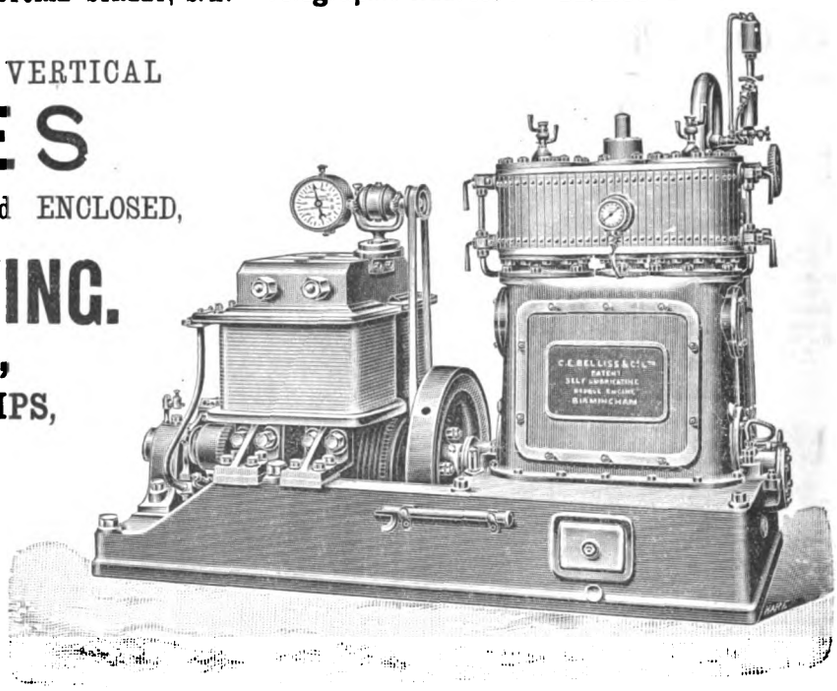

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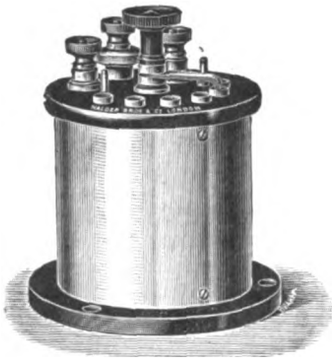

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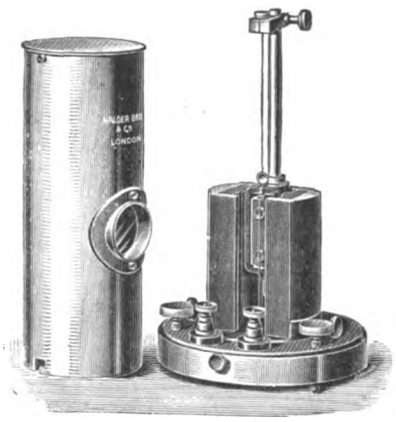

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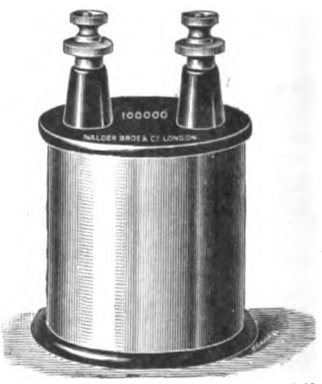


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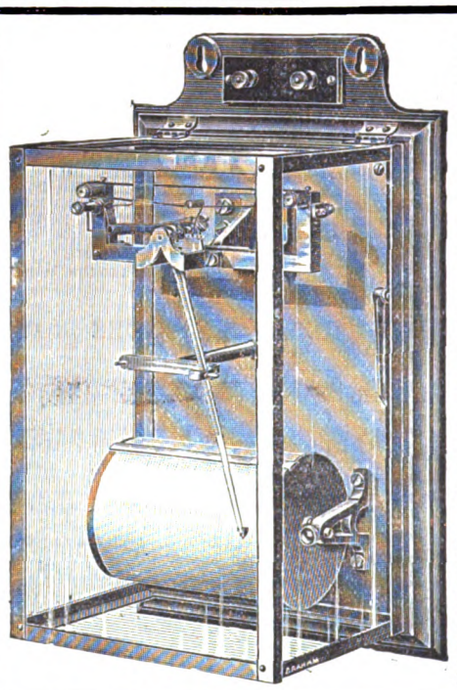

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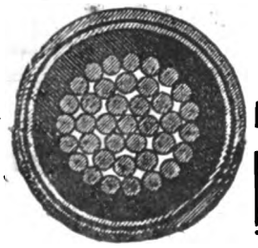

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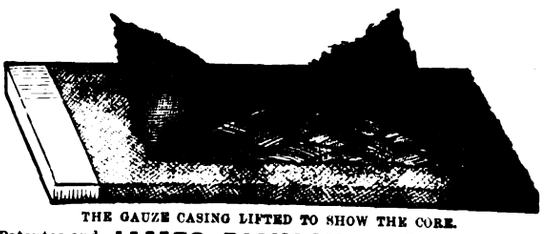

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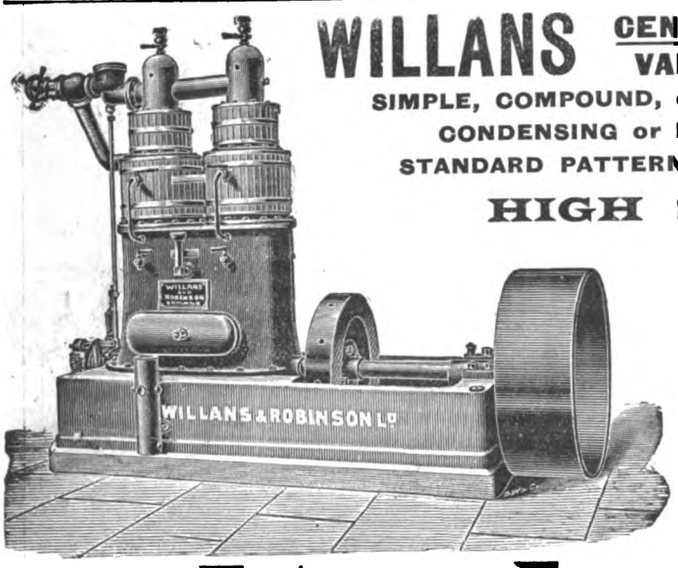


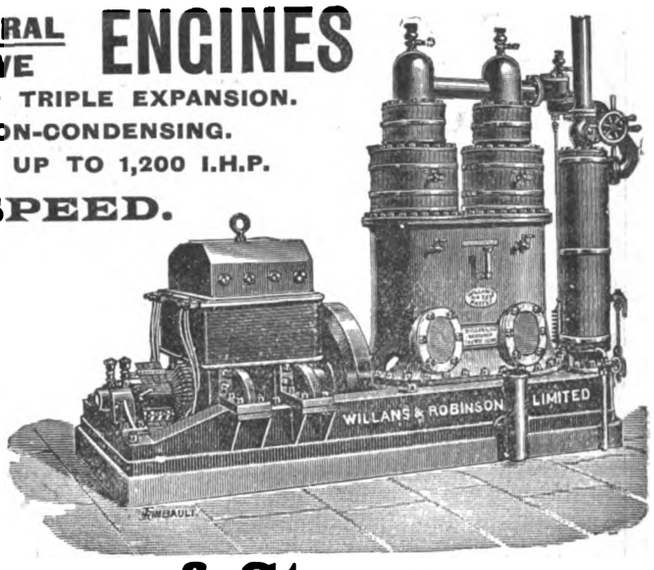


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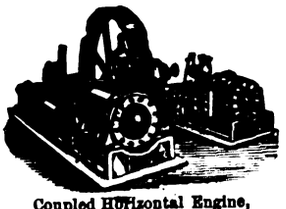
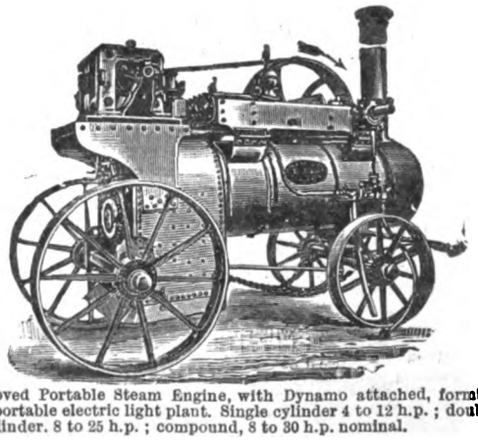
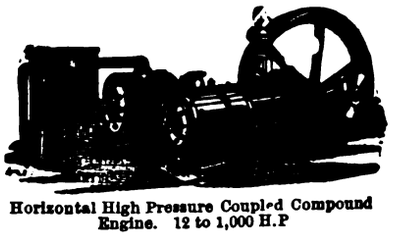


Coupled Horizontal Engine, 4C to 1,000 H.P.



Improved Portable Steam Engine, with Dynamo attached, forming a portable electric light plant. Single cylinder 4 to 12 h.p.; double cylinder, 8 to 25 h.p.; compound, 8 to 30 h.p. nominal.

TELEGRAPHIC ADDRESS:
"PAXMAN COLCHESTER."



Horizontal High Pressure Coupled Compound Engine. 12 to 1,000 H.P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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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## NOTES.

THE general impression of those who attended the meeting of the British Association at Liverpool this year, as well, no doubt, as of those who have watched the proceedings from afar, is that there was a decided and substantial advance upon previous years. There has been less of the resurrection of old and fusty Papers, and more attack upon subjects of current and leading importance. Correspondingly, however, the meeting has been unusually fatiguing; though this has been due in part to the inclement weather, and partly to the uncomfortable space distribution of the meeting places.

AT the Tuesday meeting of Section A, Mr. PREECE stated in the course o the discussion on Prof. CHUNDER BOSE'S Paper on "Electric Wave Apparatus," that a young Italian, Signor MARCONI, had described experiments in which he had, by means of Hertzian waves, transmitted signals over a considerable distance, and as a result Mr. PREECE had assisted Signor MARCONI to continue his experiments in London and on Salisbury Plain. Signor MARCONI has now succeeded in producing electric waves and reflecting them from one parabolic mirror to another one and a-quarter mile distant, the waves falling on a receiving apparatus, which actuated a relay and produced Morse signals; the experiments have been made with crude apparatus and without employing "any great amount of radiant energy." Further technical information is unobtainable just now; but, having divulged so much, and artistically whetted our curiosity, we trust Mr. PREECE will be merciful, and before long give the electrical world something more substantial. Many of us would like to know the nature of the receiving and transmitting apparatus. No doubt, short and long electric impulses could be sent by mechanically interposing suitable electro-magnetic screens between the source of energy and the receiver; but Signor MARCONI must have made a radically new departure in the "coherers" if the apparatus now enshrouded in mystery and hidden away on Salisbury Plain has been made *reliable*. So far "coherers" have been almost too sensitive, and a trifle capricious in their behaviour, and have required mechanical tapping to restore them to their high-resistance condition. The manner of announcement of this interesting advance is distinctly Edisonian, but that, no doubt, is the only Edisonian part of the business.

RÖNTGEN and cathode rays, as was anticipated, have occupied a considerable share of attention at the Liverpool meeting. Indeed, when all that has happened in connection with these phenomena is deducted, few things of importance remains in the proceedings of Section A. Two days, besides a large part of Prof. J. J. THOMSON'S opening address, were devoted to their study. Yet the final result must, on the whole, be regarded as disappointing. Perhaps it was in too sanguine a mood that we had hoped the meeting together of English and Continental authorities would result in an arrival at some sort of agreement as to the true nature of these new phenomena. When LENARD and BJERKNES debate with KELVIN, STOKES and J. J. THOMSON some useful result ought to be arrived at. The only result has been, that the several champions have, as it were, agreed to disagree. And Sir GEORGE STOKES, who it had been expected would support the hypothesis of extremely rapid transversal vibrations, created a surprise by trotting out a brand-new theory of non-periodic ether disturbances. The English physicists are just as sure as ever that Röntgen rays are essentially different in kind from the *Kathodenstrahl*, while the Continental physicists seem to be unshaken in their confidence that they are not. The English physicists are as positive as they were before LENARD came over here that cathode rays are a stream of electrified material particles; while LENARD and BJERKNES seem unmoved by the English arguments, and can only read the facts in the light of their hypothesis of ether waves.

PROF. J. J. THOMSON says there are great difficulties in accepting the view that the curved cathode ray is an ether-wave phenomenon. But are there not difficulties on both sides? Neither of the opposing hypotheses is able to account for all the facts; and when one of these is advanced by a man so evidently at home with the facts as LENARD proved to be, would it not have been better to have devoted more time to the discussion of the broad issue, rather than to haggling over the minutiæ of the English hypothesis? That this was not done is, we think, largely due to the somewhat unjudicial attitude of the chair. Politely withal, yet in unmistakable terms, Prof. J. J. THOMSON from the first set his face against the Continental views. This was a severe handicap against our distinguished foreign guests.

THE letter from Mr. JAMES PERRY, which will be found in our correspondence columns this week, raises once more the

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vexed question of the lead cell, and forces one to consider whether the defects are such as can be remedied by improvements in mechanical construction alone, or whether they arise from the chemical actions which take place during the working of the cell, and are therefore incurable by mere alterations in the method of manufacturing the plates. Whatever process of manufacture may be adopted, the positive plates consist of a greater or less amount of peroxide of lead, which forms the so-called "active material," and of a metallic support or conductor, which is formed of lead or one of its alloys, the action of the cell being due to the couple formed between lead and lead peroxide in diluted sulphuric acid. In the Planté and allied types of cell this support is made thick and heavy, and is designed to furnish fresh material to supply the place of that necessarily lost in the working of the cell; but, according to Mr. PERRY'S experience, and it is borne out by that of others, the support, the primary function of which is that of conductor, undergoes chemical action and consequent deterioration. The disintegration of the active material on the positive plates has been ascribed to the action of the gas which in all types of cell is liberated during charge at the junction of the peroxide of lead and the metallic support, and in its escape dislodges the pulverulent oxide. During rest, also, bubbles of gas are constantly formed on the surface of the plates, and in bursting remove particles of it. Herr ZACHARIAS has asserted that the life of positives may be prolonged by so constructing them as to facilitate the escape of the gas, though we are unable to speak as to the success of this device. This evolution of gas is not wholly to be ascribed to the same causes which produce the "gassing" which occurs at the completion of charge. The indictment brought by Mr. PERRY against the lead cell is a sufficiently sweeping one, and we shall be glad to hear what manufacturers and others have to say on the subject; for it is high time that the question should be settled, whether the defects of accumulators are *inherent*, or are capable of being remedied by mere alterations of construction which do not affect the couple employed, or the chemistry of the cell. It would appear that there are still some problems left unsolved in connection with the chemical reactions which take place in storage batteries.

FOR the past year and more Johannesburg and the Rand have been very much before the public; but possibly few of our readers have regarded this district as one which offers a probable field of employment for electrical engineers. We learn, however, from a correspondent who has recently gone out there, that not only is there electric lighting work to be had both in the town and at the mines, but electrolysis is largely applied to the extraction of the gold contained in the tailings. The Siemens and Halske process, on its first introduction, superseded the zinc precipitation method in many of the mines in the Transvaal; but since then its spread has not been so rapid owing to improvements introduced into the precipitation process, and also possibly owing to the weight of the lead cathodes originally employed in the electrolytic method. As first introduced, the Siemens process consisted in lyeing the tailings with a solution containing from 0·02 to 0·08 per cent. of cyanide of potassium, which was subsequently electrolysed in a bath provided with iron anodes and lead cathodes, so arranged that the electrolyte flowed over the top of the anodes and under the cathodes in a zigzag course. The current density employed was very low, 0·65 ampere per square centimetre; and a dynamo, giving 600 amperes at 8 volts, fed four baths containing 75 anodes. A 5 H.P. engine was sufficient for an installation of this size, which was capable of treating 30 tons of tailings a day, and consumed 340 kilogrammes of lead and 490 kilogrammes of iron per month. The amount of gold deposited on the cathodes varied from 2 to 12 per cent., and was recovered by cupelling off the lead. A modification has recently been introduced in the process, according to which the lead surface, which receives the deposit of gold, is not an integral part of the cathode, but is formed of a thin detachable layer of lead foil, which after receiving the deposit is placed on an inclined sheet of screening, and heated just above its melting point, so that it runs off, leaving the film of gold on the screening. Very much less lead is required by this process, and the separation of the precious metal is consequently more readily effected. The electrolytic process as first introduced lowered the cost of treating the tailings to about 3s. per ton, as against 5s. per ton by the zinc method, but since then improvements have been effected in the latter process which have secured greater economy.

AT many of the mines lodging is provided, and board can be obtained at the rate of 4s. a day, and the allowance of food is very liberal. The pay varies from 9s. to 18s. per day of nine hours, according to skill and experience. In Johannesburg a room with use of bathroom can be had for 12s. per week; and though the work of erecting the poles for the overhead wires is heavy, two Kaffirs are allowed per linesman, and he can have the services of more if requisite. Johannesburg is described as a city of fine buildings and ill-made roads; but the surrounding country is pretty, and altogether the electrical engineer who is not consumed with the desire to vote early and often might do worse than try his fortunes there.

THE purport of an article on "Gas *versus* Electricity Direct from Coal," contributed by Mr. D. M. DUNNING to the September number of the *Engineering Magazine*, is that, since in gas works 20 per cent. of the energy of coal is extracted in the gas, while the other 80 per cent. is paid for by the sale of by-products, the production of electricity "direct from coal" has not a leg to stand upon. We are constantly being reminded of those wonderful by-products with the aid of which gas companies, if they had a mind to, could give their gas away without money and without price. Mr. DUNNING now piles upon this ancient bogey the remark that illuminating gas is, and always has been, produced "direct from coal," with the inference that this being so there is no advantage in trying to generate electricity from that source. Superficially specious, these assertions when carefully examined are found to be hollow and illogical. Let it be assumed that, by a process yet to be discovered, a highly efficient carbon-consuming electric battery will be invented. Mr. DUNNING says that even then, even with 100 per cent. efficiency, "it will just about begin to get into comfortable competition with modern gas

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works." In other words, such a battery would place electric lighting in no more favourable position with respect to gas lighting than is held by the steam-and-dynamo stations of the present day. The contention is palpably absurd. Modern steam-and-dynamo stations have an energy efficiency of not more than from 7 to 10 per cent. at their best load, and a considerably lower efficiency on the yearly average. Yet these have not been without their influence upon the gas industry. Are we, then, to believe that the gas companies could view with almost complete complacency the discovery of a process by which, at one stroke, the energy efficiency of an electric station could be raised tenfold, and its capital outlay and yearly expenses be enormously diminished?

**New Berlin-Vienna Telephone Trunk Line.**—On the 5th inst. a second telephone line from Berlin to Vienna, *viâ* Dresden and Prague, was opened.

**British Association: Future Places of Meeting.**—The British Association meets next year at Toronto, under the Presidency of Sir John Evans. In 1898 it will meet at Bristol, and in 1899 at Dover.

**High-Speed Telegraphy.**—Mr. Patrick B. Delany, of South Orange, N. J., has received the Elliott-Cresson gold medal from the Franklin Institute, of Philadelphia, for his system of high speed telegraphy.

**Price of Incandescent Lamps in Germany.**—The management of the Royal Small Arms Factory at Danzig has accepted tenders for 16, 25 and 32 c.p. lamps, at prices varying from 5·9d. to 7·4d. per lamp.

**City of London College.**—The Michaelmas term of this College commences on October 1st. Classes are held in magnetism and electricity, sound, heat, light, mathematics, chemistry, and other science subjects.

**Obituary.**—The death is announced of Mr. John Warwick, for over 25 years telegraph superintendent of the Midland Railway, and the inventor of the block system. Mr. Warwick retired from the Midland Company's service in 1879.

**Electric Lighting in Chelsea.**—According to the report of Mr. T. W. E. Higgens, Surveyor to the Vestry, the number of houses in Chelsea lighted by the Chelsea Company for the last three years was as follows: 1893-4, 500; 1894-5, 598; 1895-6, 777.

**Telegraphy at the Cape.**—Supplementary estimates for 1896-7, just submitted to the Cape Parliament, propose an outlay of £70,000 for new telegraph lines and additional wires. New post and telegraph offices are contemplated at Cape Town at a cost of £72,000.

**Niagara Falls Power House.**—It is stated that the efficiency of the 5,000 H.P. turbines, at the power house of the Niagara Falls Power Company, has proved remarkably high. When once started, the turbines will run idle on as low as $\frac{1}{16}$in. gate; and at full load the efficiency of the turbine is 80 per cent.

**The Electrical and General Engineering College.**—Mr. G. W. de Tunzelmann informs us that the next session of this College begins on October 1st. He also requests us to draw attention to the fact that experimental work of all kinds, including the construction of machines for inventors, is carried out in the college workshops.

**Cable Interruptions and Repairs:—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique ..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Para—Maranham ..... | Aug. 6, 1896 ... | Sept. 21, 1896. |
| Bahia—Rio de Janeiro ..... | Sept. 4, 1896 ... | — |
| Penang—Medan ..... | Sept. 7, 1896 ... | — |
| Loanda—Benguela ..... | Sept. 13, 1896 ... | — |
| Zanzibar—Mombasa ..... | Sept. 23, 1896 ... | — |

**Liverpool Overhead Railway.**—The Directors of the Liverpool Overhead Railway threw open their line free to all the members and guests of the British Association during the whole time of the meeting. This line is in a flourishing state, and the extensions and tunnel beyond Herculaneum Dock Station are progressing rapidly towards completion.

**Science Grants.**—The total science grants of the British Association amounted this year to £1,355. These grants include the following: £5 to the Committee on Electrical Standards, £50 to the Committee on Electrolysis and Electro-Chemistry, £10 to Prof. J. E. Reynolds for Electrolytic Quantitative Analysis, and £10 to the Committee on Small Screw Gauges.

**National Physical Laboratory.**—At the meeting of the General Committee of the British Association on Wednesday the following recommendation from Section A was adopted: That a National Physical Laboratory should be established, and for this purpose that the co-operation should be invited of the Royal Society, the Royal Society of Edinburgh, the Royal Astronomical Society, the Institutions of Civil, Mechanical, and Electrical Engineers, the Chemical and Physical Societies, and other kindred societies, for securing this foundation.

**Magnetic Disturbances.**—M. Moureaux, who has just returned from Russia, says *Nature*, "has made observations of some quite surprising magnetic perturbations. On August 29th, special perturbations were observed by him of the same kind that are generally registered when connected with earthquakes. He remained several days supposing that he had been mistaken, when he learned, through a steamer which arrived, that Hecla had been in eruption on that same night. The exact times of occurrence of these perturbations were 11 hours 36min., 11 hours 42min., 11 hours 46min. p.m. Paris mean time."

**The South-West London Polytechnic Institute.**—We have received the prospectus of the day and evening classes of this Institute. The scheme of the day classes is similar to that of the Finsbury Technical College. The two years' course of electrical engineering and applied physics, under Prof. Herbert Tomlinson, F.R.S., includes laboratory and workshop practice as well as lectures. There is a long list of evening classes, including lectures on elementary and advanced physics, electrical engineering, electric wiring and fitting, and practical instruction in instrument making. The day classes in mechanical and electrical engineering and chemistry commence Tuesday next.

**The Electrical Resistance of Bismuth.**—On page 267 of our issue of June 26th Dr. J. A. Fleming announced that bismuth cooled to −186°C, and in a magnetic field of 14,150 units had a resistance **15·3** *times greater* than when at a temperature of 19°C., and not in the field. On page 17 of his recently published Royal Institution lecture the following important footnote occurs: "Since the delivery of this discourse we have been able, by the employment of a powerful electro-magnet kindly lent to us by Sir David Salomons, to increase the resistance of bismuth, when cooled in liquid air, more than **150** *times*, by magnetising it transversely in a field of 22,000 C.G.S. units."

**The Radiophone.**—It is stated, says our New York correspondent, that Prof. Alexander Graham Bell is engaged in the commercial development of his radiophone, which he devised many years ago. It is well known that this instrument involves the use of a beam or ray of reflected light—preferably sunlight—for the transmission of sounds and speech between distant points, in lieu of the ordinary wire. How soon this instrument will be in such shape as to present it for public favour of course it is impossible to state. Prof. Bell works quietly and without seeking newspaper notoriety, and he is level-headed enough to say nothing to the public unless he has something to say.

**Iron Smelting by Electricity.**—It is announced in various papers that Dr. G. de Laval and a Mr. Robsahm, of Stockholm, have obtained from the Swedish Government a concession for the establishment of a company for the smelting of ores in electric furnaces on a large scale. The capital is to be 15 million kroner (£723,000). Water power at Trollhättan is to be utilised, and all the De Laval patents for electric smelting are to be acquired. We have heard the same report from another source, but with the addition that many waterfalls in Sweden had already been bought by the Company, the capital of which was placed at a considerably higher figure than the above, and was said to have been chiefly furnished by American banks.

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**The Earth a Great Magnet.**—Under the presidency of Sir W. B. Forwood, Chairman of the Library, Museum, and Arts and Technical Instruction Committee, a thoroughly representative gathering of the working classes was held on Saturday evening at the Picton Lecture Hall, Liverpool, which was crowded in every corner, for the purpose of hearing a lecture by Dr. J. A. Fleming, who had selected the above title for his discourse. The address was listened to with the closest attention, and frequently and enthusiastically applauded. The question of the nature and origin of terrestrial magnetism was considered, and the lecturer said that if the greater part of the earth's magnetism was due to the materials of which the earth was composed being permanently magnetised, then it was tolerably certain that this magnetic effect was wholly confined to a layer not much more than 12 miles thick. The lecturer concluded by emphasising the enormous importance of the work which had been done in studying the behaviour of the compass in iron ships, and the improvements effected in the compass chiefly in this century due to Lord Kelvin. Dr. Fleming's audience numbered over two thousand.

**The Electric Furnace.**—In the current number of the *Annales de Chim. et de Phys.*, M. Moissan, says *Nature*, gives an interesting account of his experiments on the volatilisation of refractory substances in the electric furnace. The sublimates were condensed on the outside of a curved copper tube placed two centimetres below the arc, and just above the substance under examination. A rapid current of water was passed through the tube, and kept it cool during the experiments, which usually lasted for about five minutes. The volatilised metals were copper, silver, platinum, aluminium, tin, gold, manganese, iron, and uranium. Quantitative experiments were not made in every case, but it appeared that manganese was sublimed more rapidly than the others, and that the rate of volatilisation of copper was about five times as rapid as that of gold. The condensed metal was usually, in great part, in the form of little spheres. Silicon and carbon were also volatilised and condensed on the tube, though the amount collected of the last named element was very small, and lime, magnesia, zirconia, and silica were sublimed without difficulty. M. Moissan draws the conclusion that the most stable compounds hitherto known disappear in the electric furnace, being either decomposed or volatilised. Nothing resists these high temperatures except the series of perfectly crystallised compounds discovered by him, and consisting of borides, silicides, and, above all, carbides of the metals. M. Moissan intends to publish a description of these compounds shortly. He regards them as being probably among the original constituents of the globe, and as still existing in some of the stars.

**The Application of Electricity to Paper-making.**—The new plant of the Cliff Paper Company, says our Niagara correspondent, has been in operation a sufficient length of time now to determine whether or no the application of electricity to paper-making effects a saving over steam; and the verdict of the Cliff Company is that it does. Of course, it is recognised that the Cliff people are especially fortunate in the matter of water power, but apart from this they think electric power on paper machines effects a saving. First they find that the electric power gives greater speed to their paper machines to the extent that their output is increased at least 40ft. per minute. The generators require but little attention as compared with steam boilers, and there are no fires to keep up; no big coal bills, or the expense of handling the coal; no steam exhausts; none of the costly repairs such as a steam plant is always demanding. The Cliff Company see great economy in their change, from the fact that the water used to operate the Leffel turbine connected with the generators is a supply that was wasted before they put in their electric installation. So far one steam boiler has been dispensed with, and the other will rest when a dry oven has been built, so that the present steam used for drying the paper can be replaced by the oven, which is to be heated by shavings from the pulp wood. Thus it will be seen that the entire abandonment of steam power has about occurred in this mill, leaving the mill's production almost entirely dependent upon the water power available. The plant has been in operation over a month, and each day has increased the general satisfaction over the adoption of electric power.

**The Metric System.**—"The question of the early adoption in England of the metric system," said Sir Douglas Fox in his Presidential Address to Section G, "is of importance, not only to the engineering profession, but also to the country at large. The recommendation of the recent Royal Commission, appointed for the consideration of the subject, was that it should be taught at once in all schools, and that, in two years' time, its adoption should be compulsory; but it is much to be regretted that, up to the present time, nothing has been done. The slight and temporary inconvenience of having to learn the system is of no moment compared to the great assistance it would prove to the commercial and trading world; the simplification of calculations and accounts would be hailed with delight by all so soon as they realised the advantages. England is suffering greatly in her trade with the Continent for want of it. Our foreign customers, who have now used it for many years, will not tolerate the inconvenience of the endless variety of weights and measures in use in England; and they consequently purchase their goods, to a great extent, from Germany, rather than use our antiquated English system. It is no exaggeration to say that, with their knowledge of the metric system, they regard ours as completely obsolete and unworkable, just in the same way as we should were we to buy our corn, our wine, our steel and iron, by the hin, the ephah, or the homer, or to compute our measurements by cubit, stadium, or parasang. It behoves all who desire to see England regain her trade to use all their influence in favour of the adoption of this system, as its absence is, doubtless, one of the contributory causes for the loss that has taken, and is taking place. An important argument in favour of the metric system of weights and measures is that it is adopted all over the civilised world by physicists and chemists; and it may be stated with confidence that the present international character of these sciences is largely due to this."

**Contemporary Electrical Science.**—Papers on X-rays still form the staple article of the foreign scientific Press. Useful abstracts of these are found both in Wiedemann's *Beiblätter* (No. 8) and in the *Proceedings* of our own Physical Society. The latter for September mentions that Messrs. Novák and Sulc have found absorption to increase with the number of atoms in the molecule, and with their atomic weights. Fluorine has an exceptionally high absorption, and bones owe their opacity mainly to fluoride of calcium.——C. Doelter has found that the absorption of X-rays is often anomalous; rock salt, sulphur, potash nitre, and realgar are opaque, considering their lightness; cryolite, corundum, and diamond, though heavier, are perfectly transparent. He finds, in contradiction to the last author, that chemical constitution affords no guide, and the direction of the crystallographic axes is also without influence. He proposes a scale of transparency for these rays, consisting of diamond as the most transparent, corundum, talc, quartz, rock salt, calcspar, cerussite, and realgar as the most opaque.——Messrs. Eder and Valenta have failed to shorten exposures by using orthochromatic plates, but have shortened it by heating to 50°C., or by a screen of fluoride of calcium, used with a silver-bromide and celluloid film.——Among the *Beiblätter* abstracts, we find an account of Grunmach's success in discovering phthisis colonies in the lungs of a young man by means of a fluorescent screen, which also was capable of revealing arterio-sclerosis of the aorta. M. Levy, in addition, observed the working of the stomach and the heart, which is the most opaque of the internal organs. G. Brandes found that X-rays could be seen if the crystalline lens were removed from the eye. All the humours of the eye are more or less opaque to them.——There is also an abstract of a Paper on electromagnetic units from the *Proceedings* of the Tokyo Mathematical and Physical Society. It is more sober and conciliatory than a certain militant pseudo-Japanese letter we published last year, but there is not much more likelihood of these recommendations being adopted. The ohm is to be $10^8$ absolute C.G.S. units, which would make the ampere and coulomb equal to one absolute unit each. The only index will be 8, positive or negative. The old names of quantities are retained.

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## ELECTRICAL DISTURBANCES IN SUBMARINE CABLES.*

BY W. H. PREECE, C.B., F.R.S.

Many interesting problems arise from time to time in the practical applications of electricity which tend to develop, or confirm, theoretical deductions on a scale beyond the dreams of the laboratory experimenter. In no branch has this been more pronounced than in submarine telegraphy. Long-ocean cables contain invariably only a single core.† Multiple cables, that is, cables possessing more than one core, are usually short in length, and are, in consequence, free from those disturbing elements which, existing in long lengths, make such circuits difficult to operate successfully, A *disturbance* is the result of the expenditure of energy in the wrong place. It tends to loss of efficiency. In telegraphy this means mutilation of signals and loss of speed in working. In telephony it means indistinctness of speech, the presence of extraneous and distressing sounds, or the reduction of distances through which speech is practical.

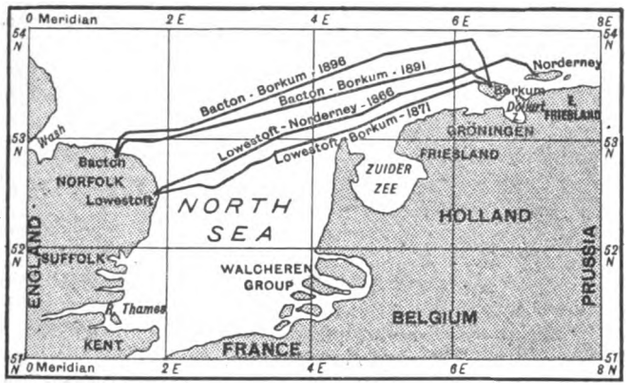


FIG. 1.—Map of Part of North Sea, showing Bacton-Borkum (2), Lowestoft-Norderney and Lowestoft-Borkum Cables.

The longest multiple cables worked by the British Post Office are those connecting the coast of Suffolk and Norfolk with Germany, and these cables have four cores each.

The following table gives their lengths and particulars :—

| Name of cable. | Date laid. | Length in naut. miles. | Capacity in microfds. K. | Resistance in ohms. R. | K R.‡ | Remarks. |
|---|---|---|---|---|---|---|
| Lowestoft-Norderney | 1866 | 225 | 73·1 | 2,710 | 198,100 | No brass tape. |
| Lowestoft-Borkum... | 1871 | 225 | 66·0 | 2,666 | 175,950 | Ditto. |
| Bacton-Borkum... | 1891 | 211 | 63·0 | 2,380 | 149,940 | Ditto. |
| Bacton-Borkum... | 1896 | 224 | 84·0 | 1,500 | 126,000 | Separate brass tape round each core. |

The Norderney and other cables in the North Sea having been attacked and punctured by the *Limnoria terebrans*, a small boring mollusc, it was decided to cover the cores of all new cables with brass tape armour, an effective remedy against this depredator. Hitherto brass tape had been used solely for this particular purpose. It was wrapped round the whole of the cores after they were stranded together; but, for other reasons which will appear, the second Bacton-Borkum cable, laid this year, had each core separately and independently so protected.

These four cables, forming 16 circuits, are worked as a rule by the Hughes type-printer; but on two circuits, the double-current-Morse system is employed. In all cases the earth is used as the return. The presence of disturbances from induction was first seriously brought under notice after the laying of the Bacton-Borkum cable in 1891. This cable is one of the ordinary four-core P.O. standard type, without any brass taping, a section of which is shown in Fig. 2. On commencing to work the four wires, it was found that, although we had a perfect cable, with better copper, and gutta-percha of lower static capacity than usual, the Hughes working upon the four circuits was very unsatisfactory. Twelve months after its submersion, a series of observations was made upon the three then existing Anglo-German cables, when it was made clear that there was still very much more disturbance upon the 1891 Borkum than upon the old cables viâ Lowestoft. After very careful examination and consideration it was concluded that the difference was due to the better mechanical condition of the new cable, upon which the compound was still practically sound, preventing a complete and continuous soaking with water of the hemp yarn around and between the cores, with the consequent absence of the shielding effect which existed in the older cables, owing to their more thorough saturation. It was consequently assumed that the new cable would improve with age. But this disturbance presented itself in a more serious manner when attempts were made to work *duplex* Hughes, and also when testing the Wheatstone automatic system upon one of the cores. It was found that duplex

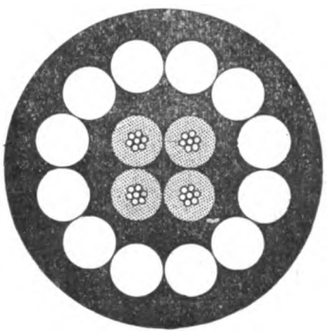

FIG. 2.—Ordinary 4-Core Submarine Cable. Deep Sea Type. 107lbs. Copper, 150lbs. G.P. to scale.

Hughes was just possible, but owing to the disturbance from the other cores the signals were mutilated so frequently that working was too unreliable for ordinary business. The disturbances from Wheatstone working were still more serious. The Hughes apparatus is worked by short, sharp, intermittent currents, separated from each other by varying intervals of time. These time intervals determine the letter to be printed.

The causes of disturbance are induction and leakage. The latter may be ignored, for the insulation of our cables is practically perfect. The induction may be either *electrostatic* or *electromagnetic*. The former is the primary agent in reducing the speed of working in telegraphs, and in deteriorating the clearness of speech in telephones. A part of the energy of the current is absorbed by the capacity of the line, and stored up as a charge producing in discharge retardation and prolongation of signals. Electrostatic induction between core and core is the principal cause of the disturbance between the conductors of multiple cables. Electromagnetic induction also produces serious disturbances on straight parallel circuits with earth return, whether used for telegraphs or telephones; but between the two wires of a metallic circuit it may have a very beneficial influence in telephone working.

It is very easy to differentiate the electrostatic from the electromagnetic effects. The former differ in direction at each end of the circuit when discharging. The latter maintain the same direction throughout. The former vary with the *voltage*, and the latter with the *amperage*.

During the experiments with the Wheatstone system, to which I have referred, it was found that the disturbances on the Hughes circuits, due to automatic sending on another core of the same cable, increased with the rate of working. Thus, with the same voltage, viz. 80, at

Key speed (30 words per minute), the effect was negligible.
Automatic (40 words per minute), the effect was distinct.
Automatic (50 words per minute), the effect was serious.

* Paper read before the British Association at Liverpool, Section A.

† The term *core* is applied to the copper conductor and its insulating sheath or dielectric.

‡ The product K R expresses the law that the time constant of a circuit varies as the product of its active capacity and its ohmic resistance.

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Maximum speed of the cable (70 words per minute), the effect was prohibitive.

The greatest disturbances were observable when automatic and Hughes were working in opposite directions. The signals on the Hughes were sometimes in advance and sometimes in retard. Hence they were so greatly mutilated that Hughes working was impossible. This was due to the *consonance* which occurs in two parallel circuits. When the mutual inductive influence, either electrostatic or electromagnetic, or both, between them, produces in either conductor greatly increased or greatly diminished currents, the one will advance and the other retard the signals so as to render telegraphy impracticable. The brass tape around each core entirely shields the conductors from electrostatic induction. The separate and independent brass taping of the 1896 cable has fully complied with my anticipations. The disturbances upon the cables are reduced to a negligible extent. They are one-sixth of those observed on the 1891 cable. They would entirely disappear if we could remove the electromagnetic effects. The possible rate of working, after several months' submersion, on the new cable, is 33 per cent. greater than on the 1891 cable, but this is due chiefly to the reduction of the K R. The improvement in the signals is shown by the two recorded curves (Fig. 3).

The surface of the conductor in such a cable is one plate and the earth the other plate of a condenser. At every point of the course of the current this capacity must be satisfied. Work is done on the dielectric in establishing an electric field. Lines of electric force are formed through the medium, varying in number with the force exciting them, and with the thickness and specific inductive capacity of the dielectric. Energy is stored up. The charge thus held must be neutralised or dissipated. Discharge to earth through each end is the result, and this, with the resistance of the circuit, produces retardation of signals.

Neutralisation has been attempted in submarine telegraphy by sending reversed currents, but with only partial success.

With parallel conductors and telephone working the conditions are very different. The total energy expended in any circuit in a given time may be considered under three heads :—

1. That expended in overcoming resistance.
2. That expended in producing the electric field.
3. That expended in producing the magnetic field.

In each case we must consider the energy stored up and that dissipated. The former tends to retardation, the latter to work done, and therefore to reduction of efficiency. Careful regard must be paid to the directions in which the different

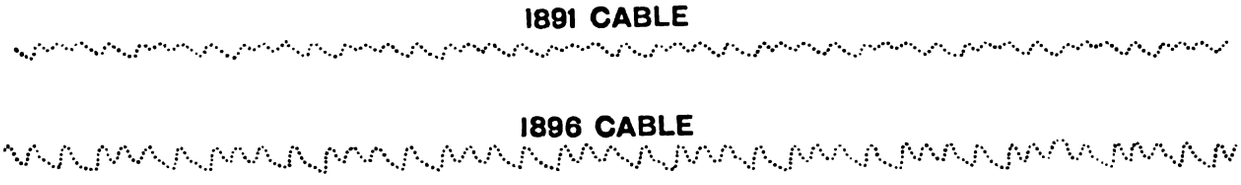


Fig. 3.

The time constant * of the 1891 cable is 0·0513 second, and that of the 1896 0·0450 second, measured by the Hughes instrument, which is a capital chronograph.

## PART II.—TELEPHONE CABLES.

An important form of multiple cable to consider is that required for telephone working. The cable connecting England and France, forming the Channel section of the London-Paris telephone circuit, has cores of the ordinary type as shown in Fig. 1, using gutta-percha as the insulating medium, but with its capacity and resistance reduced to a minimum. It gives two circuits between London and Paris, and works very satisfactorily; but we want to bridge over greater distances, and eventually we hope to reproduce speech even across the Atlantic. The Dover-Calais type would not do for a greater distance than say 30 nautical miles. The distance to Belgium is 47 nautical miles, to Holland 108, to Germany 211 nautical miles. With paper as the dielectric, having half the specific inductive capacity of gutta-percha, and with our later experiences of air spaces, cannot we devise a new form of cable that will bridge over these greater distances? We must eliminate all disturbances, and we must reduce capacity and resistance to their lowest limits. The former is simple, for well-insulated, symmetrically-twisted metallic circuits are free from all external disturbances. The latter is more complicated, and is surrounded with great practical difficulties. The problem is to diminish the time constant of a metallic circuit so that it shall approach zero.

If there were no time constant, current waves would rise instantly to their working maximum, and as rapidly fall to zero. If we could materially diminish the causes of retardation in such cables, speech by telephone would be possible to great distances. This can be done theoretically by neutralising the effect of static capacity by the opposite effect of electromagnetic induction.

The conditions which retard current waves and thus determine the time constants in single conductors embedded in a solid cylindrical dielectric are very different to those which act in double conductors or parallel metallic loops. Lord Kelvin in 1855 dealt with the cases of direct currents and distributed capacity in a complete single circuit.

* The *time constant* here referred to is the time that the current takes to rise to the necessary strength to work a relay in normal adjustment.

disturbing forces act, for it may be that they oppose each other and direct the energy into the original channel under modified and more favourable conditions. Thus, if the whole effect of the electrostatic field is neutralised by that of the electromagnetic one, the total energy developed is expended on the circuit itself, disturbances are eliminated, and the service improved. This is the case of a metallic circuit having a microphone transmitter at one end and a telephone receiver at the other. The capacity of such a system will tend to store up a portion of the energy of each current, but the electromagnetic induction between them will tend to supply the deficiency. If the two wires of the loop be far apart the influence of mutual induction will be much less than that of capacity. As they approach, the electromagnetic induction must increase at a greater rate than that of the electrostatic induction, until, finally, at the limit when they coincide, the one must exactly neutralise the other. This, perhaps, is better seen if we consider the case of a concentric cable; for, in this case, the number of lines of electric force does not increase, while the number of lines of magnetic force cutting the other conductors does increase rapidly as the outer conductor approaches the inner. The maximum induction from each source must take place when the two conductors are infinitely near each other, and this maximum must equal the primary current, for it cannot exceed it unless there were fresh creation of energy. Thus, as the separating dielectric becomes smaller and smaller, the two effects approach each other closer and closer, until, at absolute contact, they annul each other. The result must be that if these be the only conditions present, the time constant must diminish as the two conductors approach each other, and in the limit it must disappear. Twenty miles of concentric cable (Fig. 4), insulated with paper, were made and laid in the streets of London to test this reasoning, and comparisons were made with ordinary parallel cylindrical conductors, insulated both with gutta-percha and with paper and air. The result was very encouraging; but an unsuspected difficulty arose from the want of symmetry of the capacity of each conductor and the earth. The insulation resistance of each conductor was also different, and the result was that when the concentric cable was joined to overground wires, serious disturbances were experienced in the working circuits, which, however, were remedied by crossing the conductors of the concentric cable at several points, so that each side of the circuit was sometimes

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the inner and sometimes the outer conductor. This, however, is a cure that could not easily be applied to a submarine cable. It is clear that in such a cable symmetry of capacity with earth and of insulation is essential.

The experiment with the concentric cable shows that we have to consider not only the capacity between the two conductors, but that between each conductor and earth. Symmetry can be produced if the conductors be shaped and arranged as in Fig. 5. Only a certain number of lines of electric force, dependent on the voltage present, can emanate from each conductor. The closer *a* and *b* (Fig. 5) are to each other, and the further they are from the earth, the greater the number of lines between the conductors and the fewer to the earth. The electric field is, in that case, confined almost entirely to the space between *a* and *b*.

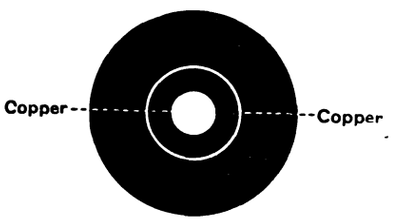


FIG. 4.

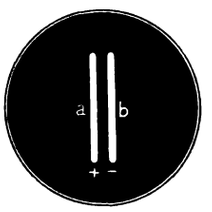


FIG. 5.

Taking the transverse action upon each element of such a core working telephones, each conductor is a source of periodic and opposite alternating electric force, and a displacement current passes through the dielectric that separates *a* and *b*, varying not only with the electric forces and the specific inductive capacity, but with the frequency of the alternations. There is no storage of energy. It is dissipated as heat, but this heat, with the very small amount of energy expended in telephone working, cannot be sensible. It must, however, ultimately limit the distance at which we can reproduce speech.

Taking the longitudinal action per unit length of each conductor, since there is no storage, but only a small expenditure of energy between the conductors, the rate of fall of voltage must be slightly greater than that required by Ohm's law. It should not, however, cause retardation, because that is the result of storage and release of energy. It is different, however, with the condenser action between each conductor and earth. Here there must be some storage of energy, but, for the reason given, this must be small; and in an insulated system like a telephone circuit, and with a thick dielectric sheath, the effect may possibly be neglected.

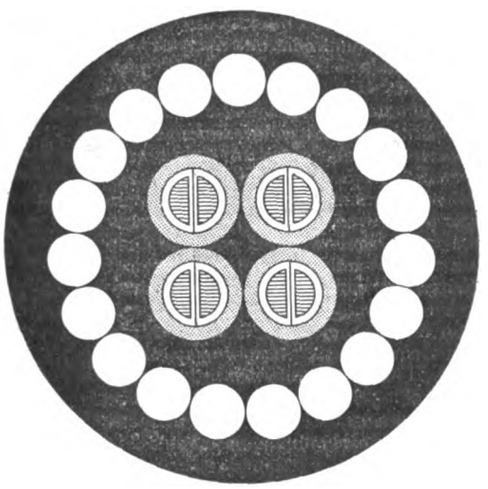

FIG. 6.

The problem resolves itself into a practical question: What is the best form to give the cable with our existing experience and our available materials? My present solution is given in Fig. 6. The conductors are insulated first with paper and then with a thick coating of gutta-percha. Paper only exists between the conductors. The cable is sheathed and compounded in the usual form. There are four circuits, instead of two, as at present in the London-Paris cable.

With such a cable I have little fear of speaking between England and Germany; but to test the practical points that arise in the manufacture of such a cable it is proposed to make and lay a short one to the Isle of Wight. If my reasoning is correct, and so far experiment has confirmed it, then not only ought we to be able to speak to great distances, but the type of ocean cables must be revolutionised, for what is true for telephony must be equally true for telegraphy. Cables such as those across the Atlantic might, with the same weight of copper, be made to transmit a greater number of words per hour than they do now.

## A DIRECT-READING WHEATSTONE BRIDGE.*

BY A. P. TROTTER.

In James Swinburne's "Practical Electrical Measurements" (1888), Major Cardew's "Lightning Conductor" bridge is described, and is followed by a modification arranged by Mr. Swinburne as "a simple bridge on an emergency, or for amateurs."

"An evenly divided scale, divided into, say, 1,000 parts, is mounted as shown in Fig. 10. A uniform wire is stretched over it from the binding screw E to N, returning by D and F to the other binding screw H. . . . The points E, K, M, and H are fixed, because they are determined by the design of the apparatus. The problem is to find the points F and D, so that the bridge will read proportionally from M to K, and will read in ohms, or tenths, or hundredths." The mode of calibration is discussed at some length.

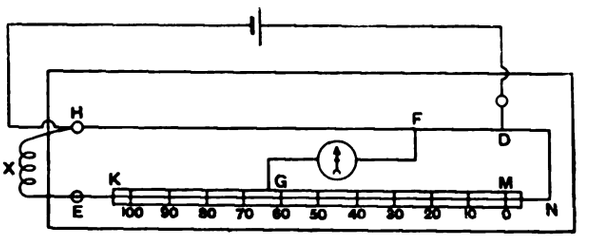


FIG. 1 (Fig. 10 reproduced from "Practical Electrical Measurements").

It is to be observed that, unlike the ordinary Kirchoff bridge, the ratio arms are H D and F D, not H F and F D. Part of the slide wire G M is proportional to the unknown resistance + the remainder of the slide wire. In no books to which I have access can I discover the inventor of this mode of using a Kirchoff bridge. In the old mode two readings were taken, one from each end of the scale, and a ratio was obtained from which the unknown resistance could be calculated. This is far too cumbersome for practical use. I assume that this very valuable mode is due to Major Cardew. Mr. Swinburne suggests that more than one pair of points, F and D, may be found for more than one ratio. The form of bridge which is the subject of the present Paper is derived from this suggestion.

The first modification is that the wire is not in one continuous length, but is arranged as in Prof. Cary Foster's mode of comparing two slide wires, and consists of two wires connected together at one end by a bar of negligible resistance. One of these wires constitutes the ratio arms, and the other is the slide wire. The former is concealed in the instrument. Ratio points are carefully found once for all, and branch wires are soldered at these points. Among other reasons for which the manufacture of this bridge has been placed in the hands of Messrs. Crompton and Co. is the value of the experience which that firm has acquired in accurate adjustments of this kind in the manufacture of potentiometers.

It does not appear, in Mr. Swinburne's book, that he recognised that if two separate wires and a low-resistance connecting piece be used, the zero of the scale of resistances on the slide wire is always to be found opposite the ratio point on the ratio wire. To take advantage of this disposition, the scale of the

* Paper read before the British Association at Liverpool, Section A.

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present bridge is made to slide. This is the second modification.

Ratio points 1:1, 1:5, 1:10, 1:20, and 1:100 are determined, and the necessary branch wires are attached. The scale sliding in a groove is provided with a spring catch which holds it accurately in place, with the zero opposite to any desired ratio point. In order to avoid the idea of applying a ratio, the ratio points are described as 2, 10, 20, 40, or 200 "ohms maximum reading," the scale being divided from 0 to 20. This constitutes the third modification. The fourth modification, arising immediately from the last, is the utilisation of the

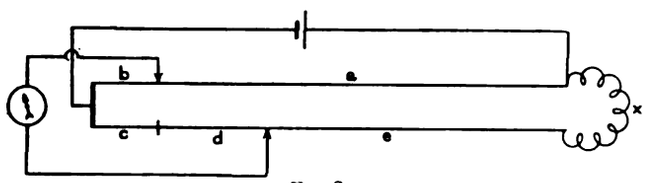


FIG. 2.

spring catch for making contact between the ratio branch wire and the galvanometer. A galvanometer wire runs by the side of the slide wire, as in the Crompton potentiometer, and contact is made by the spring catch between this wire and the ratio branch wire.

The above diagram, Fig. 2, shows the connections. The whole arrangement has been reversed, in order that the scale may read from left to right.

The ratio wire is divided into two parts, $a$ and $b$. The ratio is not $a/b$, but $(a+b)/b$. The slide wire is divided by the sliding contact into two parts, $e$ and $c+d$. The portion $d$ is a measure of the unknown resistance $x$. The portion $c$ is beyond (to the left of) the zero of the scale, and is equal to $b$. Then

$$\frac{a+b}{b}=\frac{x+e+d+c}{c+d}.$$

Let the line $b\,a$ be divided into any two parts $b$ and $a$. Draw the line $c\,d\,e\,x$ parallel to $b\,a$. Complete the right-angled triangles, as shown in Fig. 3. Then $\frac{a+b}{b}=\frac{x+e+d+c}{d+c}$, and since $b=c$ and the triangles are similar, $\frac{a+b}{b}=\frac{x}{d}$. For a $\frac{1}{10}$ ratio, $b$ is $\frac{1}{10}$ of the whole wire $a+b$, and $a$ is $\frac{9}{10}$.

Nickel steel wire is used. The strength, hardness, freedom from corrosion, high resistance and moderate temperature coefficient of this material, make it peculiarly applicable for this purpose. It has been well tested, and has been found very suitable for potentiometers. The arrangement of the bridge as described allows the terminals to be very conveniently arranged.

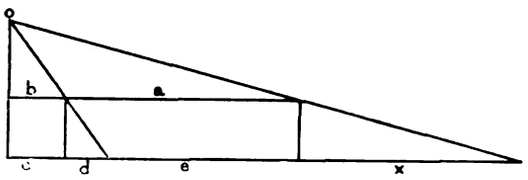


FIG. 3.

The details of the instrument have been worked out by Mr. W. C. Fisher, of Messrs. Crompton and Co. The wires are 15in. long, and have a resistance of 2 ohms each. The whole instrument is 1ft. 5in. long, $2\frac{1}{2}$in. wide and $1\frac{1}{4}$in. thick, including terminals. For low resistances the scale is pulled half way out, the maximum reading would be 2, but the two projects beyond the limits of the slider, and the highest reading is 1 ohm. One division of the scale is equal to $\frac{1}{100}$, and this

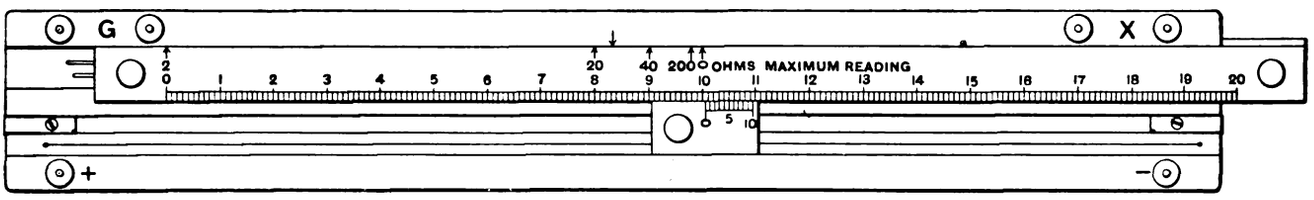


FIG. 4.

may be divided by the vernier. For high resistances the scale is pulled out 0·15in., and the highest reading would be 200 ohms. This, however, projects beyond the limits, and 198·5 ohms is the highest reading. One division of the scale is equal to 1 ohm, and may be divided by the vernier. It is hardly necessary to claim high accuracy for this instrument which is intended for general use and for measurements of the same character as those of current and pressure for which ordinary ammeters and voltmeters are used, to claim that it is at least more accurate than such instruments is perhaps not presumptuous.

## NOTES ON THE NIAGARA POWER-HOUSE EXTENSION WORKS AND THE BUFFALO POLE-LINE.

BY ORRIN E. DUNLAP.

The work of extending the great wheel-pit of the Niagara Falls Power Company at Niagara Falls is now well under way, the contract for this work being in the hands of E. D. Smith and Co., of Philadelphia. It is quite certain that more than one branch of the engineering science will find considerable gratification in the progress that this work denotes, while also feeling pride in the success of the original power installation; for it will be recalled that in no other country is power developed in such big units as in this plant at Niagara Falls, which over one year of constant service has demonstrated to be perfect of its kind. It has come to be an almost daily occurrence at Niagara to have notable engineers from foreign countries visit this plant to see what is being done and has been accomplished there.

The present work on the wheel-pit will provide accommodations for double the number of turbines and generators now in use, the plan being to instal seven more water wheels and the same number of dynamos, making a total of ten of each, or a total capacity in this section of the power-house of 50,000 H.P. Mr. William A. Brackenridge, chief engineer of the Cataract Construction Company, is in charge of the work; and under his immediate supervision the wheel-pit will be extended a distance of 294ft., making the total length of the pit 434ft., with a depth of 179ft. The average width of the wheel-pit will be 20ft., to be increased at the top to make room for masonry walls 6ft. wide.

The experience gained in the original installation has led to a decision to make some changes in the new portion of the plant, and these are worthy of mention. One change will be that all the mouthpieces of the new penstocks, seven in number, will be built in the wall. This is so that when generators Nos. 7-10 inclusive are installed, no masonry will have to be done, it all having been finished. Then it has been found advisable to increase the openings directly under the generators, and this will be done in the new work. In that portion of the wheel-pit now in use the girders have their ends built right into the walls; but in the pit now in course of construction the ends of the girders will be supported on castings, which will be placed in the walls. Still another important change is to be made in the method of supporting the wheel case and lower penstock elbow. At present they are supported on

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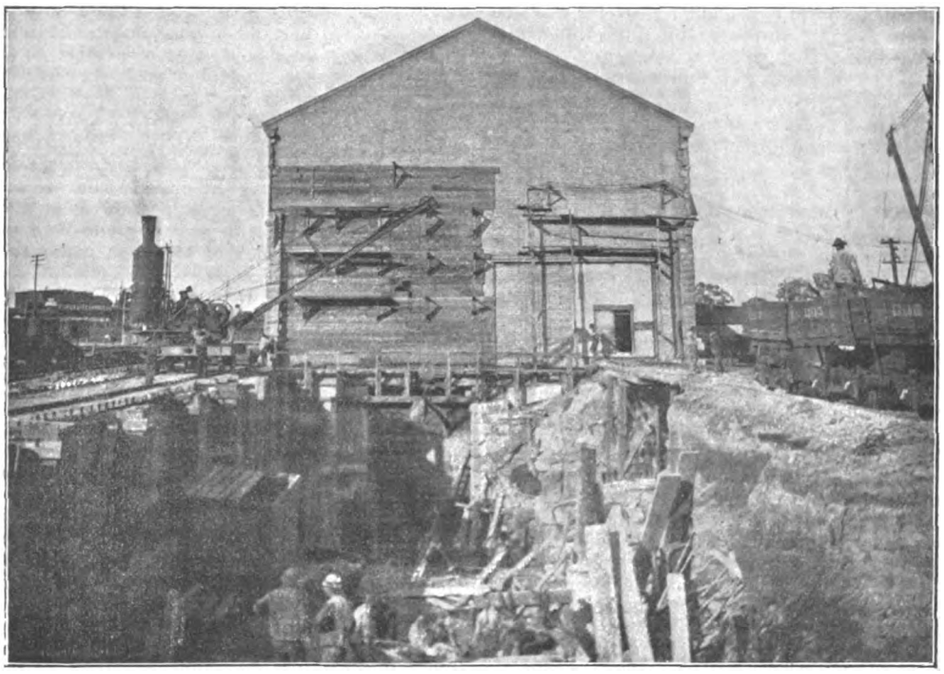
girders, but those to be installed in the future will have projecting ribs supporting them on castings, thus dispensing with the girder supports. These supports will be bricked into the walls. These changes are brought about by the belief that should a girder become damaged from rust or other cause it will be much easier to replace it if it rests on a casting than it would be if built right into the wall.

The fields of the generators now in service are excited by current obtained from 200 kilowatt transformers located at one end of the switchboard structure; but with the completion of the extension works it is proposed to do away with these exciters, and four small turbines will be placed in the wheel-pit to operate four exciters located on the power-house floor. While the present method is in every way efficient, it is felt that the new plan described will be in the line of an improvement, while it will also afford an absolutely independent source of supply for the exciters.

While the main subway is to be extended, a new conduit is provided for on the west side of the building. This will be 7ft. 6in. by 4ft. 4in., and is designed to carry light and power cables. It is worthy of mention that the changes in the arrangement of the turbines were suggested by Dr. Coleman Sellers, who is the chief engineer of the Niagara Falls Power Company. The cost of the wheel pit extension will be fully $300,000, and the work is to be done by May 1, 1897.



Scene of the Wheel-Pit Extension: Niagara Falls Power House.

In order that the turbines and generators now in use may not be disturbed, the manner of excavating is somewhat different from what it was in the original section of the pit. The blasts are not so heavy. Channelling machines cut the rock, and then it is blown loose in benches. Big steel derricks, operated by steam, raise the dumps to the cars into which the muck is dumped, and are then drawn over the tracks of the Niagara Junction Railway to the trestle of that road, on the lands of the Niagara Falls Power Company, where it is used for filling to make a solid road bed. The muck of the original excavation was used for filling in lands under water, and thus many acres were reclaimed, on some of which fine factories to-day stand. This filling in beneath the trestle of the Niagara Junction Railway will of itself be a notable improvement in connection with the Niagara project, the road affording terminal facilities of the Power Company's lands.

The letting of this contract defines in a very clear manner the success which the power development of the Niagara river has met with. The first sod in the construction of the tunnel was turned by Capt. C. B. Gaskill on October 4, 1890; and on the morning of April 4, 1895, Mr. Rudolphe Baumann, a Swiss engineer, representing the makers of the turbines, moved the small wheel controlling the initial turbine. The service the turbines and generators have seen since then has fully and successfully demonstrated the success of the plant, and now this extension is further evidence of the faith of the capitalists at the back of this great development. Not content with selling power for home consumption, they have contracted to deliver it in Buffalo, 22 miles away. Already the transmission line is in course of construction. The contract for this line, as already stated in a previous issue, has been let to the White-Crosby Company, of Philadelphia. The poles are to be of round cedar, shaved and painted, with tops 9in. and 10in. They will vary in length from 35ft. to 50ft., according to the soil in which they are erected. All cross-arms will be 12ft. long, 4in. by 6in. thick, dressed and painted. They are to be made of ¼in. by 2½in. angle iron formed hot and bored for angle screws. Each brace will weigh about 20lb. On each pole there will be two cross-arms, and on the ends of each arm iron pins will be set to prevent the conductor falling to the ground in case the tie-wire loosens or the insulator breaks. Barbed fence wire of galvanised iron will be carried on the pins of the upper arms for lightning protectors, while another fence wire will follow the tops of the poles for the same purpose. These wires will be grounded at the foot of every fifth pole. From the fact that provision is made for 12 copper conductors of stranded bare wire, each of 350,000 circular mills, every pole will have to support about 1,200lb. of copper, and thus it will be seen that the strain on the pole-line will be somewhat heavy. The poles will all be set in concrete or rock, and the line will be fenced and probably guarded by a patrol. There will be a transposition of conductors from pole to pole, in order to overcome the effects of induction, and complete transposition will be made every five poles. One of the interesting and novel features of this transmission line will be the insulator used. It is to be made of porcelain, and will be of special design. This insulator is known as the double petticoated insulator, and on the outside petticoat there is a gutter, so that the water will be drained clear of the crossarm. This is expected to prevent the formation of icicles on the insulator at any place where they would touch the crossarm. Another important feature will be that none of the weight of the conductors will rest on the die wires, as is generally the case. The transmission will be by three wires, and power is expected to be delivered in Buffalo some time this autumn.

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## APPLIED ELECTRO-CHEMISTRY.*

BY JAMES SWINBURNE.

The pressure needed to cause a given decomposition is frequently calculated from the thermo-chemical data given in pocket-books. As a coulomb decomposes a given weight of, say salt, and as the combination of the sodium and chlorine which produce that amount of salt give out a definite quantity of energy as heat of combination when they form salt, it seems at first sight that by dividing the quantity of energy by the quantity of electricity we should get the pressure corresponding to the reaction. Broadly speaking the pressure needed to electrolyse follows the heat of combination, but care must be taken not to take wrong data. The thermo-chemical data quoted in books on general chemistry are mostly taken from a four-volume book of researches by Thomsen, and are not always quoted intelligently. It is generally necessary to look up the context to see exactly what the author means. The heat of combination of, say, zinc and oxygen may be found on examination to be the heat of metallic zinc burning in gaseous oxygen. Allowance must in many calculations be made for the elements in compounds changing their physical state. Other reactions have taken place in a solution, a precipitate being formed, in which case heats of solution are involved. In working with data from Berthelot's book allowance must be made for the old notation. In many cases people totally misapply these data. For instance, in calculating the electromotive force of a Daniell cell, we are not really concerned with the heat of combustion of metallic zinc in gaseous oxygen, though it frequently figures in such calculations in spite of the fact that oxide of zinc is not formed. These thermo-chemical data should, therefore, not be used blindly; and should only be employed by those who really understand what they are doing. Chemical reactions do not necessarily take place so as to give out the maximum energy, however, so these thermo-chemical data cannot fit.

Suppose we have two primary cells; suppose at the temperature of the air they give one volt; imagine them coupled together, back to back, so that there is no current; suppose those cells, like most primary cells, have a temperature coefficient, so that the electrical pressure given depends on the temperature; suppose that at a certain higher temperature the cells give 1·1 volt; let one be kept at this temperature, and the other at the temperature of the air; we then have 0·1 volt available, and there will be a current backwards through the cold cell. The chemical work is just the same in the cells, except that all that is done in one cell is undone in the other. The capacity for heat of the whole cell is not altered by any changes in the compounds contained in it, as the specific heat of a compound depends only on the elements that compose it. We thus have a simple example of the pressure not being in accordance with the heats of combination, as the heats of combination would give the same pressure for the two cells. We can put a small motor in the circuit of the two cells, and get work done without any chemical energy being used up, as the chemical action is the same in the two cells. As this would otherwise mean perpetual motion, it is clear that the work done by the motor must be accounted for by heat disappearing somewhere in the circuit. The only place this can happen is in the cells. One or both of the cells must therefore be taking a continuous supply of heat from its surroundings and giving it out as electrical power. The cold cell cannot be taking heat from its surroundings, for if it were, and if the heat were converted into power, we need only wrap the hot cell in a non-conducting jacket, and the system would give perpetual motion. The hot cell must therefore be abstracting heat from its surroundings, and giving more pressure than its chemical reactions account for. Let us therefore divide its pressure in two parts, the chemical electromotive force $E_c$, and the heat electromotive force $E_h$. We can call the chemical and heat electromotive force of the cold cell $E'_c$ and $E'_h$, and the temperatures of the cells T and T', T being the higher temperature. Now the pressure of the hot cell is $E_c + E_h$, and that of the cold cell $E'_c + E'_h$, of which $E'_c$ and $E_c$ are equal. So the difference of pressure is due to the difference of $E_h$ and $E'_h$. The difference in this case is taken as 0·1 volt, but that is merely an example. This difference, $E_h - E'_h$, is the available part of the pressure for motor or other purposes, and it is due to heat taken in at the temperature T. As in such cases only a portion of the heat is converted into work, namely, $T - T'/T$, the available pressure, which is entirely due to the difference in heat electromotive force, as the chemical electromotive forces cancel out, can be given thus—

$$E_h - E'_h = \frac{T - T'}{T} E_h.$$

Transposing, we get—

$$E_h = T \frac{E_h - E'_h}{T - T'}.$$

If we imagine T to be infinitesimally above T', $T - T'$ is $dT$ and $E_h - E'_h$ is $dE_h$, as the increase is the same for the whole pressure of the cell. We thus find that—

$$E_c + E_h = E = E_c + T \frac{dE}{dT}.$$

This is Helmholtz's equation, put in a way that may be easy to follow. It shows that where a cell or a vat has a temperature co-efficient, the pressure does not follow the heats of combination, but depends on the temperature co-efficient in a definite way.

If the hot cell had given less pressure than the cold one, the current would have been in the other direction; but heat must still be taken in at the hot cell, and a portion of it given out at the cold one. If a cell has its pressure higher than the chemical actions account for, it must absorb heat on discharging, and give it out on being run backwards, and *vice versâ*. If a cell has a negative co-efficient, its pressure must be lower than the chemical action accounts for; so, if the hot cell has the low pressure, it will be run backwards; but the work done by the current against the back pressure is too small to perform the chemical work, and the extra heat has to be taken from the surrounding matter. It may be asked, where the heat is taken up, whether at the anode or the cathode? Though the locus of the disappearance of heat is not necessarily the seat of the electromotive force of a cell, this brings us to another question, which, though of purely theoretical interest, as far as applied electro-chemistry goes, may be discussed, the novelty of the view taken being my justification.

*Seat of the Electromotive Force in a Cell.*

There is not any. After so many able chemists and physicists have been discussing this question for so long, it may seem rather bold to make such a statement as this: but to a great extent the question is rather one of definition. It is commonly taken for granted that, say, a point on a wire must be at the same potential as itself; but this is not necessarily so. Instead of thinking of an electric circuit, with which we are a little too familiar, to be able to see clearly what I mean, let us take a magnetic circuit, that of the magnets of a dynamo for example. Imagine a "unit pole" at one pole piece. Let it move over to the other, the work it does will be the measure of the difference of the magnetic potential of the pole pieces. If the pole is still allowed to move, say along a small hole in the iron, it will go round the field magnets to the point from which it started, and will then make another tour round the magnetic circuit, and so on. Each time its path is a complete circuit which is interlinked with the electric circuit, that is to say, with the field-magnet windings. The work done on the pole in each cycle is $4\pi$ times the current turns in electromagnetic C.G.S. measure, or $0{\cdot}4\pi$ times the ampere turns in the practical system. Imagine that the iron is perfectly permeable; then all the work will be done on the unit pole in crossing the air gaps; and the fall of the potential across them will be $0{\cdot}4\pi$ times the ampere turns. There will be no force acting on the unit pole on its way through the small hole round the iron of the field magnet circuit. It will be seen that every time the unit pole goes round it falls $0{\cdot}4\pi nc$ units of potential, so that every time it passes a given place it has fallen that amount. In other words any part of the magnetic circuit differs from itself in magnetic potential by $0{\cdot}4\pi nc$. At any point the magnetic potential has an infinite number of values, differing by $0{\cdot}4\pi nc$. If we consider that the unit pole falls a height of $0{\cdot}4\pi nc$ in going across the air-gaps, in order to make up for this fall, it would have to be raised the same amount on its way through the iron; but we have specially assumed the iron to be perfectly permeable, and there is no force at all on the way through the magnets. The force there really is, due to the iron not being perfectly permeable, in the same direction as that in the air-gap. A unit pole describing a circuit interlinked with an electric circuit thus falls in potential. Its potential is not raised the same amount at some part of the circuit. If it were there would be no difference of potential between the poles. There is thus no seat of the "magnetomotive force," to use a loose term that is fashionable; in other words, there is no sudden rise of magnetic potential in the magnetic circuit.

Now take an electrical conductor, say in the form of an incomplete ring, and imagine the end of a magnet to be moving slowly through the ring, so as to generate electromotive force. Suppose the wire has no resistance, merely for the sake of simplicity, and suppose the magnet pole is large enough to produce a volt at the rate it is going. If a coulomb is allowed to go from one side of the air gap in the copper circuit to the other, it will fall one volt in potential, the fall of potential being measured by the work done, namely, one joule. Ear mark the coulomb, and let it go round the copper to the place from which it started. As we have assumed the copper to have no resistance, no work is done in this part of the circuit, and if there were any work owing to the resistance of the copper, it would be in the same direction as when the coulomb crossed the air-gap. If allowed to go in the direction of the electromotive force, the coulomb is always falling in potential. Every time that the coulomb passes a certain point in the circuit it falls one volt. Each point of the electric circuit has, therefore, an infinite

* Cantor Lecture.—II.

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series of potentials differing by one volt. It might be said that this cannot be the case, because the potential of a point on the conductor is defined as proportional to the work done by a unit quantity of electricity moving from there to the earth, or to an infinite distance. But it can choose various paths, and if it goes round the magnet pole several times, it will add or subtract a volt for each time it goes round. At first sight the analogy between the electric and magnetic circuits does not seem very clear. The moving magnetic pole, however, corresponds with a magnetic current. A magnetic conductor is unknown ; but just as there can be a displacement current of short duration, or a convection current in an electric circuit, so there can be a displacement or convection magnetic current. The moving magnetic pole in this case corresponds to a convection current ; if it had been stationary, but had been an electromagnet with increasing excitation, we would have had a magnetic displacement current. If a magnetic circuit with a magnetic current is interlinked with an electric circuit, there is cyclic difference of electric potential round the electric circuit. If an electric circuit with an electric current is interlinked with a magnetic circuit, there is cyclic difference of magnetic potential round the magnetic circuit.

The analogy between the electric and magnetic circuits is not popularly understood as well as it ought to be, and its clearness has been very much obscured by the unfortunate use of the term "electromotive force," for difference of potential or potential, instead of for the rate of decrease of potential. We have thus "electromotive force" as the line integral of "electric force"—a term not much used—and magnetic force remains as the rate of decrease of magnetic potential. Still further confusion has been produced by treating permanent magnetic displacement as analogous to an electric current, and permeability, which is really the analogue of specific inductive capacity, as magnetic conductivity. To make matters still worse, the term magnetomotive force has come in to denote magnetic potential, while magnetic force remains in the legitimate sense of rate of fall of magnetic potential. These absurdities have been approved by international and other congresses and committees, but the so-called work of holiday meetings of people with idle summers should not be taken too seriously. The idea of the interlinked electric and magnetic circuits and their analogy, and of cyclic potential, is fully worked out by Maxwell. Heaviside, however, has developed the subject very fully, making it the basis of his treatment of electromagnetic theory. I do not know if there are any Germans who do not read English as well as an Englishman reads German badly ; but if so they will, if I remember right, find the ideas of Maxwell and Heaviside developed by Föppl, without Heaviside's special kind of algebra. The idea of a magnetic current is, I think, due to Heaviside.

To sum up, in the electric and magnetic circuits the potential is cyclic. A unit charge or pole allowed to move in obedience to the force acting on it falls in potential continuously, and is not raised in potential at any point. The difference of potential is localised by the properties of the electric circuit itself, such as the resistance and the properties of the dielectric, leaving convection currents out of the question for the moment ; and as there is no such thing as magnetic conductivity, the difference of magnetic potential is localised by the permeability and arrangement of the different parts of the magnetic circuit, and not directly by the position of the excitation. The engineer will say, "The lines of induction cut the wire of the electric circuit at certain places, and must generate the electromotive force at those places, just as in a dynamo the electromotive force is generated in the wires cutting the strong field. This is shown by the force on the wires there." The answer to this is that lines of induction are a mere conventional idea. Even following the idea up it will be found to be impossible to localise the cutting of the conductors by the lines. We can find two successive distributions, and we may assume that lines move, or that a conductor moves past them and has a pressure induced in it. This is mere assumption though. All we can really deal with is the variation of the total induction interlinked with the electric circuit. No conceivable instrument will show where the lines cut the conductor. A voltmeter may be connected in shunt to a part of the conductor and give a reading. That voltmeter has leads to it, and the voltmeter and the leads form a local circuit, and any variation of the total induction through the local circuit gives a voltmeter reading. Carrying a charge on a proof plane and measuring the work done is the same thing. As to the force on the conductors of a dynamo, that depends only on the current. The force even then acts on the conductor carrying the current, not on the current. Similarly, in a magnetic circuit, you cannot find any effect due to the location of the excitation.

This may at first seem a long digression from the question of the seat of the electromotive force in a cell. But let us carry the idea of a cyclic potential to a cell with two terminals connected by two pieces of wire to, say, a resistance which, in comparison with that of the rest of the circuit, we can consider infinite. Consider a unit quantity of electricity at the positive terminal of the cell. Suppose the cell gives one volt. Call the potential at the positive terminal anything, say 100. Follow the charge along the resistant part of the circuit. It does work and falls one volt, and gets to the negative terminal. The negative is, therefore, at 99 volts. Seekers after the seat of the electromotive force seem to assume that if the charge goes on through the cell to the positive terminal, the potential there will be 100 again ; but it will only be 99. The potential of the terminals differs by a volt if considered as connected by the resistance ; but they are at the same potential considered as connected through the cell. If the charge were raised one volt on its way through the cell, the line integral of the electric force round the circuit would be zero, and the cell could do no external work.

A great deal of work has been done on contact differences of potential and allied subjects, but there is room for a fallacy. The difference of potential between A and B is defined as proportional to the work done by a unit charge of electricity going from A to B; but one cannot work with charges of electricity without something to carry them ; and if A and B are conductors which may act chemically on the carrier, or on films of moisture, or gases surrounding it, we are not really simply finding the difference of potential of A and B.

If the chemical pressure of the cell is higher or lower than the actual, so that the cell heats or cools on discharging, it might be said there must be something corresponding to glorified Peltier, Seebeck, or Thomson effects (it is difficult to remember which of these effects is which) between the metals and its electrolyte, and between the electrolytes, if there are two. But the algebraic sum of these differences taken through the cell must be zero ; so the generation of heat, or its disappearance as a whole, must be regarded as chemical, or in some other way. Some day the theory of ions may be worked out on circuital principles. In the meantime, I will go back to the usual way of discussing dissociation.

*Dissociation.*

Not so very long ago it was supposed that in aqueous solutions the water conducted the electricity, oxygen and hydrogen being given off in the nascent state. The nascent gases were then supposed to react on the substances in solution, oxidising and reducing them. Recently, however, as already mentioned, the theory of solutions and of electrolysis has made enormous strides, especially in Germany. The names of Hittorf, Ostwald, Arrhenius, Van t'Hoff, and especially of Nernst, are more particularly identified with this development.

Too much space has been already given to the theory, or, rather, to one or two details of theory, to leave room for a long account of recent ideas of electrolytic dissociation. The theory is that, when a body is dissolved in a solvent, its molecules are moving as they would be in a gas. The mean free path of the molecules must, of course, be enormously smaller in a solution ; and, I believe, that has been put forward somewhere, as an objection to Van t'Hoff's theory. Under certain assumptions, however, the figures work out right. If a small quantity of sugar, say, is dissolved in water, and the solution is separated from pure water by a diaphragm, through which the sugar cannot be diffused, water will diffuse into the sugar side of the vessel. If it is closed, water will come in, until a certain pressure is produced. This is the osmotic pressure, and it is found to depend on the number of molecules of sugar per cubic centimetre of liquid. Solutions with the same number of gramme equivalents per litre of different non-electrolytes give the same osmotic pressure, and the pressure corresponds to the pressure they would give as gases occupying the volume of the whole solution. Solutions containing the same number of gramme equivalents per litre also give the same vapour tension, and the same freezing point. Electrolytes, however, have higher osmotic pressures than Avogadro's law applied to solutions would give. This is explained by the dissociation or ionisation of salts in solution. Dissociation is a rather unfortunate term, as it is used for such splitting up as that of ammonium chloride into ammonia and hydrochloric acid when heated, in which cases both the bodies found are ordinary substances. In electrolytic dissociation, for instance, salt splits into sodium and chlorine. The chlorine and sodium atoms are not as in free chlorine and metallic sodium, but are electrically charged, and give up their charges to the anode and cathode. Only part of the salt is dissociated, the proportion not dissociated or ionised depending on the strength of the solution. Thus in a very strong solution very little of the salt is ionised. The term "ionised" is, perhaps, preferable to dissociated, as it suggests electrolytic dissociation as opposed to ordinary dissociation where the compound is not split into electronegative and electropositive radicles. As the solution is more and more diluted, the salt becomes more and more ionised. The electrical conductivity is due to the possibility of convection currents of the ions. The salt that is not ionised does not conduct. The current in the liquid consists of charged ions moving in different directions under the electric force. As the ions come against the electrodes they give up their charges, and are deposited as metals or given off as gas, as the case may be. The conductivity of a solution depends only on the number of free ions per cubic centi-



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metre. A very strong solution has very few, so it conducts badly. As the solution is diluted the ionisation goes on more quickly than the dilution, so that though there is less of the elements of the compound in a cubic centimetre, the proportion ionised is so much greater that the total number of free ions per cubic centimetre is increased, and with it the conductivity. As dilution proceeds the ionisation no longer compensates for its effect, and we finally have a very dilute solution in which, though the ionisation is nearly complete, there are so few ions in a given volume that the liquid hardly conducts. Suppose, however, that we take a given quantity of the salt and dissolve it in a right prism of water of a given length with electrodes at the ends, and measure, not the conductivity, but the conductance from plate to plate; as the liquid is diluted, the increase of cross sectional area of the prism exactly counteracts the decrease of conductivity due to there being less of the elements per cubic centimetre, so that the increased ionisation tells independently. By this method in fact the combined charge carrying capacity of all the free ions in a given quantity of salt is measured, and it increases with dilution as the ionisation goes on, and tends towards a maximum at the point of complete ionisation, which exists at infinite dilution. By making a series of observations the molecular conductivity at infinite dilution, that is under the condition of complete ionisation, is found, and the ionisation, or the proportion of the ionised part to the whole of the salt at any dilution can be found from the conductivity. The results so obtained account perfectly for the osmotic pressure of an electrolyte being greater than that of a colloid or non-electrolyte. After ionisation the separate ions act as molecules, so that a dissolved electrolyte behaves as if there were an extra number of molecules added, corresponding to the ionisation. Electrolytes also lower the freezing points of solutions, and raise their boiling points more than corresponding gramme equivalents of non-electrolytes; but the results are quantitatively right when ionisation is taken into account.

The current in an electrolyte consists of a convection transfer of charges due to the ions moving in different directions under the electric force. They move at different rates under a given electric force. This is a point of some importance in practical work, as it controls the concentration of the solution in the immediate neighbourhood of the cathode and anode. The movement or migration of the ions must not be confounded with electric osmosis, which is a different phenomenon. Suppose we electrolise a solution of hydrochloric acid. This consists of water, which is very slightly dissociated, and may therefore be regarded as not conducting at all; molecules of hydrochloric acid which also do not conduct, for the hydrogen and chlorine have equal but opposite charges, and as they move together they cannot assist a convection current; and finally, the solution consists of loose charged atoms of hydrogen and chlorine. They cannot be separated by diffusion as in ordinary cases of dissociation, for as soon as the faster moving ions begin to diffuse into a new liquid their charges alter the potential of the liquids, and thus the electric force comes into play, keeping back the fast and helping the slow and oppositely charged ions. For every atomic equivalent of electricity that passes through the cell of dilute acid an atom of chlorine comes off at the anode and of hydrogen at the cathode. There are thus two atoms removed from the electrolyte by the passage of the electric charge of a single atom through the cell. If there were no movement of the ions there would then be a hydrogen atom close to the anode and one of chlorine at the cathode. As soon as there is an excess of atoms of this sort there is a difference of potential between the sides of the electrolyte, and this causes the ions to move across. If they moved equally, for every two atoms of chlorine and two of hydrogen, deposited on the electrodes there would be a movement of one atom of chlorine and one of hydrogen in opposite directions across any surface separating the electrodes, and the liquid in the neighbourhood of the electrodes would be equally impoverished as to hydrochloric acid. But suppose the hydrogen atoms move five times as fast as the chlorine, for every six atoms of chlorine and six of hydrogen given off at the electrodes, five atoms of hydrogen and one atom of chlorine will pass an imaginary partition in opposite directions. The anode liquid will thus be impoverished by five molecules of hydrochloric acid, but the cathode solution will only lose one.

Space will not permit of a fuller account of electrolytic theory, and I must pass on to practical work, mentioning only a few processes.

*The Ashcroft Process.*

One of the most interesting of the more recent electrolytic processes is the Ashcroft method of treating the Broken Hill ores. As far as I know this process has never been fully described in print; in fact, I do not know that it has been described at all. The Directors have very kindly given me permission to explain it as fully as I can, so I take the opportunity of doing so.

As is generally known, the Broken Hill mines contain enormous quantities; in fact, millions of tons of argentiferous sulphide of lead and zinc. Where this has been exposed to the weather for many thousands of years, the zinc and lead sulphides have been oxidised, and the zinc salts have been washed away. The lead and silver are then very easily dealt with metallurgically. The exposed and oxidised ore is nearly done now. Although enormous quantities of lead and silver have been taken from the Broken Hill mines, all that has been done, so far, is but a mere scratching of the surface compared with what there is still to do. The sulphide of lead and zinc is, however, a very troublesome ore to deal with. The zinc prevents it being treated as a lead ore, and the enormous mass has been regarded as valueless until some process for treating could be discovered. The lead and zinc sulphides are very intimately mixed, so that concentration is exceedingly difficult. Of course, there have been endless schemes for the treatment of this ore, and probably every inventor in Australia has devoted some attention to the matter; but until the Ashcroft process was invented nothing very promising has been brought forward.

The Broken Hill ore may be taken to consist, roughly, of 30 per cent. of lead as sulphide, 30 per cent. of zinc as sulphide, and 25oz. to 30oz. of silver to the ton. There is not much gangue.

In the Ashcroft process the ore is first ground—not too fine—and then roasted. This converts the zinc sulphide mainly into oxide. Of course the sulphide can be roasted till practically all the zinc is in the form of oxide; but it is most economical in this case not to roast so far. It will be said that this involves waste of zinc in the form of solution of sulphate, but the zinc at this stage is practically of no value. It pays better to allow a certain amount of zinc to be wasted, rather than to go to the expense of roasting into oxide.

The roasted ore is then leached with a solution containing persalts of iron, and salts of zinc, sulphates, and chlorides. The oxide of zinc is the roasted ore dissolved as sulphate or chloride, while the iron is precipitated as ferric hydrate. The ferric hydrate is apt to remain in its colloidal form, but the solution is heated and the iron thrown down. The solid matter is allowed to settle, and the solution is run off. The solid matter contains all the lead, and some of the silver, and some zinc. There is so little zinc, however, that it gives no trouble in smelting. The iron oxide is also required for smelting, and would have to have been added in any case.

The solution is led through tanks containing zinc plates or shavings to catch any silver. It then goes to electrolytic vats, and some of the zinc is taken out. The anodes in these vats are iron, so that iron goes into solution as ferrous chloride or sulphate. A diaphragm is used, to prevent the solution mixing. The mixing of the solutions would be fatal to the process, because iron would be deposited on the zinc. This would not only give zinc containing iron, but it would prevent the zinc coming down properly. It is by no means easy to produce a smooth, even deposit of zinc of any thickness; and as soon as a deposit begins to come down badly, it is very troublesome to get it right again. In order to prevent any chance of iron getting into the cathode chamber the liquid on this side is kept at a slightly higher level, so that there is always a current through the diaphragm which prevents any trace of iron getting in. The liquid from the cathode chamber, which has been deprived of some of its zinc, is led to a second set of vats, in which more of the zinc is taken out. The solution is then led to the anode chamber first described, so as to take up iron in the ferrous state. The ferrous solution is then led to the last vat, which has carbon anodes instead of iron. This converts the iron into ferric salts, and this solution, which contains ferric and zinc salts, is used for leaching the roasted ore. The process is thus cyclic.

Most people who have had experiences of leaching processes may be inclined to think that there must be difficulty in getting the iron completely thrown down by the roasted ore. The leaching, however, goes beautifully at once, and, after heating to deposit ferric oxide, there is no trace of iron to be found in the solution. It is necessary, of course, to have excess of zinc oxide, to make sure that all the iron is thrown down. Traces of aluminium and manganese salts may find their way into the solution; but that does not matter, as they cannot accumulate beyond a certain amount, as will be explained immediately.

The leached ore and oxide of iron contains a good deal of solution, so that a certain amount of zinc salts is taken with it. As the clear solution is separated from the sludge by decantation, and the sludge is still liquid enough to be run off into settling tanks, it might be that it would pay to save the solution of zinc; but this is not the case. If the solution could be perfectly separated so that none was thrown away, and no new solution was added, the impurities would accumulate until they gave trouble in the depositing vats. A certain proportion of the solution is therefore allowed to go off with the slimes, and the solution is made up with sea water.

As explained already, the roasted ore contains zinc in the form of sulphates, and of oxide. A basic sulphate may for the moment be regarded as a mixture of oxide and sulphate. The circulating system thus consists of a stream of solution, which, after leaving the leaching vats, has its silver removed, and then goes through cathode chambers, were about one-third of its zinc is taken. It

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then goes through anode chambers while it takes up the iron, which in the second set of anode chambers is converted into the ferric state, and the ferric salt is changed for zinc salt in the leaching.

It is only zinc in the form of oxide that is taken up in the ferric solution ; that in the form of sulphate goes into the solution without any corresponding precipitation of iron. This zinc is useless, as it cannot be deposited in the tanks. All the zinc taken up as sulphate by simple solution is thus wasted. This is a very curious result, but a little consideration will show that it must be so. The zinc deposited in the vats is, of course, accurately in proportion to the iron dissolved. The vats must be arranged so that the iron anodes have twice the current of the carbon vats, otherwise there would be chlorine liberated, or ferrous salts in the leaching solution, as the case might be. This result is easily secured by having two iron vats in series with one carbon cell. Suppose two gramme equivalents of zinc—that is to say, 130 grammes of zinc—are deposited in the cells with iron anodes, two gramme equivalents of iron—that is to say, 112 grammes—are dissolved as ferrous salt ; in the next cell, with carbon anodes, the ferrous salt is raised to the ferric state, and another gramme equivalent of zinc is thrown down. For every three gramme equivalents of zinc we thus have two gramme equivalents of iron, and two gramme equivalents of ferric salt act on three gramme equivalents of zinc oxide in the leaching vats The zinc deposited is, therefore, equivalent to the iron, and is thus the zinc that is taken up by action of the ferric salt on the oxide. If the same liquid always circulated without any being drawn off, the zinc would increase till the solution was saturated as regards zinc sulphate. The zinc sulphate is therefore drawn off, to some extent, with the slime after leaching. It may be utilised by other processes, but as far as this process goes it is a waste product. It still pays, however, not to trouble to roast the zinc sulphide completely into oxide.

Only about a third of the zinc is removed from the solution during one tour through the electrolysis house. There has always been some difficulty in getting a good, smooth, dense deposit of zinc. It is very apt to come down in a spongy form, and in this case it is practically impossible to deposit it commercially. For that reason many people have advocated the use of alkaline solutions of zincates, such as the solution of zinc oxide in caustic soda. On the other hand, zinc sulphate will sometimes give very very perfect deposits ; and zinc sulphate was the electrolyte employed in the Edison electrolytic meter, where it seemed to work with almost perfect success. The deposition of zinc on a large scale from the sulphate has, however, generally given great trouble. In the Ashcroft process this trouble is overcome by the use of a solution containing basic sulphate and chloride of zinc. There is always excess of zinc oxide in the ore, that is to say in leaching, the roasted ore and iron solution are so proportioned that there is more oxide than the iron can deal with. Though the basic salts of zinc are insoluble in water they are fairly soluble in solutions of the corresponding neutral salts, so that the electrolyte really contains basic salts. This seems to make all the difference in the nature of the deposit. Even then the deposit is somewhat brittle. New wooden vats will sometimes add something to the solution which makes the deposit come down badly.

The vats are wooden tanks and the cathodes are sheets of zinc suspended in cells which are dropped into the larger cells. The diaphragms are made of close texture canvas. The anodes are crude wrought iron. It is probable that crude pig iron will do ; but cheap wrought iron is at present used. The circulation is arranged so that the current of liquid through the cathode chambers is quite distinct from the anode circulation ; the liquid in the cathode chambers being kept at a little higher level, as already explained, so as to make sure that no iron gets into the cathode cells. For the carbon electrodes either plates or rods of the same material as electric light carbons are used. This material is, of course, expensive, but it is not practicable to arrange for retort carbon, or any other cheap substitute, as, to get a reasonable output from a given area of a vat house, the vats have to be deep. The circulation systems make it difficult to have sets of shallow vats one above the other. The carbon is attacked, to some extent, but the corrosion is small, as there is plenty of chloride available. The oxidation has to be carried a trifle further than would suffice for the complete conversion of the ferrous into a ferric salt, so that a trace of chlorine or hypochlorite is formed. This oxidises any traces of ferrous salt that may not have come into contact with the anodes. It is most important to have no ferrous salt in the leaching vats, as they are not precipitated by zinc oxide, and would find their way into cathode vats, and spoil the deposit.

The process is the invention of Mr. Edgar A. Ashcroft, and is now owned by the Sulphide Corporation (Ashcroft's process) (Limited), who are commencing to work it in Australia. This Company also own a block of the Broken Hill mines, so that they have an almost unlimited supply of the raw material to work upon. The process has already been worked on a manufacturing scale, and works are now being started in Australia and the United States.

## TESTS OF A DE LAVAL STEAM TURBINE.

We have on previous occasions* published several tests of the De Laval steam turbine, and once made a comparison of the steam consumptions of De Laval and Parsons' turbines. Although these figures were low, they did not lead us to expect that this type of engine will entirely supplant fast-speed reciprocating engines in modern central-station practice. Some tests just made by the New York Edison Illuminating Company on a 300 H.P. steam turbine give a slightly lower steam consumption :—

The data in Table I. are the operating data of a six-hour test under conditions of full load, while Table II. is a *résumé* of some tests under partial load when operated with 2, 4, 6 and 7 steam jets, each test lasting one hour. The brake horse-power was obtained from the electrical horse-power by assuming that the commercial efficiency of the 100-kilowatt dynamos was 90 per cent. Table III. gives the temperature readings.

The 300 H.P. steam turbine on which these tests were made was built by the Maison Bréguet, of Paris, for the Société de Laval. It drives, by means of gearing, two 100-kilowatt Desroziers dynamos, one on each side of the turbine shaft. Operating with a steam pressure of 145lb. to the square inch and a vacuum of 26in., the steam consumption, operating condensing, was to be not over 18·7lb. per brake horse-power hour. The turbine disc has a diameter of about 2ft. 6in., and a thickness through the blades of about 10mm. (0·4in.). The turbine disc runs at a speed of about 9,000 revolutions per minute ; the dynamos at 750 revolutions per minute. The total equipment, comprising steam turbine, gearing and dynamos, occupies a space 13ft. 4in. long, 6ft. 6in. wide, and 4ft. 3in. high.

**Table I.**—*Full Load Test.*

Average of readings :

| + | + | − | − |
|---|---|---|---|
| 127·25 volts. | 692·48 amps. | 128·26 volts. | 709·18 amps. |

127·25 × 692·48 = 88,118·080 watts + side.
128 26 × 709·18 = 90,959·427 watts − side.

Avg. watts .....179,077·507 watts both sides.

179,077·507 is 90 per cent. of 198,975·01 watts = 266·72 H.P. × 6 = 1,600·32 H.P. hours.

Weight of water discharged from air pump .....6 hrs. = 27,763lb.
H.P. hours developed .....6 hrs. = 1,600·32
Lbs. of water per B.H.P. hour .....17·348lb.
Llbs. of water per E.H.P. hour .....19·275lb.

**Table II.**—*Test with Varying Load.*

| No. of jets used. | Average load. | | Average watts. | | Per cent. of full load. | Vacuum. | Lbs. of steam per E.H.P. |
|---|---|---|---|---|---|---|---|
| | + Amps. | − Amps. | + | − | | | |
| 2 | 153·78 | 147·15 | 18·707 | 18·283 | 18·50 | 27·00 | 27·35 |
| 4 | 433·60 | 455·80 | 54·156 | 57·886 | 56·02 | 26·43 | 20·22 |
| 6 | 700·85 | 718·65 | 87·746 | 91·268 | 89·51 | 26·07 | 19·75 |
| 7 | 771·94 | 787·33 | 97·418 | 100·856 | 99·14 | 25·79 | 19·95 |

**Table III.**—*Temperature Readings after Six Hours' Run with Load as Indicated.*

| | + Dynamo. | − Dynamo. |
|---|---|---|
| Armature | 120° F | 129 |
| Average of fields | 98° | 107° |
| Commutator | 144 | 132° |
| Temperature of room | 82° | |
| Temperature above room: armature | 38° | 47 |
| Temperature above room: fields | 16° | 25° |

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* *The Electrician*, December 27, 1895, and February 21, 1896.



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## A NATIONAL PHYSICAL LABORATORY.

In another column will be found the Report of an unusually representative and powerful Committee of the British Association appointed to consider the question of the establishment of "a National Physical Laboratory for the more accurate determination of physical constants and for other quantitative research." The tone, contents, and incubatory period of this Report is eminently characteristic of this country "When a satisfactory scheme has been elaborated," says the Report, "it will not be unreasonable to ask the Government to assist in providing the necessary buildings." The necessary buildings for what—War Office or Admiralty clerks?—no, nothing so important: merely the necessary buildings for an Institution which the Committee hold to be essential "if England is to keep pace with other countries in scientific progress." Then, again, no bold absolutely new departure is contemplated. The functions and buildings, the staff and superficial area of Kew Observatory are merely to be extended. And that not by any startling amount. Some £30,000 for buildings and equipment, and some £3,000 annually, will "do all that is essential to carry out the scheme in a wise and worthy manner." It was at Cardiff five years ago that Dr. OLIVER LODGE first found "a cathedral opportunity" of urging upon the British public the advisability of establishing a National Physical Laboratory; and this mild-mannered document is the net result up to date of that eloquent plea. We do not wish for one moment to question the policy of pitching proposals of this nature in a minor key, when the tune is by an English composer and intended for the delectation of an English audience. The curious and interesting point is the necessity under which our scientific leaders always rest of singing *sotto voce*.

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The cause of this phenomenon is not far to seek. There exists as yet in England no wide-spread enthusiasm for natural knowledge, no general clear perception of the intimate connection which exists to-day between scientific activity and national progress, moral, material and industrial. When, some ten years ago, the Navy fell below imperial requirements, the "alarmists" appealed to a public imbued with a great tradition and sufficiently educated in the matter at issue to appreciate its *pros* and *cons*. Hence we are to-day spending on the Navy just double what we were ten years ago, and money has only to be asked for to be granted. But not the most sanguine of *savants* expects to arouse public opinion over the high and dry question of establishing a National Physical Laboratory. And why? Because in the nature of things there can be no inspiring tradition to appeal to, and because not only the general public but their leaders, that is to say the politicians, Government officials, and men of wealth and leisure, have for the most part been brought up on a classical or theological pabulum, and take their science on trust. They give a languid and grudging assent to the irrefragable logic of the natural philosophers, and retain in their hearts their old convictions. The only enthusiasm really worth arousing, the only enthusiasm not likely to be misdirected and to do more harm than good, is an enthusiasm based upon actual personal knowledge. So far as science is concerned, that enthusiasm cannot be expected to-day from more than one per cent. of those who directly and powerfully influence public opinion. The more open-minded indeed admit the cogency of the reasons brought forward, and make praiseworthy efforts to learn their lesson, and to bring themselves into the proper frame of mind; but a second-hand propaganda of this kind, although better, much better, than nothing at all, is no efficient substitute for original ideas emanating from minds trained from youth upwards in a scientific atmosphere.

And so we are brought back to the subject of our leading article of last week. Our engineers, civil, mechanical, and electrical, our chemists, and even our doctors, are, thanks to technical colleges up and down the country, becoming more and more able to appreciate the value of science. But although a valuable addition to the body of educated public opinion, it must be remembered that engineers, chemists, and doctors are mostly busy men, silent men, and numerically negligible—an important consideration in an era of ballot boxes. It is our merchant princes, our lawyers, our politicians, our men of culture, who influence and form what may be called "effective" public opinion; and it is just these who require to be "caught young" if anything is to be made of them in after life as supporters of demands like that for a National Physical Laboratory. Owing to this comparative neglect of science as an integral part of a "liberal education," the fact that England is in danger of not taking its proper share of the highest scientific work of the world, has no meaning to many, and does not appeal with any particular force to any.

On the other hand, there can be no gainsaying that science, in one way and another, meets with considerable pecuniary support in this country. We do not know how much of the three-quarters of a million annually spent on technical instruction is devoted to science, but it is probably a very large proportion of the whole. And if we take into consideration governmental, local, individual, and collegiate disbursements, the aggregate will, in all likelihood, be found to bear a by no means insignificant ratio to the sums rightly lavished on "our bloated armaments." We are inclined to think that accurate knowledge on this point would be as useful as in other cases. If we knew the sum total of our expenditure on scientific research and education, and the heads under which the money was spent, those who advocate yet further expenditure would speak with more authority, and might even find that with a different allocation there is even as it is money enough for all.

Meanwhile, pending "such a change of public opinion as will make it possible to reproduce in England the conditions which have long obtained elsewhere," to quote the Report of the British Association Committee, the immediate object to be achieved is to make the need for a National Physical Laboratory sufficiently clear to the powers-that-be to induce them to grant the modest financial support required to make a start. To those of our readers who may be inclined to doubt the necessity for any such national institution, we can only say, read Dr. LODGE's Address to Section A, delivered at Cardiff in August, 1891, and the Report of the Committee to be found elsewhere in our present issue. The work of our National Physical Laboratory is to be confined to the observation of what may be termed "long period" natural phenomena; the construction, preservation and verification of standards and the determination of physical constants. Apparently, the technical side of the Charlottenburg institution is to be omitted; advisedly, in our opinion. There is certainly scope for a central institution which shall perform for applied science much the same functions as it is intended that the proposed National Physical Laboratory shall perform for pure science. But the support of such a technical institution should be left to the "enlightened self-interest" of those more immediately concerned. At present technical research work of the non-paying, large-scale order is carried out in spasmodic fashion by here and there an institution, and here and there a big firm, or long-headed, long-pursed engineer or manufacturer. It has taken half a decade to pass from the proposal to the report stage of this scheme for the establishment of a National Physical Laboratory. Perhaps we shall not be too sanguine if we look forward to see England commencing the XXth century provided with this "essential of scientific progress."

## OBITUARY.

### HIPPOLYTE LOUIS FIZEAU.

The schoolboy who is told of the enormous velocity of light usually carries with the information, in the same pigeon-hole of his memory as the names of Roemer, Bradley and Foucault, the name of Fizeau. We in these days have the figure representing this velocity established by many different kinds of determinations, astronomical, optical and electromagnetic; but in 1849 it rested only on the observations, first made by Roemer in 1675, of the eclipses of the inner satellite of Jupiter, and the corroboration by Bradley in 1728 by means of the aberration of light. It is to Fizeau that we owe the first direct determination of the velocity through air over terrestrial distances.

Born on September 23, 1819, the son of a professor of the Faculty of Medicine of Paris, his education in mathematics and natural philosophy fitted him to become a physicist of the first rank, and his fortune enabled him to give himself up entirely to his taste for science.

So early as 1841 he began his series of memoirs on photography and optics, and in his thirtieth year made his famous experiment on the speed of light described in the *Comptes Rendus*, XXIX., p. 90, 1849. The device employed consisted of a revolving toothed wheel, the rate of rotation of which could be accurately observed, and which was placed in the path of the light. When at rest the light passed outward through a space between two teeth to a distant

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station, where it was reflected back over its own path, passing through the same space on its return. If now the wheel were rotated with a gradually-increasing speed, a time would come when, during the interval required for the light to go from the first station to the second and back, the wheel would have revolved so far that a tooth would have taken the place of a space, and the light would be eclipsed. The stations chosen were at Suresnes and Montmartre, near Paris. Fizeau found that the light was eclipsed when a wheel of 720 teeth revolved at a rate of 12·6 times a second. From this he calculated the speed of light to be 314,000 kilometres per second. In 1874 Cornu repeated the experiment, and obtained the figure 300,400 kilometres per second.

In 1850 Fizeau made researches on the velocity of propagation of electricity; and for 30 years continued to bring before the Académie des Sciences, to the membership of which he was nominated in 1863, the results of various experiments dealing chiefly with wave motion and the effects of heat.

Now he is dead; but so long as light continues to shine, and there are men in the world eager to inquire into its behaviour and its method of propagation, the name of Fizeau will live in connection with this first direct determination of its velocity.

## THE BRITISH ASSOCIATION AT LIVERPOOL.

Great expectations preceded the meeting of the British Association at Liverpool on Wednesday, the 16th inst.; for was it not to be held for the first time for several years in a large and wealthy city, and had it not been rumoured that Liverpool would surpass itself and all rivals in the warmth of its welcome, and was not this to be the last meeting in England for two years to come? So it came to pass that many who had grown to look upon the British Association as a cosy picnic began to look forward to a time of greater things, greater activities, greater usefulness—at Liverpool. Many of the 2,972 members who, by the evening of Wednesday, had already arrived, and of those who foregathered in the Philharmonic Hall to hear Sir Joseph Lister's address, must have thought thus. The full title of the Association declares its mission to be the advancement of science. Sir Joseph's address, and, indeed, not a few of the events of the subsequent days' proceedings, assigned to the advancement of science that practical value which an utilitarian age insists upon seeing in all the things which it deigns to tolerate. We need not follow the details of Sir Joseph's arguments, where he shows the dependence of "the healing art" upon scientific knowledge, research and progress. It is sufficient for electrical engineers that in a corresponding manner the national wealth, prosperity and even vitality depend upon the nation's recognition of the importance of scientific progress, research and knowledge. Thus was the presidential address the true keynote of the *raison d'être* of the British Association.

*Thursday, September 17th.*

As if to clinch the matter and to bring home to any doubting Thomases the national importance of physical science, the very first item following the presidential address in Section A was the reading of the Report of the Committee on the Establishment of a National Physical Laboratory. Ugly comparisons, odious but necessary comparisons, were made between the enterprise of Germany in creating and supporting the Physikalische-technische Reichsanstalt, at an initial outlay of £200,000 and a yearly cost of £15,000, and our own meagre expenditure upon the Kew Observatory. A cry was raised for action—practical, national action; and Prof. Rücker brought the matter to a crisis by proposing that the physicists present should sign a memorial to be presented to the Government in support of an initial expenditure of £30,000 and an annual grant of £2,500 for a national physical laboratory on the lines of the Charlottenburg institution. Truly a paltry sum for the British exchequer, but one-seventh of what Germany spends! Prof. FitzGerald advocated a memorial asking for 2½ millions, and Dr. Lodge deprecated the spending so much money on ironclads and so little on physical research; for ironclads, he said, were not the only means of carrying on a "friendly competition" with other nations.

Meanwhile, in Section G, Sir Douglas Fox had delivered himself of his presidential address, and Mr. W. Worby Beaumont had been explaining why railway rails break. The cause of fracture of rails Mr. Beaumont attributed, not so much to inherent defects in the rails, as to the accumulated destructive effect of the stresses set up by passing trains. These stresses he regarded as momentarily exceeding the limit of elastic compression, which, if such is the case, would certainly break down the rail in course of time. Stresses originating in the same manner were assumed to explain the fracture of railway tyres.

*Friday, September 18th.*

A glance at the *Journal* on Friday morning showed that Section A would be the centre of a severe electrical disturbance, and that the proceedings of that Section in the discussion of Röntgen, Lenard and Becquerel rays, *et hoc genus omne*, would be likely to tax the attention of the audience for several hours. It proved even so. Nor did the ultimate postponement of a part of the programme prevent the continuation of the debate well into the afternoon. First in order of time, and in the importance of its popular interest, came an address "On Cathode Rays," from Prof. P. Lenard, the anticipation of which had gathered together an immense audience out of Sections A and B. Although announcing his intention to speak in German, Prof. Lenard gave the chief part of his lecture in fluent English, and the initiated and the ignorant alike were delighted to hear from his own lips so lucid an account of his principal experiments in the properties of cathode rays outside the generating tube. After briefly sketching an outline of these researches, Prof. Lenard passed on to the most important part of his address, viz., a statement of his views of the nature of cathode and Röntgen rays. Here he came into collision with the views of English physicists who were present, and thereby kindled the fire of an interesting but rather one-sided debate. Indeed, all the English physicists who took part—Sir George Stokes, Prof. FitzGerald, and the President of the Section (Prof. J. J. Thomson)—stated unqualifiedly views opposed to those advanced by Lenard. It is to be regretted that after this discussion Prof. Lenard was not given an opportunity to reply, as it would have been instructive to hear his criticisms of his critics.

In a lucid speech, lasting over one hour, Sir George Stokes gave an historical and critical account of the controversy. We will notice only his criticisms. In the first place he observed that although the cathode rays fell upon one side of an aluminium window and were diffused from the other side, it did not necessarily follow that they actually passed through the thickness of the aluminium. He conceived that the action which was transmitted through the metal in such a case was not in the nature of a cathode ray, but bore to the cathode ray a relation which was analogous to the relation which the passage of ions of copper in an electrolytic copper salt bore to the dissolution and deposition of metallic copper at the anode and cathode. He believed the cathode ray to be a thing quite distinct in its nature from the Röntgen ray; and the confusion between them which had arisen from the similarity or identity of some of their properties he considered to have been brought about by the difficulty in completely separating the two classes of radiation. The cathode ray he regarded as a stream of electrified material particles; while the Röntgen ray he believed to be ethereal. Instead, however, of regarding the Röntgen ray as a harmonic or periodic wave of high frequency, he considered it to be due to one brief, non-periodic impulse in the ether; and the continuity of the ray through any period of time he attributed to the rapid succession of such impulses from an immense number of molecular sources. Adopting this view, Sir George Stokes proceeded to show that the Röntgen rays would of necessity be non-refrangible, owing to the vanishing of the volume integral of the tendencies to displacement of the ray, arising from the several actions of the elements of the source of disturbance which gives rise to the ether disturbance causing the radiation. With regard to Prof. Lenard's difficulty in believing that the cathode ray is a stream of material particles, Sir George Stokes

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pointed out that it was by no means essential to believe the particles were those of the gaseous medium. They might be molecules torn from off the aluminium window; in which case their easier projection through a less resisting medium would be explained.

Prof. G. F. FitzGerald followed up the attack on the ether hypothesis of the cathode ray. He pointed out that Hertz had likened to the Hall effect the deflectability of this ray in a magnetic field. Since the Hall effect was one which only took place in the presence of matter, it followed that the cathode ray could not be a purely ethereal phenomenon. Hertz's inability to detect any reaction of the cathode ray upon the magnet deflecting it, Prof. FitzGerald attributed to the existence of a return stream of electrified molecules surrounding the cathode stream. This return stream would counteract the magnetic reaction of the ray upon the magnet.

The next Paper was one by Prof. J. J. Thomson and E. Rutherford, dealing with "The Laws of Conduction of Electricity through Gases Exposed to Röntgen Rays." This dealt with the continuation of the researches on the effect of Röntgen rays upon the conductivity of matter; and the surprising result has been arrived at, that the passage of these rays through a gas or vapour deprives it of its insulating properties, during a period extending some time beyond the cessation of the passage of the rays. Moreover, the temporary conductivity or pseudo-conductivity thus set up in a gas may be immediately destroyed, and the insulating properties be restored, by the passage of an electric current through the modified gas. Obviously, then, the influence of the rays is opposed by the influence which the current will exert which they permit to flow through the gas; so that at that point at which the opposing influences are equal, the maximum possible current through the gas has been attained. Thus this maximum is found to depend, not on the electromotive force causing the current, but on the intensity of the stream of Röntgen rays which passes through the gas and modifies its properties. Prof. J. J. Thomson has referred at some length to these researches in his presidential address to Section A (*see* page 672, *et seq.*).

In a Paper which followed, Prof. A. W. Rücker described how Röntgen rays might be used for distinguishing between various qualities of porcelain, those containing phosphatic china being opaque relatively to those porcelains of which this substance is not an ingredient. Lord Kelvin then read a Paper by himself, Dr. J. T. Bottomley and Mr. Magnus Maclean, on "The Measurement of Electric Currents through Air at different Densities down to One Five-Millionth of the Density of Ordinary Air." After describing the apparatus they had used, he stated that they had found that at ordinary atmospheric density it requires a potential difference of between 2,000 and 3,000 volts before any measurable current passes, the thickness of air being 1·5cm. between two pointed terminals. As the difference of potential is increased the current increases in a greater ratio; thus currents of 3·2, 7·8 and 28·1 milliamperes respectively were produced by 3,000, 5,000 and 8,000 volts. When the density of the air was diminished, the difference of potential necessary to start a current gradually diminished also. At about $\frac{1}{1000}$th of ordinary density it required but "a few score of volts" to start a current. Below about $\frac{1}{35}$mm. of mercury, a further reduction of density caused an increase in the volts necessary to start a current. Thus, when the density of the air was reduced to one five-millionth of ordinary atmospheric pressure, differences of potential of 3,000, 5,000 and 8,000 volts gave currents of 0·6, 1·95 and 6·5 milliamperes respectively. Experiments are being made on the behaviour of air between ball terminals, $\frac{1}{2}$cm. diameter and about 2mm. apart. This Paper provoked no discussion; and the meeting returned with great alacrity to the ever fresh topic of X-rays, in the discussion of which Lord Kelvin's Paper had come somewhat as an hiatus. Dr. Trouton now gave a Paper on "The Duration of X-Radiation at each Spark." He found the duration to be sometimes only $\frac{1}{10000}$th of a second, sometimes as long as $\frac{1}{800}$th of a second, and that the duration varied in a very erratic manner. Rather inconclusively, he announced that the duration seemed to depend on the kind of photographic paper used, "and on a lot of things." Prof. J. J. Thomson remarked that radiation so brief showed how inefficient was a spark coil as an instrument for producing it, since the period of the spark was so much longer than the period of the radiation. He himself proposed to use a replenisher and a very high-voltage battery for producing the discharge in a focus tube or other Röntgen ray apparatus.

A Paper was next read by Prof. S. P. Thompson on "The Relation between Cathode Rays, X-Rays, and Becquerel's Rays." The discussion on this Paper was postponed until the following morning.

*Saturday, September 19th.*

A much smaller audience assembled in the little lecture theatre of the Physics Department of the University College, to continue the debate on Röntgen rays, on Saturday morning. The proceedings commenced with the reading of a "Report of the Committee on Magnetic Standards." The discussion on the above-mentioned Paper by Prof. S. P. Thompson followed. This, like all the discussions on Röntgen rays, was of a desultory and rambling character, and was by no means confined to the subject matter of the Paper. The most important part of the Paper was probably that in which Prof. Thompson showed that the shadow of an object within the tube projected by cathode rays on the glass behaved differently from the shadow of that same object projected upon a fluorescent screen outside of, and some distance from, the glass bulb. When the object was electrified, the cathode shadow on the glass expanded or contracted very markedly, according to the sign of the electrification; whereas no such movement was observable in the shadow on the fluorescent screen, the production of which was due to Röntgen radiation. Prof. Thompson stated that he had observed no image or shadow on the glass at the point where the trajectory of the Röntgen ray shadow passed through the glass.

In our opinion, one of the most important points brought before the meeting at any time was that which was raised, during this discussion, by Prof. V. Bjerknes; and its effect upon the opposing camp of English physicists was well marked by their guarded criticisms of it. Prof. Bjerknes attacked the view that the "magnetic spectrum" of the cathode rays—viz., the assortment of the various rays by their deviation in a magnetic field—is a continuous spectrum. He described some recent researches of Prof. Birkeland, of Christiania, which tended to show that this magnetic spectrum is discontinuous, and is broken up into a number of separate lines or patches, after the manner of the luminous spectra of gases. This effect Prof. Bjerknes considered to be inconsistent with the molecular hypothesis of the cathode ray, and he thought it supported the theory of ether waves. Prof. J. J. Thomson elicited the information that the gas in the tube was of a composite nature, and also that no less than 40 distinct lines of cathode rays had been detected at times in the magnetic spectrum.

"Hyper-Phosphorescence,"* the subject of the next Paper, by Prof. S. P. Thompson, was regarded by Sir George Stokes as tending to support his new theory of non-periodic disturbances. Glow worms, it transpired, exhibit hyper-phosphorescence; and a member of the Association who had experimented with the fickle glow of these curious creatures asserted his belief that they "hyper-phosphoresce" even while they do not glow. Prof. Thompson thought that the eye of the glow worm, constructed as it is independently of refraction, might be a hyper-phosphorescent or Röntgen ray organ.

Mr. W Hibbert's Paper "On a One-volt Standard Cell with Small Temperature Co-efficient"† was now read. Prof. Ayrton elicited from the author the information that it might be possible, though it would probably be difficult, to draw up a specification of the cell, such that a skilled person might set up, say, a dozen cells which would not differ among themselves by more than $\frac{1}{1000}$-volt.

The cell, though having a very low temperature co-efficient, was very sensitive in regard to the composition of the

* See *Phil. Mag.* Papers in *The Electrician*, July 24th, p. 417.
† See *The Electrician*, July 3rd, p. 320.

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solutions contained in it. In order to guard against acidity in the chloride of zinc it was desirable to have the solutions slightly basic; and the electromotive force of the cell would depend on the degree of basicity of that solution.

A Paper by Dr. J. A. Harker and Mr. A. Davidson, on "Reostene, a New Resistance Metal," concluded the proceedings for the day. The authors of this Paper described a new alloy of iron and nickel, which it was proposed to use for cheap resistance frames. The alloy will stand a high temperature, tarnishes but slowly, has a high specific resistance, and possesses many qualities useful for its purpose.

*Monday, September 21st.*

Section G usually devotes attention on Monday to electrical matters, and this year proved no exception to the rule. It commenced by taking a report, indirectly interesting to electrical engineers, viz., that of the Committee on Small Screw Gauges. This Committee recommends among other things the construction and housing of the comb form of gauges or templates of the B. A. screw thread, by comparison with which master gauges or templates may be exactly and conveniently verified. The Committee has been re-appointed.

Mr. W. H. Preece next read his Paper on "Tests of Glow Lamps." The purpose of these tests, which have been undertaken by Mr. Preece at the Post Office during the past two years, has been the drawing up of an efficient specification for glow lamps. This specification is appended to the Paper, and it provides that samples of the lamps shall be subjected to several tests, principally based upon the assumption that the normal life of a lamp may be ascertained from the behaviour of a sample lamp highly over-run for a few minutes. In the discussion Dr. Fleming pointed out that no directions were given in the specification as to the position of the filament relatively to the photometer bar. Criticising the standard candle, which Mr. Preece recommends, Dr. Fleming said he did not care for standard candles, nor for the Hefner amyl acetate standard, which was too red for glow lamp tests, and that he thought the pentane standard of Mr. Vernon Harcourt very good. As a secondary standard he used a glow lamp with an abnormally large bulb, the great size of the bulb delaying blackening of the glass.

Mr. S. B. Cottrell now read a Paper on "The Liverpool Overhead Railway and the Southern Extension of it." The Paper is so full of detail that it is difficult to give much account of it here. Probably the most interesting part is that which relates to the southern extension of the line. This extension is about five-eighths of a mile long, and consists of a viaduct 250 yards long, and a tunnel 800 yards long. It terminates at the Dingle. To provide for the extra power required when this extension shall have been opened, the existing generating station is being enlarged. Two new engines are being erected, each driving a 250-kilowatt dynamo. The engines are each 400 I.H.P. "Corliss" horizontal condensing steam engines, built by Messrs. Hick, Hargreaves and Co. The additional dynamos and switchboards are built by Messrs. Thomas Parker (Limited). To cope with the increased traffic on this line, three-coach trains are now being run, and, to enable the existing motors to draw the additional coach, roller bearings are used. Mr. Cottrell's Paper is illustrated with a number of useful curves, which, together with the Paper, we hope shortly to publish in full. In the discussion Sir William Forwood, Chairman of the Company, spoke in praise of the high ability of Mr. Cottrell, the engineer of the line, and of the excellent efficiency of the service. He considered that the weak point in the system of electric traction was the car motors, which, in his opinion, cost rather too much for repairs. He said he spoke as a layman, not as an expert.

In the "Notes on Electric Cranes," which were contributed by Mr. E. W. Anderson, the author ably summarises the relative advantages of the various methods of adapting motors to cranes, and compares electricity with other sources of power, such as hydraulic power, steam and rope-gear transmission. The Paper was not discussed, owing to the author's absence.

In a Paper on "Experiments on the Hysteresis of Iron in Revolving Magnetic Fields," Dr. Fleming, Mr. R. Beattie and Mr. R. C. Clinker described their researches on the influence of the number of test discs composing the test piece upon the values obtained for the hysteresis, the variations in these values being due to the changes in the amount and distribution of the magnetic induction according to the number of the discs. Prof. Ewing observed that the action of discs was not necessarily the same as the action of the test strips in his hysteresis meter; but he was unable to say that the induction in his test strips was appreciably uniform.

In Section A, "A complete Apparatus for the Study of the Properties of Electric Waves" was described by Prof. J. Chunder Bose, of Calcutta, and "A Method of Detecting Electromagnetic Waves" * was described by Mr. E. Rutherford.

*Tuesday, September 22nd.*

Electric waves and thermometry were the two subjects principally discussed in Section A on Tuesday. The proceedings commenced with the adjourned discussion on Prof. Bose's Paper, and the ingenious and comprehensive apparatus devised by Prof. Bose for the investigation of the properties of electric waves was again exhibited. This apparatus is arranged in the fashion of an optical bench, and is the most compact and at the same time the most comprehensive apparatus we have seen for making researches on electromagnetic radiation. There are few, if any, researches in this class of work which might not be conducted with this apparatus, while for many researches a high degree of quantitative accuracy is obtainable. The refractive indices to electric waves of a large number of substances have been determined by means of it. The discussion on this Paper, unfortunately, drifted away from electric waves to Röntgen rays, and speedily degenerated into a triangular word-war between Lord Kelvin, Sir George Stokes and Prof. FitzGerald, as to the adequacy of Stokes's hypothesis of Röntgen radiation.

An important stage in the day's proceedings was reached when the report was read of the Electrical Standards Committee (on Thermal Units). This report advocates international discussion on the subject of a new thermal unit. It proposes to adopt the erg as the absolute primary standard of heat. As a secondary standard, of sometimes more convenient magnitude, an amount of heat equal to $4{\cdot}2 \times 10^7$ ergs is suggested; and it is proposed to call this secondary unit the "Calory" (why *y*, and why capital C?). As a method of defining this secondary unit, it is suggested that it might be specified as being one water-gramme-degree between 9°5C. and 10°5C.; or if this range of temperature is not consistent with a value of 42 million ergs, then any other range of temperature of 1°C. as shall in future be determined to give a value of 42 million ergs to the water-gramme-degree. This device has the advantage of fixing the value of the secondary unit independently of thermometry.

*Wednesday, September 23rd.*

So many Papers remained on hand by Wednesday morning that Section A had to subdivide into two parts, while many of the other Sections did not sit at all. Every year Section A overworks itself. In one of these subsections of A several electrical Papers were read, the proceedings of this branch commencing with a Report of the Committee on the Sizes of Pages of Periodicals. After this came Mr. W. H. Preece's important Paper on "Disturbances in Submarine Cables." Mr. Preece lamented the smallness of the audience, but hoped the discussion would be thoroughly carried on in the pages of *The Electrician*. Lord Kelvin, criticising the type of cable proposed by Mr. Preece, said he feared its working over long lines would be marred by excessive capacity. He agreed, however, that the proposed form would be more completely free from external disturbances. Dr. Bedell said he had wondered whether alternately cross-connecting the inside and outside of a concentric cable was not like having humps in one mile of road to compensate for holes in the next mile. Prof. S. P. Thompson remarked on earth currents as a form of disturbance not taken into account by Mr. Preece. He advocated the introduction of artificial leaks and inductance coils bridging across the two cables of a completely metallic circuit for ocean telephony. Mr. Preece, in his reply, observed that the K R law was modified in telephony by dielectric

* See *The Electrician*, July 17th, p. 367.

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hysteresis, which, he thought, relieved to some extent the retardation.

"Carbon Megohms for High Voltages" were described by Mr. Mordey, who has had great success in the use of long, wide strips of carbon-blacked stiff paper or pressband. This form will stand very high voltages without appreciable deterioration. Mr. Mordey also read a Paper describing "An Instrument for Measuring Magnetic Permeability," this instrument being now used by Mr. Mordey in his testing rooms. Neither great accuracy nor absolute measurement is aimed at, the instrument serving merely to indicate which, of a number of sample bars, should be rejected and which passed. The instrument is adapted to the rough-and-ready work of the workshop, and not to the refinements of the laboratory. We hope to give fuller description of this instrument in a later issue.

The "Direct-reading Form of Wheatstone Bridge," invented by Mr. A. P. Trotter, and described by him in a Paper which followed Mr. Mordey's, is an ingenious combination of a slide-rule and a slide-wire bridge, but with a scale of equal and not logarithmically divided parts. The Paper will be found on p. 691 of our issue this week. The Paper was well received, but met with no discussion, owing no doubt to the lateness of the hour at which it was read.

In conclusion, Prof. S. P. Thompson (the Chairman of the Subsection) had a word of praise for the Paper on "The Division of an Alternating Current in Parallel Circuits with Mutual Induction," which was read by Dr. F. Bedell. He admired, he said, Dr. Bedell's happy combination of analytical with geometrical methods of proof.

Meanwhile the other, and, generally speaking, more important Subsection had been occupied with a number of Papers on general physics. The single electrical Paper on the programme of this Subsection was contributed by Profs. Elster and Geitel, on "Photo-Electric Sensitisation of Salts by Kathode Rays."

## LIST OF THE ELECTRICAL PAPERS READ AT THE BRITISH ASSOCIATION.

The following is a complete list of the electrical Papers read and Reports presented at the Liverpool meeting of the British Association :—

SECTION A.

Prof. P. LENARD.—"On Cathode Rays."
Prof. J. J. THOMSON and E. RUTHERFORD.—"On the Laws of Conduction of Electricity through Gases exposed to the Röntgen Rays."
Prof. A. W. RUCKER, F.R.S., and W. WATSON.—"On the Transparency of Glass and Porcelain to the Röntgen Rays."
Lord KELVIN, F.R.S, Dr. J. T. BOTTOMLEY, F.R.S., and Dr. MAGNUS MACLEAN.—"On Measurements of Electric Currents through Air at Different Densities down to One Five-Millionth of the Density of Ordinary Air."
Dr. F. T. TROUTON.—"The Duration of X-radiation at each Spark."
Prof. S. P. THOMPSON, F.R.S.—"On the Relation between Cathode Rays, X-Rays and Becquerel's Rays."
Prof. S. P. THOMPSON, F.R.S.—"On Hyper-phosphorescence."
H. H. F. HAYSMAN.—"Observations on the X-Rays."
Dr. L. A. BAUER.—"On the Component Fields of the Earth's Permanent Magnetism."
W. HIBBERT.—"On a One-volt Standard Cell with Small Temperature Coefficient."
Dr. J. A. HARKER and A. DAVIDSON.—"On Reostene, a new Resistance Metal."
Lord KELVIN, F.R.S., Dr. MAGNUS MACLEAN, and ALEXANDER GALT.—"On the Communication of Electricity from Electrified Steam to Air."
E. RUTHERFORD.—"On a Method of Detecting Electromagnetic Waves."
Prof. J. CHUNDER BOSE.—"On a Complete Apparatus for the Study of the Properties of Electric Waves."
E. H. GRIFFITHS, F.R.S.—"Note on the Measurement of Electrical Resistance."
W. H. PREECE, F.R.S.—"Disturbance in Submarine Cables."
W. M. MORDEY.—"Carbon Megohms for High Voltages."
W. M. MORDEY.—"On an Instrument for Measuring Magnetic Permeability."
A. P. TROTTER.—"Direct-reading Form of Wheatstone Bridge."
Prof. E. BEDELL.—"On the Division of an Alternating Current in Parallel Circuits with Mutual Induction."
Profs. ELSTER and GEITEL.—"Photo-Electric Sensitisation of Salts by Cathode Rays."
Report of the Committee on Electrolysis.
Report of the Electrical Standards Committee (on Thermal Units).
Report of the Committee on the Establishment of a National Physical Laboratory.
Report of the Committee on Magnetic Standards.
Report of the Committee on the Comparison and Reduction of Magnetic Observations.

SECTION B.

Dr. J. H. GLADSTONE and W. HIBBERT.—"Action of Metals and their Salts on the Ordinary and Röntgen Rays: A Contrast."
Report of the Committee on Electrolytic Analysis.

SECTION G.

W. H. PREECE, F.R.S.—"Test of Glow Lamps."
S. B. COTTRELL.—"The Liverpool Overhead Railway and the Southern Extension of it."
E. W. ANDERSON.—"Notes on Electric Cranes."
Prof. FLEMING, R. BEATTIE and R. C. CLINKER.—"Experiments on the Hysteresis of Iron in Revolving Magnetic Fields."
W. G. WALKER.—"Street Lighting by Incandescent Electric Lamps."
Report of Committee on Small Screw Gauges.

## ON THE ESTABLISHMENT OF A NATIONAL PHYSICAL LABORATORY.*

At the Ipswich Meeting of the British Association held in September, 1895, the Committee were reappointed for the purpose of reporting on "the establishment of a National Physical Laboratory for the more accurate determination of physical constants, and for other quantitative research, and to confer with the Council of the Association."

It will be convenient in the first place briefly to enumerate the present facilities afforded by the Government, by educational establishments, and by private societies, for aiding research in Great Britain, independently of that direct aid which Government Departments are continually furnishing for their own purposes.

The most direct sources of aid given to research are the £4,000 a year given by the Government for research purposes, and administered by the Government Grant Committee of the Royal Society; the Donation Fund of the Royal Society, derived from its surplus income; the contributions made to research by the British Association; the investigations carried on at the Royal Institution, which afford magnificent examples of private munificence in aiding science; the City and Guilds of London Institute; the Royal Commission of the Exhibition of 1851, which devotes £6,000 a year to research scholarships; research committees of various scientific societies; the Clarendon Laboratory at the University of Oxford, and the Cavendish Laboratory at Cambridge; the laboratories at Glasgow, Edinburgh, and Aberdeen; the Victoria University; and the larger Colleges not yet incorporated into universities.

The facilities which the laboratories of the Universities and of the University Colleges afford for research are much reduced by the large demands usually made upon the time and energy of the professor and the staff for elementary teaching. Nor is a thorough appreciation of the essential connection between research and all higher scientific education so widely diffused in England as it is in Germany, in the United States, and elsewhere. It must be manifest that the cure for this latter evil is not to be found in the establishment of a National Laboratory, but in such a change of public opinion as will make it possible to reproduce in England the conditions which have long obtained elsewhere. It is to be hoped that the research work now conducted at educational establishments in this country will largely increase in the future. We should earnestly deprecate any divorce between higher teaching and investigation, and should regard anything tending in that direction as a retrograde step.

There are, however, investigations of particular types which have been recognised both in this country and abroad as lying outside the range of effort possible either to an individual or to a great teaching institution.

These may be divided into three principal classes, viz. :—

1. The observations of natural phenomena, the study of which must be prolonged through periods of time longer than the average duration of life;

* Report of a British Association Committee, consisting of Sir Douglas Galton (Chairman), Lord Rayleigh, Lord Kelvin, Sir H. E. Roscoe, Profs. A. W. Rücker, R. B. Clifton, Carey Foster, A. Schuster, and W. E. Ayrton, Dr. W. Anderson, Dr. T. E. Thorpe, Mr. Francis Galton, Mr. R. T. Glazebrook, and Prof. O. J. Lodge (Secretary).



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2. The testing and verification of instruments for physical investigation, and the preservation of standards for reference; and

3. The systematic accurate determination of physical constants and of numerical data which may be useful either for scientific or industrial purposes.

A laboratory for such purposes would aid and would not compete with laboratories maintained by individuals or institutions for more general physical research, and the reasons for establishing it as a National Institution are much of the same kind as those for maintaining a National Astronomical Observatory. If England is to keep pace with other countries in scientific progress, it is essential that such an institution should be provided; and this can scarcely be maintained continuously on an adequate scale, except as a national laboratory supported mainly by Government.

In a Paper read at Ipswich on the Reichsanstalt, it was suggested that the Kew Observatory might be extended so as to afford a satisfactory nucleus for a national physical laboratory. The Kew Observatory, endowed by the late Mr. Gassiot with an income that is now somewhat less than £500 a year, is under the control and management of an unpaid committee appointed by the Council of the Royal Society. It is the central observatory of the Meteorological Office, from which it receives £400 a year; and it has gradually become an important standardising institution, as well as a recognised base station for observations in meteorology and terrestrial magnetism. Its gross income from these various sources is now over £4,000 a year; but the greater part of this is derived from testing fees, and is almost entirely absorbed in working expenses.

The building of the Observatory† stands in the Old Deer Park at Richmond, and is the property of the Government, from whom the Committee hold it at a small rent. They have latterly been permitted to add about five acres to their holding. The work of the Observatory is very varied, but may be roughly divided into (1) Routine observation—magnetic, meteorological, and solar. (2) Experimental work connected with the routine observations and research work generally. (3) Standardising of between thirty and forty different kinds of instruments, whose number in the gross now exceeds 30,000 annually. The general heads under which most of these instruments fall are (*a*) Thermometers of all kinds; (*b*) Barometers, anemometers, and all sorts of meteorological apparatus; (*c*) Theodolites, sextants, artificial horizons, compasses, and telescopes; (*d*) Watches and chronometers; (*e*) Photographic lenses. Particulars will be found in the annual reports, printed in the *Proceedings* of the Royal Society. The present work of the Observatory is therefore of a character which is strictly consistent with a large portion of the work which would find a place in a national physical laboratory.

Having thus briefly shown what the Kew Observatory now performs, it will be convenient to consider what would be (*a*) the function which a national laboratory should fulfil, (*b*) the system which should be adopted for its control and management.

(*a*) *Functions.*—In addition to the special research work, the scope of which we have already partially indicated, the work of the proposed institution would include an extension of certain branches of work now performed by the Kew Observatory. This work has now for its object the verification of standards for instruments of utility in scientific investigation, but it hardly attempts investigation into the properties of the materials of which they are, or should be, composed. An enlargement of this work to its proper extent would, in the case of many delicate standards, relieve British investigators from their present dependence upon foreign laboratories. Indeed, in the prosecution of research the necessity for accurate standards is being daily more and more felt. This class of work, as recognised in the Reichsanstalt, comprises not only comparisons of length, weight, capacity, gravity, sound, light, &c., but variations of conditions due to temperature, vibration, or other causes, as well as quality of materials in regard to their uses. It is a class of work which is not touched by the Standards Department of the Board of Trade, for this department is restricted by Act of Parliament to the work of making standards of length, weight, and capacity, and of such electrical quantities as may be of use for trade.

(*b*) *Management.*—The present form of government of the Kew Observatory affords a basis upon which the management of the extended laboratories might be safely founded. The present government is by a paid superintendent, who is controlled by an unpaid Committee appointed under the Council of the Royal Society. The Committee consists of the leading authorities on the special subjects which form the present work of the laboratory, and they lay down the general lines on which investigations are to go on. It would appear to be desirable that the government of the enlarged Institution should be in the hands of a Committee appointed either as now by the Royal Society alone or in conjunction with one or more of the chief scientific bodies in the country. But it is to be hoped that in addition to this Council of Advice the immediate executive and initiative power would vest in a paid chief or Director of the utmost eminence attainable. Unless such an appointment were made, either an altogether unfair amount of work would be thrown upon some members of the governing committee, or the institution would fail to rise to the highest usefulness.

The present accommodation at Kew Observatory is quite insufficient for the proposed extension of its work; and to carry out the idea suggested will require increased space, increased buildings, and increased staff. There would probably be no difficulty in obtaining from the Government an extension of space out of the park at Richmond; but the proposal would entail an expenditure of money for new buildings. It would be unfortunate if such expenditure had to be taken from the small fund which Parliament allots to scientific research under the Royal Society; but there can be little doubt that when a satisfactory scheme has been elaborated it will not be unreasonable to ask the Government to assist in providing the necessary buildings. Additions to buildings require much consideration, and, therefore, as a preliminary to any action, a small committee might be asked to draw up a detailed scheme, with the aid of an architect, for an extension of Kew Observatory, having regard to the site and to utilising the present erections upon it.

Since it is difficult to foresee the direction in which a rapidly-growing subject like Physics may develop, it is probably wisest to begin with buildings of an adaptable and not too elaborate character, and to stock them with but a moderate supply of the best available apparatus. In such a subject as Physics a large annual maintenance grant is more useful than an extravagant initial equipment which might speedily become antiquated. We would suggest to those whose business it may be hereafter to approach the Government that some such sum as £20,000 or £25,000 would serve to erect a building sufficient for all immediate necessities, and that posterity may be left to increase it as need arises. A sum of £5,000 would provide a fair amount of initial instrumental equipment of a permanent kind, and the rest should be met out of an annual grant.

The commercial testing department may be considered self-supporting; but for secular research and the determination of constants considerable expense would be entailed. This would fall under the heads of salaries, new apparatus, maintenance, warming, lighting, and taxes.

We propose that the head of this National Laboratory should receive £1,200 a year, and we estimate that the additional assistance required would raise the sum expended on salaries to a total of £2,500 a year. The maintenance expenses and the apparatus fund would be adequately covered by another equal sum, much of which could be derived from fees, so that we estimate altogether that a supplementary annual grant of £3,000 per annum, and an initial expenditure of £30,000 for buildings and equipment, would do all that is essential to carry out the scheme in a wise and worthy manner.

## APPENDIX.—Physikalisch-technische Reichsanstalt.

### *I. Department (Physical).*

| | | Marks. |
|---|---|---|
| 1. Value of land (originally presented by W. S. Siemens) ..... | | 500,000 |
| 2. Buildings, &c.: (*a*) Laboratory building ..... | 387,000 | |
| (*b*) Engine house ..... | 50,000 | |
| (*c*) Administration building ..... | 100,000 | |
| (*d*) President's house ..... ..... | 99,254 | |
| (*e*) Gardens, drainage, &c. ..... | 10,472 | |
| (*f*) Paving adjacent streets ..... | 30,274 | |
| (*g*) Accumulator house..... | 8,500 | |
| | | 685,000 |
| 3. Furniture, &c., for (*a*), (*b*), and (*c*) ..... | | 58,000 |
| 4. Machines, engines, apparatus of all sorts ..... ..... | | 82,310 |

### *II.—Department (Technical).*

| | | |
|---|---|---|
| 1. Value of land ..... ..... ..... ..... | | 373,106 |
| 2. Buildings: (*a*) Principal laboratory building..... | 922,000 | |
| (*b*) Smaller ditto ..... | 218,000 | |
| (*c*) Engine house ..... ... | 180,000 | |
| (*d*) House for officials ..... | 140,000 | |
| (*e*) Additional structures, &c..... | 348,000 | |
| | 1,808,000 | |
| In budget 1895-6 reduced by ..... ... | 47,500 | |
| | | 1,760,500 |
| 3. Furniture, &c., for these buildings ..... ..... | | 81,000 |
| 4. Engines, machines, instruments, &c. ..... ..... | | 363,690 |
| | | 3,904,106 |

In round numbers—£200,000 sterling capital expenditure.

### *Yearly Expenses.*

| | |
|---|---|
| 1. Personal: Salaries, remunerations, &c..... | 172,357 |
| 2. Repairs to buildings, cost of administration, experimental work ... .... ..... ..... ..... | 115,000 |
| | 287,000 |

In round numbers—£15,000 sterling a year.

† See the "History of Kew Observatory," by Mr. R. H. Scott, in *Proceedings of the Royal Society*, 1885, Vol. XXXIX., p. 37-86.

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## NOTES ON ELECTRIC CRANES.*

BY E. W. ANDERSON.

One of the earliest applications of electricity as a convenient medium for the transmission of motive power was to the driving of travelling cranes; and the fact that this, at that time, newly developed method of transforming heat energy into a subtle vibration and reconverting into work was so soon applied to this purpose shows that there certainly was a need for it. Now, after some 10 or 12 years' experience, it may be fairly stated that the system is not only a success, but is the very best method that has yet been devised.

The object of this Paper is to give some of the experience the writer has had with electric cranes in practical use in the Erith Ironworks.

In May, 1888, Dr. W. Anderson, then a member of the firm of Easton and Anderson, of Erith, conceived the idea of applying electricity to a 20-ton travelling crane in the foundry; and in due course this was carried out successfully. At the next meeting of the British Association he read a paper before Section G, in which this crane was described and illustrated, the results of some experiments with it being given as well.† It is, therefore, not necessary to describe in detail the arrangements of this crane, as they may be found in that Paper; but it will be sufficient to say that the several motions are controlled by gearing driven by three transverse shafts on the top of the girders, and which are themselves rotated in either direction at will from a longitudinal shaft through the medium of three nests of bevel wheels and friction clutches. The longitudinal shaft is driven by means of a double helical spur wheel and pinion from a five-unit shunt-wound motor made by the then existing firm of Elwell-Parker. Each motion has two gears by which fast and slow purchase may be given as desired. The shunt coils of the motor are always in circuit with the conductors, and the starting switch simply turns on the current through the armature and through the usual resistance coils, which are so arranged that they can be used to regulate the speed if necessary. The motor is started light—that is, moving only the longitudinal shaft—and when it has attained its proper speed the several movements can be independently worked in either direction as required. The conductor conveying the current consists of a piece of angle iron, having one face roughly ground up, fixed to the shop columns above the crane by means of wooden blocks, and upon which a brass contact-piece attached to the crane by a spring slides, while the return circuit is taken through the wheels on to the rails. The pressure used is 100 volts.

When first started there was, as might naturally be expected, some little difficulty and trouble. The friction clutches were not quite up to the mark, and had to be altered a little, and the fuses inserted in the dynamo circuit had an uncomfortable habit of melting at the most critical times, generally when a ladle full of melted iron was being manipulated. These mishaps at first raised some prejudice against the crane, but when they were got over by improving the clutches and by the simple expedient of putting in larger fuse wires and chancing a burn out, such prejudice gradually disappeared. The writer is aware that the remedy to the fuse difficulty is hardly one to be justified on scientific grounds, but practically it has proved quite successful, owing, no doubt, to the fact that the heavy currents are only on the armature for such a short time that the heating from them cannot become destructive. The motor is frequently called upon to give 10 H.P. for a short time, and seems none the worse for it, while on one memorable occasion, when an accident occurred and prompt measures had to be taken, the crane is known to have lifted at least 35 tons, and to have been none the worse for it.

Shortly after this crane was started, and before it was quite in a satisfactory condition, a steam crane was purchased and set to work in the foundry on the same gantry, so that the two cranes could be admirably compared in a practical manner. It was of an ordinary type, having its own boiler, engine and gear on the travelling crab, so that it was entirely self-contained. At the present time these two cranes are practically doing the whole work of the main bay of the foundry, and have been steadily running—except, of course, occasionally when under repair—ever since they were started. The result is that, while the electric crane was looked upon by the foremen and workmen with some little distrust at first, now it is much preferred to the steam one, and has all the most important work given it to do by preference. The atmosphere of a foundry provides an excellent test for the durability of electric machinery under trying circumstances, and in this case not only is there the dust and dirt arising from the foundry itself, but there is the steam and smoke from the other crane, which does not by any means improve matters.

When first installed considerable doubts were entertained as to the ability of the motor to work well in so trying a situation; but the practical result has quite dispelled any fears on that score. It is not easy to get any exact statement of the repairs that have been required, as no record has been kept of them, and the care of it has been through several successive hands; but it is found that they have been very small indeed, and much less than have been found necessary in the case of the steam crane. The friction clutches require occasional adjustment, and from time to time some new parts, while two new commutators have been fitted to the motor, and it was considered desirable to rewind the armature once, otherwise an occasional turning-up of the commutator and adjustment of the brushes has sufficed. The starting switch requires a little trimming now and then, and one or two new contact-pieces have been fitted. Of course, the other parts of the gearing have required attention as in all other cranes.

A great advantage which this electric crane possesses over the steam one is that the attendant has nothing to think of except his work, and can give his whole attention to it. In the other case there is the fire and the feed water to look after and be borne continually in mind, distracting attention from the work that is being performed, and even constituting a source of danger in case of its being neglected. Moreover, it is necessary for the steam crane attendant to come to his work an hour and a-half before general work begins, in order to get up steam, and on Mondays this is increased to two hours; whereas, with the electric crane it is not required, as the dynamo supplying the current is driven by the main turnery engine, for which, of course, steam has to be got up by starting time in any case.

An important matter in foundry work is to have complete command of the crane at all speeds, to be able to lift and lower at exceedingly slow rates, and by the smallest possible amounts, so as to be able to draw large patterns and put moulds carefully together. It has been found that the electric crane answers admirably for such purposes, thanks, no doubt, partly to the sensitive friction clutches, and partly to the resistances provided for slowing down the motor, and is much superior to the steam crane.

Having said so much as to its good qualities, one objectionable feature must be pointed out, and that is, the noise made by the first-motion gearing. In the first instance, the motor running at 1,200 revolutions per minute drove the longitudinal shaft by means of an ordinary cast-iron spur wheel and pinion having a ratio of 8⅓ to 1. The rattle made by this was terrific, and as it was found that, owing to the narrowness of the space available between the crane and the shop columns, mortice gearing, which would of necessity be broader, could not be got in, it was decided to substitute double helical-toothed wheels for the straight-toothed ones. The result was not so good as might have been expected, and at first the noise was nearly as great; but after having worked a little, so that the faces of the teeth had worn into better order, it improved a little, but still was very objectionable. It was then suggested to block up the triangular spaces between the arms of the wheel with wood, in order to deaden the vibration; and this did a great deal of good, as it converted the sharp, noisy rattle into a dull rumble, which was much less objectionable, and in this manner the crane has worked ever since.

The foundry crane promised to be so successful, that in May, 1889, it was determined to adapt electrical driving to a 15-ton crane in the main bay of the turnery. None of the cranes in this department had, however, been arranged with a view to the ultimate application of power driving like that in the foundry, but were simply fitted with ordinary hand-gear, so that a different system altogether had to be adopted.

The company had not at that time commenced the manufacture of electric machinery themselves, and therefore three "Manchester" motors of suitable sizes were obtained from Messrs. Mather and Platt, provided with jockey pulleys, so as to run with very short belts, and brushes arranged so that the armature might revolve in either direction, and were duly fixed, as described, on one of the platforms. On the other platform a framework was fixed carrying three reversing switches and resistances, each controlling one motor, and a foot lever connected with the automatic lowering brake was arranged conveniently for the attendant. The crane is worked simply by the manipulation of these three switches and the lowering lever, while from the position in which they are placed an excellent view of the work being done can be obtained. The crane is driven by the same dynamo that supplies that in the foundry, the voltage being therefore 100, and the hoisting, cross traversing, and longitudinal traversing motors are respectively 10-unit, 1½-unit, and 2½-unit machines, all being shunt wound, with a few series coils to assist them in starting under full load. The current is collected in a different way to that described for the foundry, the arrangement having been suggested and carried out by Messrs. Mather and Platt. Two bare copper wires about ⅛in. diameter are suspended parallel to each other and about 8in. apart by means of earthenware insulators from every sixth roof principal, making thus a series of loops, each 60ft. long, extending all down the shop, a length of nearly 600ft., and with a moderate amount of sag given, to them. A standard is fixed at the outside edge of each platform

* Paper read before the British Association at Liverpool, Section G.

† See *The Electrician*, Vol. XXI., September 28, 1888, p. 665.



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and thus, as far apart as possible, directly under the two conductors, and each one carries two insulated brass plates, one under each conductor, and at such a height that except at the insulators and a few feet on either side of them, the wires are able to rest upon them. The plates on the two standards, which are under the same conductor, are electrically connected together and to the switch frame.

It will now be understood that wherever the crane is, the conductors will be resting on one or other pair of the contact plates, and sometimes on both; because, while at or near the insulators the conductors are held up clear of the plates, a few feet on either side they sag down so much that they come in contact with them, and the distance between the two sets of contacts is sufficient to prevent at any time both sets being in such a position as to be simultaneously clear of the conductors. By this means the supporting insulators are easily passed. The wires were not put up quite carefully enough in the first instance, and the crane used sometimes to stop from all the contacts getting clear at once, but a little readjustment soon put this right, and it has worked well ever since. This crane has worked very well always, and has given no trouble at all. Owing, however, to the motors being made to reverse, the brushes have to be placed on the horizontal axis of the commutator, and thus no lead is given them except that due to the small arc of contact, the result being that there is always some sparking, and the life of the commutators is less than in the foundry crane, where practically sparkless running is obtained. In the shorter time that this crane has been at work three new sets of commutators have been fitted. Likewise the switches, from being so much more used, require more repairs than that of the foundry crane, and recently it has been found necessary to put in a complete new set. With these exceptions, however, but little repairs are needed, as there are no friction clutches or anything liable to much wear. The conductor contact plates occasionally require renewal, but this is a very small matter, and the conductors themselves are in very good order. The system of driving the gearing from the motors by means of belts makes the working of this crane practically noiseless.

As already stated, experience has convinced the writer that, at any rate for travelling cranes, electricity is more satisfactory than anything else, and there can be but little doubt of its cheapness. It is not possible to make any actual experiments to determine the useful work done per hundredweight of coal or anything of that sort, to settle such a point as this absolutely, on account of the intermittent nature of the work and the variations of the power required, added to the fact that no measurement of the energy expended in traversing can be made at all, except at the motor itself, in which case the loss in the gearing must be assumed; and as the same applies to all similar cranes however driven, the comparative cost of different systems can only be arrived at by common-sense reasoning.

Electricity has the following economical advantages: the current may be generated by a highly economical engine, and, therefore, at the cheapest possible rate; the loss in transmission to the motors may be kept very small without serious initial outlay, as the distance of transmission is usually very small, and the motor will only use current in approximate proportion to the work it has to do. On the other hand, however, there is perhaps rather more loss in the gearing than in some of the other methods of driving, on account of the great reduction in speed that it has to effect. Compare now the self-contained steam crane, such as that in the foundry. Both boiler and engine are necessarily much less economical than need be used for electric crane driving, and it would probably be fair to say that a given power generated in this manner costs three to four times as much, though as a set-off against this the engine is close to its work, and the losses of conversion and transmission of the electric energy are avoided, as well as some of that in the gearing. The net result, however, must be considerably to the advantage of the electric system.

Attention has already been called to the necessity for the attendant to come an hour and a half before the crane is required in order to get up steam; and this, together with the expenditure of coal in getting up steam, makes a considerable extra expense, which is avoided where the cranes are driven from the main factory boilers. A small item of expense is also due to supplying the crane with the fuel and water, which, of course, have to be lifted up to it.

The comparison of electrically-driven cranes with those worked by other modes of transmission is more difficult, because all such methods may employ an economical engine as the generator of the power, and so far may place themselves on a par with electricity; but whether the transmission is effected by wire ropes, cotton ropes, or by a square shaft, a large amount of gearing is involved which must always be running and absorbing power, no matter what kind of work the crane may be doing. The writer's opinion is that, while for short gantries such methods compare well with electricity from an economical point of view, for long ones, such as in the Erith works, they cannot approach it. Picture to yourselves a shop 600ft. long, having, on the one hand, either a square shaft continually running on one side of it with the numerous bearings requiring, of course, continual attention in keeping them properly oiled, or else a wire or cotton rope with the array of pulleys and their bearings required by it; and, on the other hand, two small copper wires suspended in the roof out of the way and requiring no attention whatever. In such a case there can be no question as to the best system.

As regards repairs, the writer is only able to give personal experience derived from a 20-ton crane driven by a wire rope in one bay of the high erecting shop at Erith. The longitudinal travel of this crane is only 120ft. It has been found that a new rope is required every year, and the cost of this, together with the splicing and putting up, comes to about £10, so that the expense on this score alone has probably exceeded considerably the electrical repairs on either of the electric cranes, taking an average over the eight years they have been at work. Obviously, if this rope-driven crane had the same travel as the others, the cost would be very much heavier.

It has been urged by some that a more skilful, and therefore better paid, attendant is required for an electric crane than for the ordinary types. The experience at Erith has shown that such is not the case, and any labourer of ordinary intelligence will very soon acquire what little special knowledge is needed to keep the electrical machinery in proper order.

In considering the general design of electrical travelling cranes, several points present themselves to which attention may be directed. Is it best to have one motor to work all the three motions, or a separate one for each? There is a great deal to be said on both sides of this question; and, taking it all round, the writer is disposed to think that there is not much to choose between them. The single motor is best from an electrical point of view, as it avoids the necessity of reversing, saves a good many connections, and gives only one high-speed machine to look after. On the other hand, it entails the use of friction clutches or their equivalent, and a good deal of gearing to properly control all the motions. The three-motor system is more economical in power, as the motors are never required to run light as the single motor has to, and therefore the small current taken under such circumstances is saved. The control may be effected entirely by switches, which are very easily worked, and may be even operated from below without anyone being on the crane at all. If two or three motions are being operated simultaneously, the speeds of them can be independently varied if desired, whereas in the single motor arrangement this cannot be done, as any variation of the motor of course affects all the motions equally. On the other hand, the motors require more frequent repairs, and there are three commutators and sets of brushes to wear out as against one in the other system—though, of course, each only does one-third of the work. The fact, however, remains that the reversing motor commutators wear out more quickly than the other even with the lesser work and with a much cleaner situation to work in.

A consideration that constantly arises in the application of electric motors is the best system to adopt for reducing their usual high speed to the slow one often required—as, for instance, in crane work. In the cranes that have been described, unquestionably the belt reduction is by far the best, not only for its noiselessness, but also on account of the absence of vibration, which is considerable in the case of the gear reduction. The motor of the foundry crane does not seem to have suffered much from this vibration; but cases have occurred where the jar of spur gearing has damaged armature windings, and it is, therefore, best not to run any risks, but use some other form of reduction gear where practicable. Mortice wheels, with wood teeth, are, of course, better than either ordinary spur or double helical gear. Worm gearing is often a very convenient means of effecting the reduction, and is much more economical when properly made than is generally supposed. The writer's firm have used it very considerably in cases where other forms of gear were not suitable. It should be enclosed in an oil-tight casing, so that ample lubrication of all parts may be obtained, while dirt is excluded. The worm should be, by preference, on the top of the wheel, as it makes it more easily accessible, and the thrust should be taken upon properly-constructed ball bearings. The angle of the thread is an important factor in the economy of the gear, and, in common with all the other details, requires careful consideration to get the best results. As a matter of fact, it is found that for economical results a treble-threaded worm is about the best to use, while double thread and single thread of ordinary proportions are less good.

From some experiments that have been made at Erith it may be taken that the efficiency—that is, the ratio between the output and the input—of an ordinary single-thread gear, including the losses in the thrust and the wheel shaft bearings, should not be less than 52 per cent.; a double-thread gear should be not less than 68 per cent.; while a treble-thread gear should be not less than 75 per cent. A better result still may be obtained from quadruple-thread;

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but it is not so generally useful, and is rather troublesome to make. Better results than these have been obtained, and in one carefully-conducted trial with a treble-thread gear that had been running for some time, and had worked all the surfaces into the best possible condition, the combined efficiency of an electric motor giving out about 9 H.P. and the worm gear, including the thrust block and shaft upon which the Prony brake for testing was fixed, was as high as 85 per cent. This, however, cannot be relied upon in ordinary practice, especially when the gear is new, and therefore the figures given above are to be recommended for general use.

Friction gearing is occasionally employed, and if properly made and adjusted is good, at any rate for small powers. The best form that the writer is acquainted with is Hollick's patent, which has been successfully used for crane work, giving good efficiency, and which may be thus described: The shaft to be driven has a large flat-faced pulley keyed to it, while another similar but smaller pulley is carried by bearings in a swinging frame in such a manner that the two pulleys are in the same plane, but separated from each other a short distance. Round them an endless belt is tightly stretched. The motor is supported on a flexible base, and has on its spindle a pulley made of compressed paper with a perfectly flat face, the size being rather larger than the space between the two iron pulleys. The ratio of reduction is given by the ratio of the diameters of the large iron pulley and the paper one. By exerting a slight pressure on the swinging frame, the paper pulley may be caused to wedge itself between the other two with considerable force, and if the motor is set in motion, the two iron wheels will both be driven by the paper one, the smaller transmitting its power to the larger by means of the belt, which also takes the thrust and prevents any stresses on the bearings. By making the motor base flexible, the paper pulley adjusts itself so as to bear equally against the two iron ones. Of course, to get the best results, this gear requires careful design and manufacture.

It will be interesting to make a comparison between hydraulic power transmission and electricity as applied to crane-driving. There can be no doubt that the hydraulic system is a very simple and convenient one in cases where the power has to be applied from a more or less fixed position, and is especially suitable where the work to be done is fairly constant, as, for example, a crane that always has to lift approximately its full load. In such a case the power may be used to its full advantage, which with variable work cannot be the case, except by the employment of double and treble powered machines, which to a certain extent adjust the water expended to the work it has to do. In this respect electricity has an advantage, as the motor has an inherent power of automatically adapting the amount of current it uses to the work that is demanded of it, though not quite in direct proportion. The motor, therefore, adjusts itself to all loads, while the hydraulic machine can only do so in steps, so that the former must be more economical. Moreover, the motor does this without the aid of any external devices, whereas the hydraulic machine requires a complicated and expensive arrangement to effect the result. But hydraulic power can often be applied in a much more direct manner than electricity, as the latter almost always requires the high-speed rotation of the armature to be converted into a lineal movement in the hoisting arrangement of cranes or lifts involving a good deal of gear, which is, as a rule, not needed by the former. It is evident, therefore, that every case must be judged on its merits, and that sometimes one form of transmission will be more suitable, and sometimes another. But in the case of the particular kind of machinery with which the Paper has been more especially dealing—namely, travelling cranes—there can be but little doubt that the electric system is much more advantageous, mainly on account of the great difficulty in satisfactorily taking the high-pressure water to the moving crane, especially with such a travel as the Erith cranes, say 600ft.

A hydraulic travelling crane was made at Erith a few years ago for the new ranges of the War Department at Shoeburyness to general designs furnished by the Royal Engineers, and this is the only instance the writer knows of where this method has been used for a true travelling crane. The lifting was performed by a direct acting hydraulic cylinder, which would, of course, use as much water to lift one ton as 150 tons, the maximum for which the crane was made, and the two traversing movements were actuated by a rotary hydraulic engine driving a system of shafting and gearing. The principal feature of interest was, however, the method of transmitting the power to the crane, which travelled over a gantry 130ft. long. At the centre of the gantry on one side was a large hose keel containing a coil of "Sphinx Grip" armoured hose, one end of which was coupled to a hollow trunnion, through which the water was admitted to the coil, and the other to a swivel coupling on the crane. The hose was about half the length of the gantry, and thus, according to which side of the centre the crane was, and to the direction in which it was travelling, so the hose coiled or uncoiled from the drum, arrangements being made by means of weights and gearing for the drum to coil up the hose as the crane approached it. The exhaust ran into a continuous gutter laid down all along the gantry. This arrangement worked well, but is clumsy and expensive. The hose requires occasional renewal, and the system could only be applied satisfactorily to short gantries. Contrast this with the simplicity of electric transmission over any gantry, no matter how long it may be, and the advantage will at once become apparent. Besides, it would not be easy to work more than two cranes over the same piece of gantry, one having its coil on one side and one on the other; while with the electric system any number of cranes may work off the same conductors and over the same gantry, provided only the conductors are large enough to carry the required current.

## THE RECENT TELEPHONE CONVENTION IN AMERICA.*

BY FRED. DE LAND.

It was a happy thought that resulted in the election of Judge Barstow as the presiding officer of the Convention, for the honourable judge is a prince among optimists, and a firm believer in the gospel of good cheer. Thus, no amount of croaking could entirely dispel that hearty cheerfulness that permeated every session. To be sure, now and then the discussions were tinged with melancholy, and on the whole the proceedings were of a depressing character; but the judge was as bland as the honey of Hyblea. What matter if Waukesha had "ceased business and sold the plant for a nominal sum, sufficient to cover outstanding indebtedness, leaving the original investment a total loss;" that La Grange had gladly laid down its burden and pocketed the loss; that Selma's doors had been slammed in the face of an ungrateful public who could now pay the higher rates of the Bell Company, simply because they desired some return on an investment that ought to have been given freely from a sense of pride in a home institution? To be sure, the officials admitted that the prices charged and the services rendered were so unsatisfactory that the service had to be abandoned, but their opinion was naturally biassed. Or that St. Joe was wondering how so much money could be for ever lost so quickly, though the local Press laid the blame on "unsatisfactory service—want of out-of-town connections, inferior appliances to the Bell Company, and a rate too low to enable them to attempt a comprehensive service." Suppose the competing telephone plant at Nevada that cost £400 was sold for £30, and that the Pittsburg plant on which over £600 was invested was disposed of under the hammer for £120. Did not the smooth promoter get away with his commission? What if the courts have ordered the notorious Harrison Topeka telephone plant to be sold to satisfy judgments aggregating £6,000. Is there not an abundance of wealth yet remaining in Kansas yearning for just such profitable investment? And who can locate a soft mark quite so quickly as the slick telephone promoter who was the understudy of Dusty Rhoades but a brief space agone? Why should the learned judge care if the Florida long-distance telephone system was disposed of for £30 at Orlanda by a brutal sheriff clothed with a little brief authority? or that the Ypsilanti automatic telephone exchange had been discontinued? The judge was content to look upon the bright side of life, even if 12 members had been side-tracked by the sheriff or for some similar reason since the last meeting, for he well knew that though the hot sun was now roasting the members, yet with the opening of the gates of night would come the stars, and the cooling breeze, and the refreshing sleep, and in that land of dreams that yet may prove to be the real world there is no worry over doomed financial ventures voluntarily assumed; so why worry?

And having called the meeting to order, the judge declared the convention of independent telephone companies open, and directed the calling of the roll. This being done, the secretary reported a gain of 22 new members and a loss of 12 members. As the names of these 12 delinquent members were called, only harsh and unpleasant comments were heard on every side, due, apparently, to no other cause than that some among these ill-fated 12 had allowed an uninvited and ill-bred deputy-sheriff to enter their respective exchanges and levy on the entire plant, merely to satisfy claims for small amounts of filthy lucre. But the judge rapped for order, and said the remarks were uncalled for. "We should learn to bear easily the misfortunes of our friends, and, with Euripides, remember that that man is wise among us, and hath understanding of things divine, who hath nobly agreed with necessity."

After the various committee reports had been read and disposed of, the meeting was declared open for the discussion of special topics germane to the best interests of the association, and the chair urged the members to participate in a full and spontaneous expression of opinion on the rumoured consolidation of all the property interests of the principal Bell licensees and their absorp

* From *Electrical Engineering*.

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tion by the parent company, thus doing away with the royalty fee and effecting a marked reduction in the operating expenses, enabling them the better to meet competition. The chair also desired that the sentiment of the association be placed on record regarding the attitude of the manufacturing telephone companies towards the operating telephone companies. He did not believe that the manufacturing companies were standing up as manfully as they had agreed to, and there was little doubt in his mind that the independent exchanges would have to fight their own battles, while the manufacturing companies exhausted their energy in petty internal squabbles. Thus he believed that the association was not interested so much in what the telephone manufacturing companies were going to do, as whom; for experience had shown how honest they could be when certain of being detected. Nor would he advise any member to lean on any telephone manufacturer for legal assistance in defending the suits the Bell Company would certainly institute. For, basing his opinion on personal observation and the published statements in the electrical press, the chair felt confident that the affairs of these manufacturing companies were in such shape that they could immediately close down or assign in the event of the United States Supreme Court again deciding in favour of the Bell interests. Thus, it is really the part of wisdom to look upon the bond and the guarantee of telephone manufacturers as absolutely valueless, for the Court proceedings already taken show that some, if not all, "are pecuniarily irresponsible and unable to respond to a decree for damages in favour of the complainant in this suit."

The question was asked by one of the members whether there was any reliable information on record regarding the financial standing of the Home Telephone Company claiming several thousand subscribers in many cities, according to the very reliable electrical journals. The secretary replied by reading extracts from a report on the Committee on Telephones for the district of Columbia, on Bill S. 2,498, showing a claim on the part of the promoter of having secured 3,400 subscribers in the district of Columbia at a rate of £8 and £6. 8s., taken from "the portion of the business people of the city who have not been so successful in life, and who have no particular use for the more expensive metallic connection." "We expect to serve people who cannot quite afford to use telephones unless this company is chartered." The gist of the testimony showing that "if the franchise were granted to-day, two years from now would not see 200 commercially working Home telephones in the district of Columbia, if any." The secretary also read extracts from the Cleveland *Plain Dealer* and the Cleveland *Leader*, of May 12, 1895, showing that the Home Company "has no serious intention at present of going ahead with its project." Yet in each city they were successful in disposing of privileges, stock, &c., at good prices. These comments reminded the president of the story of the practical politician who boasted that he had made £50,000 in the last two years, "but I worked for it." "Of course you did," was the reply, "but whom did you work?"

Mayor Pingree's Detroit Telephone Company that is to be operated for 50 per cent. less than the present exchange, next came in for a fair share of criticism for masterly inactivity, and in closing this discussion later on, the chair remarked that the good mayor's comments on the absence of proper protection for the rights of the people were worthy of the able politician who said that all knowledge which does not increase a man's virtue makes him the more dangerous. And he recalled a brief conversation between two politicians accidentally overheard in one of the lower wards in his city: "You look done up, Chimmy. Is it worryin' yuh to make all those reform speeches to the people of your ward?" "It isn't the reform speeches, Tim, it's the work of gettin' the boys to understand how I don't mean 'em, that's worryin' me." The deduction drawn from the printed statements issued by this Detroit Company is that with an average telephone rental of £6. 16s. a year for 5,000 telephones, 10 per cent. dividends can be paid on £120,000 in capital stock, and 6 per cent. on £80,000 in bonds. And all purchasers of stock would be given an equal amount of interest-bearing bonds. In other words, this "reform" organisation would not pattern after the highly improper methods adopted by the grasping corporations so heartily denounced by his honour, "the friend of the people," but would add the water before winning success. In the prospectus issued by the Pingree-Detroit Company earnings and expenses are itemised, thus enabling a comparison to be made with the present expense account of the Bell Company in Detroit, having 4,300 subscribers. Female switchboard operators, Pingree Company, 60 at £1 a week, or £3,000 annually; Bell Company, 107, averaging 24s. per week, or £6,677 annually. The Pingree Company will have ten linemen and three labourers at an annual outlay of £1,500, while the Bell Company finds it necessary to keep 56 linemen and inspectors continually employed at an expense of £6,720. Batteries have to be renewed every few weeks, this item aggregating £2,000 annually for the Bell Company, yet the Pingree Company make no provision for this very necessary expenditure. For new material and repairs to Bell circuits nearly £5,000 are expended annually, yet the Pingree prospectus makes no allowance for this, nor for depreciation, though in 1893 the Bell Company replaced a switchboard that cost £10,800 with one that cost £24,800, and had previously discarded boards costing over £12,000. Yet the Pingree Company add: "And on every additional 1,000 telephones used, the net profit per annum would be £5,000, the ratio of profit being higher as subscribers increase."

The member from Pittsburg suggested that the Pingree Company should secure the services of the bland promoter who has been weaving his meshes about the gullible citizens of Kansas City, as he possessed the ability of operating an exchange of 3,000 telephones at a total expense covering all items averaging but £2. 8s. per telephone, while the Pingree Company allowed the extravagant sum of £3. 1s. 3d. per instrument. To be sure, the Bell Company claims that it costs them about £12 an instrument to operate their exchange, but who believes the fairy tales of successful dividend-paying corporations? Then this Kansas City weaver offers his telephones at only £6. 8s. a year, and his circular clearly demonstrates that if only 3,000 telephones are rented at this figure the annual income will be £19,200, the total annual expense £7,200, leaving the handsome net income of £12,000, or a return of 12 per cent. on an investment of £100,000. But for fear that the holders of this stock may become proud in spirit, the weaver limits the number of shares that any one person should hold to 10 shares of £20 each.

Comment was also made on the promised competition that has failed to materialise in Chicago, Philadelphia, St. Louis, and other large cities, and to the feeling of pride that must permeate the bosoms of Messrs. Clarkson, Egan, Tracy, Aldrich, Porter et al., when they gaze upon all that has been accomplished.

Incidentally, the chair remarked that there was ample legal talent both within and without the Association ready for sacrifice in fighting this gigantic monopoly—for a consideration, but that he had fully made up his mind that the only safe course to pursue, when the United States Supreme Court delivered its opinion sustaining the validity of the Berliner patent, was to surrender and have his loss as small as possible, unless in the meantime he could find some good-natured relative on whom he could unload his holdings in the independent exchanges.

Here the member from Oskaloosa interrupted the President's remarks by asking if he could name an actual independent exchange; there were plenty of dependent exchanges, dependent on the holders of overdue notes and mortgages; but an independent competing exchange? Impossible! One of the exchanges in Iowa was so anxious to be absorbed by the Bell or any other Company without money and without price that its beseeching attitude reminded him of the tramp's reply. Weary Willie had entered the yard with the firm intention of disabling all competition, but by a masterly retreat he had scaled the fence just in time to escape the fangs of a savage bulldog: "Madam, I did intend to demand something to eat, but all I ask now is that, in the interests of humanity, you'll feed that dog."

The next question that came up for discussion was the advisability of erecting toll lines. One of the members appeared bent on forcing each company to bear its share of an assessment that would enable interconnecting lines to be built, and thus afford subscribers in one exchange full communication with the subscribers in any other exchange in the State. But he talked so long and digressed so widely, that when he finally subsided someone was cruel enough to intimate that there are a great many ginger-pop people in the world. After they have been uncorked for a few minutes they get to be dreadfully flat.

Mr. Cleveland doubted the wisdom of erecting many toll lines "until we have had more experience in this business. If we do we shall probably have good cause to regret the outlay. For few toll lines have proved to be a profitable investment, either in the East or the West. Take the lines that connect the small outlying village exchanges with any large city, and the income rarely equals the operating expenses, while the deficit—to make good the cost of maintenance and the fixed charges—must come out of the income of the city plant which creates and maintains a toll line and exchange for the convenience and benefit of its city patrons, rather than from any expected profit that would accrue from village conversations. Rarely will the public pay more than ½d. a mile for short distances of 50 miles or less, and ¼d. for distances exceeding 50 miles, and as an average of only five conversations per hour can be held over any ordinary toll line, the income never justifies the outlay save from the standpoint of favouring the subscribers of the large exchange."

A spirited discussion followed, in which nearly every member participated, but it was soon evident that some prearranged plan existed for forcing the association to endorse a movement in favour of toll lines. The minority protested against any action that necessitated further expenditures of moneys. Toll lines were necessarily expensive to build properly, as well as difficult to maintain in good working order in this section so often visited by severe storms, while it was doubtful if the receipts would ever equal the cost of operating the lines; and as not one shilling of

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legitimate profit had yet been secured from any investment in these small independent exchanges, any motion to increase the investment until a dividend had been declared would meet with determined resistance. Even with their more profitable rates the Bell Companies did not dream of general toll lines for several years after the principal exchanges had been established, and only since August 1st has it been possible to talk direct from Davenport to eastern points over the long-distance trunk lines.

Mr. Cleveland said that he fully appreciated the great value to a local exchange of the right of way for transmission of messages over trunk lines, and he felt that in the near future some concerted action that might bring about inter-State connections would be not only desirable but absolutely essential to preserve the integrity of the capital already invested. But this was not the time nor the place to adopt coercive measures. No one appreciated more fully than he did the great value of the telephone as a time-saver to business men, and he had heard of many instances of men travelling by rail to Chicago and then using the long-distance line to close some important deal in Boston or New York, or some Eastern city. But these long-distance trunk lines were owned by a separate company, and built and maintained by capital invested independently of any investment in the local exchange. No doubt an independent long-distance company might be formed, but he did not care to invest any money in such an enterprise. To build a pole line properly, and string two wires for one complete metallic circuit, would cost £80 to £90 a mile; additional circuits could then be added from time to time as the traffic justified, at comparatively small expense. Yet, he understood that toll lines had been built for £50 a mile, and rebuilt after the first heavy storm. Even the lines in the city of Madison, the headquarters of a branch of promoters, could a tale unfold were they inclined to be talkative.

Mr. Bartin defended the other side of the question by saying that experience had taught some very good Wisconsin people that profits can only be realised when capital is invested in a productive enterprise operating more fully, more satisfactorily, and at less cost than existing competition, and more especially is this true of public or semi-public service plants, where the ultimate profitableness of the investment is so largely dependent on the general acceptance of the service supplied. This was well illustrated in the case of the Waukesha telephone exchange. No Wisconsin town enjoys so many advantages, so many well-to-do, progressive, and public-spirited citizens, who never hesitate to make any investment that will aid in building up their town, and making it still more famous, not only for its beautiful surroundings and its health-restoring mineral waters, but for the public conveniences afforded the citizens. Thus, when a new telephone exchange was proposed, ample capital was quickly forthcoming, and in a short time an excellent exchange was in operation, with a large number of subscribers, and there was every indication of it being a prosperous undertaking. But after the third or fourth month the receipts began to drop off, and gradually one subscriber after another relinquished the service, until the plant was sold for a sum that merely covered the current bills, leaving the original investment a total loss. The explanation is easily given. It was not so much a question of the inferiority of the instruments or the indifferent service furnished, as it was the absence of all toll-line connections. Now, the majority of the well-to-do residents of Waukesha have their places of business in Milwaukee, Chicago, or in one of the towns in the valley, and necessarily must have telephonic communication that is at all times available to those points. Thus, when they found that the new telephone circuits were limited to the subscribers within the town, and that to have constant telephone facilities with outside places it was necessary to also subscribe to a Bell instrument, they naturally came to the conclusion that a second telephone was of no real value, and quickly dropped it. And thus, while the new exchange had more subscribers than the old Bell Company at the start, the new company could not give the service demanded, and thus had to close its doors. And Mr. Bartin believed this would be the fate of every exchange represented in this Convention, unless they joined in the building of interconnecting lines that would enable them to give the class of service any customer might desire.

The report of secretary E. M. Hopkins, of the Board of Trade, Saginaw, Michigan, who was commissioned to investigate and report upon the advisability of establishing a competing telephone exchange in Saginaw City and the Valley, came up for consideration, and was severely criticised because of his adverse decision. Mr. Hopkins reported that "There is one conclusion you quickly reach, and that is that someone has been lying about the telephone business. You cannot by any possible reasoning reconcile the figures put forth by telephone company promoters and the Bell people. They are as far apart as daylight and darkness. . . Judge Gages states that each individual subscriber to the stock of a telephone company is individually liable for all material and labour used." And his recommendation was adverse to investing any capital in a competing telephone exchange "until the decision of the Supreme Court is had in October."

## SOME CONTINENTAL ELECTRIC LIGHTING STATISTICS.

We recently published (see *The Electrician*, September 4, p. 614) a table containing statistics of some continental central stations. Herr F. Ross, in an article in the *Elektrotechnische Zeitschrift*, gives two more useful tables comparing the outputs of gas and electric-lighting stations in some of the largest towns in Germany. He observes that an important factor in comparing the performances of central stations is the ratio between the useful output during the year, the maximum output for one hour, and he calls this factor the "yearly burning time" (*Jahresbrenndauer*).

Table I. gives the value of this factor for a few of the gas works in Germany. In this table the high figure against Hamburg is due to the fogginess of the atmosphere, to the narrowness of the streets in the old portion of the town; and, further, to the large scale on which the public lighting is carried out. This last reason also applies to Cologne and Stettin. The high figures for Bremen and Düsseldorf may be occasioned by the day-load in these towns. In both the consumption of gas for cooking, heating, and motors, exceeds 27 per cent. of the total output. The numerous factories in the neighbourhood of Chemnitz and Mühlhausen decrease the mean burning time.

Table II. is calculated on the assumption of an average output of 669 watts per horse-power delivered by the machine. For central stations, which have batteries of accumulators, it is assumed that the batteries can discharge themselves in three hours if required. In the first column is given the ratio of the actual maximum output to the maximum possible output reduced to a percentage, in column B the corresponding figure for the distribution network, and in column C the "yearly burning time," defined as above.

Among the stations where the number of motors on the mains is very small, Vienna shows up the best. This is due to the size of the network. The house frontage is 155 miles long. Also, the time of maximum demand in private houses usually comes after the time of absolute maximum demand.

The highest figure for *Jahresbrenndauer*, which obtain for gas works as compared with the electric light works in the same town, may be attributed to the more varied *clientèle* of the gas undertakings.

**Table I.**—*"Yearly Burning Time" of some German Gasworks.*

| — | Hours. | — | Hours. |
|---|---|---|---|
| Berlin ..... | 1,590 | Darmstadt ..... | 1,500 |
| Bremen ..... | 1,810 | Düsseldorf ..... | 1,810 |
| Breslau ..... | 1,490 | Hamburg ..... | 1,900 |
| Chemnitz ..... | 1,180 | Mühlhausen ... | 1,090 |
| Cologne ..... | 1,720 | Stettin ..... | 1,740 |

**Table II.**

| | A. | B. | C. | Station opened. |
|---|---|---|---|---|
| Aix-la-Chapelle ..... | 31 | 52 | 1,515 | Jan., 1893 |
| Altona ..... | 34 | 25 | 1,930 | March, 1892 |
| Hamburg ..... | 65 | 55 | 1,690 | Dec., 1883 |
| Mühlhausen ..... | 78 | 80 | 1,052 | March, 1888 |
| Barmen ..... | 37 | 38 | 834 | Dec., 1888 |
| Bremen ..... | 57 | 40 | 1,000 | Oct., 1893 |
| Breslau ..... | 60 | 60 | 1,069 | June, 1891 |
| Christiania ..... | 64 | 67 | 893 | Dec., 1892 |
| Cologne ..... | 40 | 42 | 1,121 | Oct., 1891 |
| Copenhagen ..... | 65 | 55 | 842 | March, 1892 |
| Darmstadt ..... | 82 | 77 | 673 | Aug., 1888 |
| Dessau ..... | 40 | 40 | 713 | Oct., 1886 |
| Düsseldorf ..... | 36 | 28 | 1,100 | Sept., 1891 |
| Elberfeld ..... | 54 | 60 | 735 | Nov., 1887 |
| Hanover ..... | 56 | 57 | 1,129 | March, 1891 |
| Königsberg ..... | 51 | 16 | 914 | Dec., 1890 |
| Stettin ..... | 63 | 44 | 1,061 | Oct., 1889 |
| Stockholm ..... | 26 | 30 | 1,150 | Sept., 1892 |
| Vienna ..... | 50 | 60 | 1,701 | Nov., 1890 |

## BOOKS RECEIVED.

"Roentgen Rays and Phenomena of the Anode and Cathode." By Edward P. Thompson, M.E., E.E., and Prof. William A. Anthony. (New York: D. Van Nostrand Company). Price $1 50c.

"Proceedings of the American Association for the Advancement of Science." Springfield Meeting, 1895. (Salem: Published by the Permanent Secretary.)

"Proceedings of the Royal Society." No. 358, Vol. LIX. Price 3s. 6d. No. 359, Vol. LX. Price 4s.

"Die öffentliche Beleuchtung von Berlin." By Dr. H. Lux. (Berlin: S. Fisher.)

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# CORRESPONDENCE.

## POSITIVE PLATES FOR ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: For the past six years I have had to do with a small central station, which has been altogether, up to the present, worked by water power. It is easy to see how important accumulators become under circumstances of this kind. I have had to do with accumulators during these six years, and I have been trying to settle which of several kinds is best. The important question is the life of the plates. If we divide the various kinds of plates into three families we have:—

1. Grid plates, including pasted plates and plates in which a grid has been cast round pellets.

2. Gill plates, including those in which a considerable surface action has been produced by the makers.

3. Planté plates, mere sheets of lead.

If we consider No. 3 first; everybody is familiar with the enlargement of the plates by use, and their finally becoming rotten and falling to pieces. My experience of No. 2 kind is that they soon begin to throw off a quantity of fine mud, which settles at the bottom of the boxes and, mounting up, short-circuits the plates. I have had repeatedly to go over such a battery, cleaning out the boxes and straightening the plates. Ultimately the plates become rotten right through and fall to pieces. The troubles with No. 1 arise from the grid becoming rotten (I would say Plantéised, but I do not desire to associate so honourable a name with a difficulty of this kind).

I speak in no spirit of antagonism to makers of plates. They are our friends. But my experience is that we must recognise the comparatively short life of positive plates, and we must arrange for the constant replacing of them as a part of the regular routine of the station. Batteries will have to be put together in such a way as will allow of regular cleaning of the boxes and renewal of plates, and each station must organise a shop for remaking plates on the premises. Can arrangements be made with makers of plates in this direction? The question seriously concerns engineers. I shall be glad to get the views of other men.—Yours, &c., JAMES PERRY.

Galway Electric Works, Galway,
September 12, 1896.

## PHOTO PRINTING OF TRACINGS BY ARC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If my own experience in photo printing tracings by arc light agrees with that of others, I should feel inclined to offer your correspondent, "B. M. J.," *Punch's* advice, and say "Don't," for I have found it a terribly slow business.

For instance, with two 6-ampere naked arcs—in series on 110 volts—suspended side by side about 18in. from frame (standing on edge), and with a sheet of white paper arranged as a reflector behind arcs, I find it takes about four hours to get a decent print—double elephant size—with ordinary good quality blue printing paper, and then the position of frame wants changing from time to time; otherwise the print is patchy.

For the sake of comparison I may say that five minutes' exposure to a clear sky gives a far better print; but, of course, the "clear sky" is not always to hand when wanted, and if the prints cannot wait, artificial light must be used, in which case I trust that "B. M. J." will find the experience given above of assistance.—Yours, &c., S. H. BLAKE.

Leeds, Sept. 19, 1896.

## LOCK-ARMOURED ELECTRIC LIGHT CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have read with much interest the letter from Mr. Callender referring to our high-conductivity lock-armoured electric cables. We see that he gives you notice that this is an infringement of certain patents issued to Messrs. Latch and Batchelor as far back as 1884. We may say that these patents refer to matters with which we are not concerned, and they do not affect the novelty of our new electric cable. If Messrs. Callender and Co. consider that they can prevent our manufacturing and selling our armouring we shall be willing to meet them at the proper time in the Law Courts, where the question can be settled by proper authorities. Meanwhile we shall continue to advertise, vend, sell and use our new electric cables; and we desire, through your columns, to inform our friends that we are perfectly prepared to protect them against any action that Messrs. Callender and Co. or others may think proper to take.

We would also like to thank Mr. Callender for his letter to you, for we very much appreciate his kindness in calling the attention of the Trade to our manufactures.—Yours, &c.,

W. T. GLOVER AND CO.

39, Victoria-street, Westminster, London, S.W.
September 21, 1896.

# TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d.; abroad 9s.**

**The New Edition for 1897 is in active preparation, and circulars and full information will shortly be forwarded. The Subscription price remains 5s., postage 9d.; abroad, 6s. 6d., post free.**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. *The New Edition is now ready.* Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated; price 12s. 6d. *Now ready.*

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. is also ready; price 7s 6d. (abroad 8s.). Prospectus on application.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables, 30s., post free.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d., post free.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY."—By E. Tremlett Carter, C.E., M.I.E.E. *Ready in a few days.* Price 12s. 6d.; post free, 13s. 6d.

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TENDERS INVITED.—The Directors of the Dundee Royal Lunatic Asylum invite tenders for boiler, fittings, steam pump and piping, wiring, fittings, accumulator batteries, steam and oil engines and dynamos, for the electric lighting of the Institution. Specifications and forms of tender may be obtained from the engineer (Mr. Walter H. Tittensor), Dudhope Crescent-road, Dundee, and tenders must be sent in to the Secretary (Mr. Robert C. Walker), 5, Whitehall-street, Dundee, by noon of Friday, Oct. 9th. Further details are given in our advertisement columns.

——— The Leyton Urban District Council invites tenders for the installation of the electric light in the Public Library. Forms of tender may be obtained at the Surveyor's Office, Town Hall, after Monday next. Tenders must be delivered at the meeting of the Council at 7 p.m. on October 6th, at the Town Hall, Leyton. Further particulars appear in our advertisement columns.

——— The Leeds City Council invites tenders for the supply and erection of two overhead cranes for the engine house of the tramways electricity generating station. Tenders have to be in by noon 13th October.

——— The Spanish Minister of Marine invites tenders for the laying of a submarine telegraph cable between the islands of Luzon, Panay, Negros, and Cebu (Philippine Islands). Provisional deposit, £2,000; definite deposit, £4,000. All particulars may be obtained from the Ministerio de Ultramar, Madrid, and tenders must be in by December 13th.

——— The Spanish Post and Telegraph authorities invite tenders for the supply of 60,000 porcelain insulators. Tenders to be sent to the Direccion General de Correos y Telegrafos, Madrid, by October 12th.

——— The Société Nationale des Chemins de Fer Vicinaux invites tenders for the electrical equipment of about 14 miles of suburban railway at Charleroi and elsewhere, on the overhead trolley system. Particulars from the Company, Rue de la Science, 26, Brussels. Tenders to be in by October 28th.

——— Tenders are invited by the French Post and Telegraph authorities for the supply of 137 kilometres of paper-insulated electric cables in 12 lots. Tenders to the Sous-Secretariat d'Etat des Postes et des Telegraphes, 103, Rue de Grenelle, Paris, by October 8th.

TENDERS ACCEPTED.—The tender of the Callender Company has been accepted by the Dewsbury Town Council for the supply of cable for electric light extensions.

TENDERS RECEIVED.—The Armagh Asylums Board have received the following tenders for the installation of the electric light at the asylum:—

| | |
|---|---|
| Cooney and Swann, Belfast | £2,142 |
| Inrig and Chester, London | £1,961 |
| Cox Walkers, Darlington | £1,766 |

These tenders have been referred to a committee who are to interview the consulting engineer (Mr. J. H. Greenhill, of Belfast) as to the most suitable scheme.

APPOINTMENTS.—Mr. Alexander Davidson, an old pupil at the Glasgow and West of Scotland Technical College, has been appointed electrician to the Central and South American Telegraph Company.

——— Mr. W. R. Bower has been appointed lecturer in Physics and Applied Mechanics at the Huddersfield Technical School. Mr. Bower was until recently lecturer in electricity and electrical engineering at the Municipal Science School, Brighton.

APPOINTMENTS VACANT.—An assistant lecturer and demonstrator in engineering is required for the University College of South Wales and Monmouthshire. Salary £150 and allowances. Applications to the Registrar (Mr. J. A. Jenkins, B A.), University College, Cardiff, by October 2nd.

——— The County Borough of Salford require the services of a good cable engineer, with experience in compound and india-rubber high-tension cables and house-service connections. Some particulars will be found in our advertisement columns, and applications must be sent in by 5 p.m., on September 30th.

——— A teacher for the electrical class at the Belfast Technical School is required. Applications should be sent to the Secretary, 10, Donegal-square West, Belfast.

———A clerk of works is required for the foundation work in connection with the extension of the Bristol electricity station. Applications to the Secretary of the Electricity Department, Temple Back, Bristol, by October 3rd.

WORKHOUSE AND INFIRMARY LIGHTING.—Mr. Charles Taylor, Clerk to the Guardians of the Isle of Thanet Union, Minster, Ramsgate, wishes to receive information and particulars relating to the installation of the electric light in workhouses or infirmaries, as the Board of Guardians of the Union are considering the subject, and would be glad to have particulars furnished which would assist them in their deliberations.

FAILURE.—Thomas Lomax Harrison, electrical engineer, Back Church-street, and 30, Devonshire-road, Blackpool, has filed a deed of arrangement with his creditors. The unsecured liabilities are estimated at £221. 13s., and the assets at £115. 11s. 8d.

LIQUIDATIONS.—A meeting will be held at 86, King-street, Manchester, on October 20th, to receive an account of the winding-up of Thomas Barraclough and Co. (Limited), late cable covering machinery makers.

——— It has been resolved to wind up the British Engineering Company (Limited) voluntarily; and the liquidator (Mr. H. E. Abbott) has been authorised to consent to the registration of a new Company with the same title.

——— A meeting will be held at 32, Victoria-street, Westminster, S.W., on October 16th, at one p.m. for the purpose of receiving an account of the voluntary winding-up of the Fowler-Waring Cables Company (Limited). In February last a new Company was registered with the same title for the purpose of carrying on the business of the Company.

——— A petition has been presented by Messrs. Taylor and Hubbard, engineers, Kent-street Works, Leicester, for the winding up of the Wigston Electrical and Engineering Company (Limited). The petition will be heard by Mr. Justice Vaughan Williams, at the Royal Courts of Justice, Strand, London, on October 28th. Messrs. Crowders and Vizard, 55, Lincoln's Inn-fields, W.C., are solicitors for the petitioners.

——— A petition has been presented by the Debenture Corporation (Limited), Worcester House, Walbrook, London, for the compulsory winding-up of Dietz, Davis, and Co. (Limited), electrolier and lustre manufacturers, 44, Upper East Smithfield, E., and will be heard at the Royal Courts of Justice, Strand, W.C., on October 28th. Messrs. Linklater, Addison, Brown, and Jones, 2, Bond-court, Walbrook, are the petitioners' solicitors. In our issue of the 4th inst. we announced that the Company had gone into voluntary liquidation, and that Mr. A. G. Clark, 39, Beech-holme-road, Upper Clapton, N.E., had been appointed liquidator.

ANUARIO DE LA ASOCIACIÓN DE INGENIEROS INDUSTRIALES DE BARCELONA.—We have received a copy of the list of members of this Association corrected to the end of 1895. The list is issued in handy form, and should prove useful to engineers and manufacturers having business relations with Spain.

ALUMINIUM.—Messrs. F. Braby and Co. inform us that they have obtained a solder for aluminium, which they have proved will make a strong, bright, clean and neat joint.

FORTHCOMING BOOKS.—Messrs. Whittaker and Co. will issue in a few days Mr. Gisbert Kapp's translation into English of his work "Transformers for Single and Multiphase Currents," and a series of electrical engineering design sheets by the same author is also being issued by Messrs. Whittaker, who have in the press a work on "Central Station Electricity Supply," by Messrs. A. Gay and C. H. Yeaman, of the Islington Municipal Electricity Works.

DOMESTIC TELEPHONES.—We have received a copy of the supplement to the sixth edition of the Telephone Catalogue of the General Electric Company. The first portion of this *brochure* is devoted to prices, explanatory letterpress, and diagrams referring to the "General" intercommunication system. The special advantage claimed for this system is that the switch can be left in any position as last used and a call still received. The system is already in use in many suites of City offices, hospitals, institutions, private houses, mansions, &c., and has given satisfaction. The second half of the pamphlet is devoted to the "Stanley" telephone, which has been specially brought out for ready connection to existing electric-bell lines. Besides the ordinary wall combinations there is the "Commercial Stanley Set," and a combined hand telephone (transmitter and receiver), in the handle of which is a ringing and speaking key of ingenious construction, enabling the ringing circuit to be switched out and the speaking circuit in, or *vice versâ*, by a simple compression of the hand.

GLOW LAMP REFLECTORS.—We have received from the National Reflector Syndicate a sample of the "National" Patent Glow Lamp Reflector, by the use of which it is claimed a largely increased percentage of light is obtainable. The fitting can be instantly attached to any lamp on the market, and is easily removed with the bulb for cleaning. The reflector is made of metal, and costs only a few pence per dozen. It hides the socket fittings of the lamp, and certainly adds to the light given, especially from blackened bulbs. The fitting is an effective one, and is not unornamental. It might be made in two or three sizes, and should meet a large demand.

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ALLEGED EMBEZZLEMENT.—Edward Charles Offor, formerly secretary to the Bournemouth and District Electric Supply Company, was again charged at Bournemouth, on Wednesday, with embezzling £420 of the monies of the Bournemouth Company, between January, 1893, and March, 1896. The prisoner, who appeared deeply impressed with his serious position, was arrested at Gilling-

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ham. Mr. Francis, who appeared for the Company, said he was unable to proceed with the case, and asked for another remand, as the accountant in London who had gone through the Company's books was away, and unable to reach Bournemouth that day. On behalf of the Company Mr. Francis stated that there was no objection to bail being allowed, especially in consequence of the prisoner's state of health. Mr. Trevanion, who appeared for the prisoner, asked that he might be admitted to bail on his own recognisances, as his friends had kept aloof from him, and anything like prohibitive bail he would be unable to obtain. The magistrates agreed to admit prisoner to bail in one surety of £50 or two of £25 each, and the prisoner himself in £50, with 48 hours in which to find sureties. The prisoner was formally remanded until to-morrow (Saturday), when there will be a further remand until Tuesday.

ASTLEY BRIDGE (BOLTON).—A meeting of the District Council was held last week for the purpose of considering the proposal to equip the Bolton and suburban tramways on the overhead electric traction system. After a prolonged discussion it was unanimously resolved to give every facility for the improvement of the tramway service and for the introduction of electric traction on the lines, provided the experiments being made on the Bolton-Daubhill section were successful.

AYR.—The revenue account of the electricity department for the three months ended May 31st showed a deficiency of £25. 18s. 5d., and after taking interest and sinking fund into consideration, the total deficiency amounted to £252. 7s. 10d. The capital expenditure to the end of May amounted to £20,768. 12s. 4d.

BIRMINGHAM.—The *Birmingham Post* states that tenders will shortly be invited for the construction of the Kidderminster and Stourport Tramway. The promoters of the line are the British Electric Traction (Pioneer) Company, of 1 and 2, Great Winchester-street, London, E.C., the engineers being Messrs. Alfred Dickinson and Co., of Colmore-row, Birmingham. The overhead trolley system is to be employed.

BOLTON.—The Town Council has decided to expend an additional sum of £30,000 in the extension of the electricity works and plant.——The Spinners' Hall has just been wired for the electric light, the work having been executed by the staff of the Corporation's electricity department.

BRIGHOUSE.—The Town Council has decided to apply for a Provisional Electric Lighting Order. The corporate seal has been ordered to be affixed to the agreement with Mr. A. B. Brook, electrical engineer, for the purchase of his electric lighting plant.

CITY AND SOUTH LONDON RAILWAY.—The City and South London Railway Company have entered into a contract with Messrs. J. Mowlem and Co. for the construction of the extension of the railway to Islington. Messrs. Mowlem, who are the contractors for the Waterloo and City Railway, will, it is stated, proceed with the work forthwith. It has not yet been decided what course will be adopted with regard to St. Mary Woolnoth church, the question as to whether it is possible to construct the station under the building being still before the Company's engineers.

DOVER.—The residents of Biggin and Cannon-streets are alarmed at the prospect of these two thoroughfares being lighted by means of gas lamps, and have presented a unanimous memorial to the Town Council in favour of the adoption of the electric light. The memorial states that "in the presence of the large number of handsome private arc lights which have been put up by the enterprising merchants of these streets, the effect of the combination therewith of incandescent gas lights, however good in themselves, would be incongruous."

ELECTRIC TRACTION IN THE MIDLANDS.—An important project for the connection of Birmingham and Walsall by means of a tramway to be worked by electricity has been brought forward by Messrs. Dickinson & Co., electric traction engineers, of Birmingham. It is proposed to construct the tramway from Perry Bar, Birmingham, along the Walsall main road. An outline of the scheme was submitted to the Walsall Town Council on Monday, and is looked upon with favour in municipal circles, a sub-committee having been appointed to consider and report upon the matter. Plans and particulars are being prepared for submission to the other authority concerned, viz., the Staffordshire County Council. The proposed line would be partially in the nature of a light railway, and, if carried out, would be the first application of the provisions of the Light Railways Act to the Midlands. The scheme provides for laying the lines along the greater part of the route on the light railway system, viz., a single line on one side of the road, and as close to the hedge as possible; but near the termini at Perry Bar and Walsall the track would be laid in the centre of the roadway and would be paved. It is stated that, should the Board of Trade approve the scheme, the necessary powers for beginning the work would be obtained almost immediately. The length of the line would be about five miles, and the cost has been roughly estimated at £30,000, assuming that the line is built throughout on the light railway principle. In addition to the ordinary passenger traffic, it is estimated that a considerable income would be earned by carrying parcels and light goods.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from September 16th to September 22nd, with the ports of destination:—

*Argentina*—Buenos Ayres, £829 (telegraph wire). *Australasia*—Brisbane, £763 (telegraph material); Melbourne, £846; Nelson, £15 (telegraph material); Sydney, £1,395 (including £45 telegraph material); Wellington, £1,115. *Ceylon*—Colombo, £193 (including £172 telegraph material). *China*—Shanghai, £213; Tientsin, £45. *Egypt*—Port Said, £63. *France*—Boulogne, £41. *Germany*—Borkum, £4,818 (telegraph cable). *Gibraltar*, £15. *Holland*—Amsterdam, £75; Flushing, £6; Rotterdam, £28. *India*—Calcutta, £139; Madras, £161. *Japan*—Yokohama, £8. *Mauritius*, £29 (telegraph material). *Portugal*—Lisbon, £112 (telegraph apparatus). *Russia*—St. Petersburg, £88. *South Africa*—Cape Town, £156; East London, £733; Port Elizabeth, £93. *Spain*—Pasages, £49; San Sebastian, £35. *Straits Settlements*—Singapore, £34 (including £75 telegraph material). *Sweden*—Gothenburg, £94 (telegraph wire); Malmo, £21 (telegraph material); Stockholm, £339. Total, £12,606.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows:—

*Hong Hong*, £75 (telegraph material). *Straits Settlements*—Singapore, £50. *Sweden*—Stockholm, £45 (telephone apparatus). Total, £171.

GREAT GRIMSBY.—A syndicate has been formed for the purpose of constructing a light railway from Saltfleetby to Grimsby and Cleethorpes. Messrs. Allen and Geves are engineers for the project, and application is to be made forthwith to the Light Railway Commission for an order authorising the construction of the line.

HALSTEAD (ESSEX).—As a result of the canvass of the ratepayers recently made by Messrs. Crompton and Co.'s representative, offers to take 500 lights have been received by the District Council. The question of the advisability of applying for a loan for the erection of electricity supply works for public and private lighting is being considered by the Lighting Committee.

HOYLAKE.—The question of the purchase of the undertaking of the local gas company has been before the District Council for some time past; but the matter has now been shelved, and it has been decided to apply for a Provisional Electric Lighting Order.

HULL.—The Chairman and Deputy-Chairman of the Electric Lighting Committee have been requested to confer with the borough electrical engineer (Mr. A. S. Barnard) as to the appointment of a consulting engineer at a fee not exceeding 50 guineas to report upon the proposed electric light extension scheme.

LEEDS.—Already the question of the extension of the tramway system is engaging the attention of the Highways Committee. A special meeting of the Committee was held on Tuesday to consider a proposal to visit certain parts of the city in which it is proposed to extend the tram lines; and as the result of a tour of inspection in the East Ward it was unanimously agreed to recommend that the lines be taken along East-street as far as Easy-road and along that thoroughfare into York-road.

LEICESTER.—The Leicester Guardians have decided to fit up the Board and Committee rooms, clerk's offices, &c., of the workhouse for the electric light, at a cost of £60.

LIMERICK.—As the Town Council has now discovered that it cannot, by virtue of its Provisional Order, prohibit private firms from supplying themselves with the electric light, it has decided to abandon its proposed electric light scheme, and has instructed the consulting engineer (Prof. A. B. W. Kennedy) not to proceed further with the preparation of plans. The Limerick Order was obtained in 1892, and no serious attempt was made to put its provisions into force until about six months ago, when it was discovered that some of the largest establishments in the town proposed to put down independent plant; in fact, quite a number of private installations are already in existence in the city. With a singular lack of foresight the members of the Council have allowed their best customers to slip away, and the present outlook for municipal electric lighting works in Limerick is anything but promising.

MOSS SIDE (MANCHESTER).—A conference recently took place between the Lighting Committee of the Manchester Corporation and the District Councils of the adjoining townships relative to the proposal of the former body to extend their electric lighting mains to the suburban districts. The deputation from the Moss Side Council has presented a report recommending the Council to acquiesce in the proposed arrangement. The Manchester Corporation offered to supply electric current to these districts at the same price as that charged to customers within the city. The terms would be 5 per cent. upon the entire outlay, or 6d. per unit, and the Corporation would take all risks. The Clerk, however, explained that the Council would have to apply for a Pro-

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visional Order, and this Order could not be transferred to the Manchester Corporation. A special meeting of the Council is to be called for the purpose of considering the question of applying for an Order.

PRESENTATION.—On Friday last Mr. Francis Teague, late engineer to the Scottish House to House Company, was presented at the Coatbridge Electricity Works with a set of drawing instruments as a mark of esteem from his late colleagues and other friends, on the occasion of his appointment as Burgh Electrical Engineer for Paisley. The presentation was made by Mr. Dale, assistant engineer at Coatbridge, who referred to the three years' connection of Mr. Teague with the Scottish House to House Company, and to the pleasure which the staff and all concerned felt at the important appointment which Mr. Teague had obtained at Paisley. The chair was taken by Mr. John Spittle, and representatives of various industries in the town were present. Mr. Teague, in acknowledging the remarks made by the chairman and Mr. Dale, referred to the hard work that they had sometimes to undergo at Coatbridge and the cheerful manner in which the staff had always worked while under his direction. The chairman alluded to the satisfactory manner in which Mr. Teague had overcome the difficulties encountered at Coatbridge, and to the satisfaction which the electric light was giving in the town.

ROBBERY.—Two "electricians" named Sharp and Frost, in the employ of the National Company, were sentenced by the magistrate at Richmond (Surrey) Police Court to two months' imprisonment, with hard labour, for stealing a call-room pay-box. It was stated for the prosecution that there had been lately a large number of robberies from call-boxes in different parts of the metropolis, evidently the work of persons acquainted with the construction of the Company's apparatus. As the prisoners pleaded guilty, other serious charges were not gone into.

STIRLING.—The refusal of the Police Commissioners to carry out the provisions of their Provisional Order is at present agitating the minds of the citizens of this burgh. A largely-attended meeting of ratepayers was recently held to protest against the inaction of the Commissioners, and a resolution was passed requesting them to introduce the electric light without delay. When this resolution was submitted at last week's meeting of the Commissioners, Provost Kinross stated that there was no obligation on the Commissioners to introduce the electric light, which would at present mean a deliberate waste of money. Exception is taken to the Provost's statement, and it is probable that another meeting of ratepayers will shortly be held to consider the matter.

STOCKTON.—It is stated that the Stockton and Middlesborough Water Board are considering the possibility of utilising the motive power from the waterworks for generating electric current.

WIMBLEDON.—The District Council has formally resolved to apply for a Provisional Order. The Council obtained an electric lighting licence so far back as 1889; but nothing was done to comply with its provisions until 1895, when Mr. A. H. Preece formulated an electric lighting scheme, and application was made to the Local Government Board for sanction to borrow the money necessary to carry out the scheme. The Council's application was, however, rejected by the Board on account of the unexpired period of the licence being too brief. After this check the Council turned its attention to the question of public lighting by oil lamps; but we learn that these experiments have been anything but satisfactory, and another attempt is to be made to introduce the electric light.

WINDSOR.—Work in connection with the Windsor electric lighting scheme is proceeding apace. The premises formerly known as the Royal Albert Brewery are being rapidly converted into an electricity supply station. The mains will shortly be laid in the principal streets, and a number of establishments have already been wired. It is anticipated that current will be available in November next.

WORKHOUSE LIGHTING.—The Committee recently appointed by the Thanet Board of Guardians to consider the question of the illumination of the workhouse has presented a report recommending the introduction of the electric light. At present the Guardians pay about £400 per annum for gas lighting. Incandescent gas burners had been fitted in the house to a limited extent, and the general adoption of the system was under consideration, but, owing to the adverse report of the officers, the idea was abandoned. The Committee therefore obtained the following tenders for a complete electric lighting installation:—

| | Installation. | Annual cost. | No. of lights. |
|---|---|---|---|
| Harrap, Hewett and Duffield | £1,550 | £270 | 410 |
| F. A. Glover and Co. | 1,484 | 200 | 383 |
| W. Mackie | 1,130 | 287 | 368 |

Messrs. Glover did not include in the annual cost any allowance for depreciation. After discussing the matter at some length, the Clerk was instructed to obtain information as to the result of the introduction of the electric light into other Unions and institutions, and the further consideration of the matter was adjourned. This matter is also referred to on page 711.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

August 26, 1896.

18,843. H. G. RICHARDSON. Manchester. Improvements in electrical switches.

18,867. E. K. SCOTT. Wolverhampton. Improved electric trolley mast.

18,878. THE MIDLAND PURCHASE SYNDICATE (LIMITED) and W. H. GRITTON and W. WHITINGTON. London. Improvements in gas valves actuated by means of electrical energy.

18,889. A. P. LUNDBERG. London. Improvements in electric light switches

18,892. C. J. HALL and H. J. FULLER. London. Improvements relating to switch fuses or electric safety fuses.*

18,907. H. IMRAY. London. An electric coin-freed apparatus for dispensing liquid refreshments. (Octave Valdobra, Belgium.)

18,908. F. C. LEHFELDT and J. STEVENS. London. An improved writing desk or slab, more particularly applicable as an adjunct to telephone receivers.*

18,912. M. FRENDENBERG. London. Improvements in or relating to telephone systems. (Date applied for under Patents, &c., Act, 1883, Sec. 103, 7th August, 1896, being date of application in France.)

August 27, 1896.

18,951. A. CONDER and E. P. MICHELOT. London. Improvements in electrical accumulators.

18,974. J. L. DOBELL. London. A new or improved apparatus for electrically smelting metals, and for other like purposes.

18,987. W. R. LAKE. London. Improvements in regulators for electric arc lamps. (Agostino Ferrario, Italy.)

August 28, 1896.

19,021. J. RENOUS and B. BRONISHLAWSKI. London. A new or improved incandescent electric lamp.

19,045. A. HEIL. London. Manufacture of secondary galvanic elements.

August 29, 1896.

19,114. J. T. ASHTON. London. Improvements in automatic switch devices for electric currents.

19,148. W. R. LAKE. London. Improvements relating to electric current transformers. (The Elektricitats-Aktiengesellschaft vormals Schuckert and Co., Germany.)

August 31, 1896.

19,218. E. J. CONSTAM and A. VON HANSEN. London. Manufacture or production of chemical products by electrolysis.

September 1, 1896.

19,290. A. J. BOULT. London. Improvements in or relating to electrical furnaces. (O. Patin, France.)

19,301. A. PRESS. London. Improvements in storage batteries.

19,303. T. MCKENNA. London. Improvements in electromagnets. (Electric Selector and Signal Company, United States.)*

19,304. T. MCKENNA. London. Improvements in electric selectors and adaptations thereof and in transmitters therefor. (Electric Selector and Signal Company, United States.)*

19,305. T. MCKENNA. London. Improvements in electrical selecting instruments. (J. M. Drysdale, United States.)*

19,308. W. WALKER, jun., R. WILKINS, J. LONES, and J. LONES. London. Improvements in utilising the residual products obtained in the working of certain kinds of voltaic batteries.

19,316. L. A. JACKSON and ACME ELECTRIC LAMP COMPANY. London. Improvements in electric lamps.

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

15,445. STIELTJES. Printing telegraphs.

16,659. BELFIELD (Foreign Electric Traction Company). Electric railways.

15,695. CLUBBE and SOUTHEY. Electrically propelled carriages.

17,365. BELFIELD. Motor vehicles for electric railways.

17,430. BELFIELD. Methods of and means for making and breaking electric circuits.

17,525. KELLNER. Electrolytical manufacture of bleaching liquid.

17,529. MILLS (Hopkins). Arc lamps.

1896.

543. HUMMEL. Means for producing differences of phase in alternating current apparatus.

3,910. KLOSTERMANN. Magnetic regulator for the carbons of arc lamps.

4,944. PORRAIN (Foote). Electric arc lamp carbon.

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6,952. BIERMANN. Electrical water level indicators for steam boilers.

8,382. DEVONSHIRE (Potter). Automatic circuit breakers.

11,451. THOMPSON (Breed and Bragg). Producing musical sounds by electricity.

11,552. ADAM. Electric motor cars.

13,553. DUBBERT. Ear piece for telephone receivers, &c.

14,462. BOULT (Scott and Janney). Systems of electrical distribution.

15,102. ROYCE and CLAREMONT. Method of winding armatures for multipolar continuous-current dynamo-electric machines and electromotors.

14,500. STOCK. Call counter suitable for telephone exchanges.

# COMPANIES' MEETINGS AND REPORTS.

## Rand Central Electric Works (Limited).

The annual ordinary general meeting of shareholders in this Company was held yesterday (Thursday), at Winchester House, Old Broad-street, London, under the presidency of Sir C. Rivers Wilson, G.C.M.G., C.B.

The SECRETARY (Mr. H. Militz), having read the notice calling the meeting,

The CHAIRMAN said: A small printer's error occurs in the balance-sheet. On the credit side the equipment contract with Messrs. Siemens and Halske is dated May 29, 1895, but that should have been March 29th. [The report and accounts were then taken as read.] My duty is really a very light and simple one. The report before you is short, but it states very fully all the information which I think the shareholders would desire to receive. As you know, we are still in the period of construction. This period would terminate at the very earliest on November 3rd next, but it is provided in the contract with Messrs. Siemens and Halske that in case any causes of impediment should arise beyond their control, some extension of time for the completion of the works should be allowed. In the event, however, of any delay arising from causes within their control they will be subject to penalties specified and provided for by the contract; but we do not anticipate any delay through any such causes. As you are all aware, however, there have been very considerable labour troubles in South Africa in the district where our works are proceeding, and those troubles have no doubt acted prejudicially on the operations of the contractors; and a short time ago they asked, in consequence of those troubles and the delay which had been caused (altogether beyond their control), for some slight extension of time. It was a very moderate extension, however, and would have taken the date of construction up to November 20th instead of the 3rd. Since then, I am sorry to say, there has been a railway accident in which certain portions of the machinery have been damaged. That will necessitate a reference back here, and it is possible that some additional delay will be caused; but it will not be anything which you will regard as of importance. There is, I think, the fullest possible expectation that the works, which we know are very far advanced, will be completed and in full operation very shortly after what I may call the statutory time—the contract time. This is the first ordinary general meeting which we have held; the only time the Directors have had the pleasure of meeting the shareholders before was at the merely formal meeting on July 30, 1895. Since then, under the general supervision of the Board here, and more especially of the local Board appointed out in South Africa, the contractors have been hard at work, and we have received a most satisfactory report from our engineer on the spot, who supervises all the work done by Messrs. Siemens and Halske. I will just read to you a few paragraphs of the last report we have received from our engineer, which will show you the progress of the works up to the date of the latter—namely, August 15th. This report says: "Building operations at Brakpan were commenced about September 1, 1895. There are at present erected one large boarding house, with reading room and two large dining rooms; one building for married men's quarters and two buildings for unmarried; the manager's house, and one stable and coach house. The iron structure of the engine house is completed, being also roofed in for the greater part, and having about half the walls covered with corrugated iron. The foundations of the boiler house are also ready, as well as the foundations for the two first engines. At the top of the building the large 20-ton travelling crane is in position, and can be moved to all parts of the large engine room. The foundation for the first chimney is completed, and the erection of the chimney will be taken in hand within a few days. The greater part of the machinery for the works has arrived at Brakpan, and nearly all the remainder is now on the water. The branch line from the Netherlands Railway to our works is completed. The large lake known as the Brakpan and embankment has been constructed, separating our reservoir for condensing purposes from the rest of the Pan. The main wire is in course of erection. About 900 iron poles have been erected, and the laying of the wires has been commenced at the Brakpan end." I have read that to show you that the works on the spot are very far advanced. You will no doubt wish to hear what steps have been taken for obtaining employment for our works when they are completed. There again I think that the report which I can make to you is highly satisfactory. As you are aware, the power which under the contract with Messrs. Siemens and Halske our machines are capable of supplying will be 2,100 B.H.P.; of that we have placed with contiguous mines 1,200 H.P., and no doubt but for the uncertainty caused by the troubles in the mining district we should have had contracts for considerably more. We have, however, done very well. We have absolute agreements with about ten companies to take up very nearly 1,200 H.P., and contracts are very far advanced for taking up five other companies, which will absorb another 600 H.P. We have no doubt whatever, from the communications we have received from our representatives, that directly the works are completed the whole of the horse-power will be taken up; there is hardly any doubt about that. I may mention that the contracts which have been made with these various companies and mining proprietors are of a nature to ensure the remunerative return which was contemplated when the contracts were entered into with Messrs. Siemens and Halske. The basis we have proceeded upon in our calculations was a payment of £45 per horse-power, and the agreements we have made hitherto with the companies I have mentioned have been on that basis. Our original estimate—taking into consideration the expenses, on the one hand, which have been placed at a very liberal figure, and this payment of £45 per horse-power in respect of the total capacity of 2,100—will ensure a handsome and very remunerative return; and, so far as we can judge now, I think that the estimates we then formed will certainly be realised. I was not quite certain that Mr. Brakhan, who is a member of our local Board, would be present, but I am glad to say that he is here; and as he is so thoroughly cognisant of all that has taken place on the spot, I think it would be very agreeable to you if he would give us a statement respecting our affairs there. I have no doubt that he will corroborate the very satisfactory expectations which I have been able to lay before the meeting.

Mr. A. BRAKHAN: It may, perhaps, be interesting to you to hear the opinion and views of one who has been connected with the Company since it started at Johannesburg. I have the pleasure of being a member of the local Board, and I have seen the great interest which has generally been taken in the Rand in your Company. Electric power is quite a new thing out there. Formerly everything was done by steam; but the mine managers are of opinion, under the favourable conditions relating to this Company with regard to the cost of coal and the high class of machinery they can employ, that for small installations the power that is transmitted over the wires—electric power—will be of great advantage; and I know from leading managers on the Rand that they look forward to a very good future for this Company. Already many contracts have been entered into, and I am sure that when the installation is ready and commences working, the full amount of power which can be given will be at once contracted for, if that does not take place still earlier. Of course, managers out there want to push ahead, and as long as they cannot employ a certain method they have makeshifts, and that is at present a little disadvantageous for us; but they say, "When you are ready we will take some of your power." I know, however, from what the managers of leading mines have told me, that they are at once ready to take it; and personally I am quite certain that you will have to look forward to extending the works later on. The scope for this Company is a very wide one. It will not be that the min[illegible] alone will employ your power; there are a multitude of other purpo[illegible] for which it will be required. Everything is in its infancy there at present, and there will be a great demand for electric power. I am sure that you can look confidently forward to the future of your undertaking. As to the management out there, from personal observation and prior knowledge of the man I am sure that your general manager, Mr. Singels, is very efficient and capable. Not only is he cognisant of everything as a technical man, but he is also a commercial man, and that is of great advantage. Everything, therefore, will be looked after properly on the spot. Your London Board have great experience in commercial matters, and also of South Africa. It affords me great pleasure to be here and to tell you that your Company will be a very prosperous one; there is every indication of it.

The CHAIRMAN: I will just mention one other matter which I think I ought to have referred to earlier; namely, that we have entered into a most satisfactory arrangement with the Transvaal Coal Trust Company. They are our landlords for our main station, and they are also to supply us with coal and water, two most important matters for us. By the contract we have made with them we shall obtain, first of all, a location of seven acres at Brakpan at the moderate rent of £100 per annum, with the option of taking another five acres, should the extension of our works render that necessary, at another £100 rent. They have engaged to supply the full requirements of our works for coal and water on very satisfactory terms under penalties for the non-fulfilment of their obligations. These contracts for the supply both of coal and water are for five years; and, altogether, I think it is most creditable to your representatives that they have been able to enter into such a favourable contract, putting them completely at their ease with regard to these very important elements of the undertaking. Unless any questions or remarks are to be addressed to the Board by the shareholders, I will propose—

*"That the report and accounts, as submitted to the meeting, be and are hereby received and adopted."*

Mr. AUGUST BARSDORF seconded the motion.

The resolution was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. BARSDORF, the retiring Directors, Messrs. Alfred H. Mirker and G. Zwilgmeyer, were re-elected; and Messrs. Price, Waterhouse, and Co., were afterwards re-appointed auditors of the Company for the ensuing year.

A vote of thanks to the Chairman and Directors terminated the proceedings.

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The Directors' report, which covers the period of 15 months to June 30th last, states that £116,305 has been expended on the Company's works during the 15 months, and that the Directors have been able to place the capital not immediately required on deposit at satisfactory rates, the interest thus earned amounting to nearly £3,000.

The cession of all contracts entered into by Messrs. Siemens and Halske prior to the formation of the Company having been duly completed and registered at Pretoria, the fully paid 25,000 Vendors' shares in respect of and in payment for such contracts were issued in April last

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## Halifax and Bermudas Cable Company (Limited).

The seventh annual meeting of this Company was held at the offices, 33, Old Broad-street, E.C., on Friday last, when the report of Directors and statement of accounts to 30th June last was adopted. The Directors' report was as follows :—

The cable receipts in the past year were £3,339. 4s. 5d., compared with £4,203. 7s. 10d. in 1894-5. This decrease is chiefly due to the diminution in shipping messages. The net result of the year is a profit of £492. 11s. 10d., compared with £1,023. 9s. 8d. Offers for the sale of Debentures to the trustees were invited in December and June last, when £5,300 of Debentures were acquired and cancelled, at a cost of £4,911. 10s. Of the profit of £492. 11s. 10d., £164 has been placed to the reduction of the Spare Cable Account. The balance (£328. 11s. 10d.) and the £5,300 on account of Debentures redeemed during the year are applied to the writing down of capital expenditure. The Company's cable has throughout the year worked with complete efficiency, and its electrical condition continues excellent.

## NEW COMPANIES, STATUTORY RETURNS, &c

**ELECTRIC LIGHTING EXTENSION SYNDICATE (LIMITED).**—This Company was registered on September 19th, with a nominal capital of £5,000, in £1 shares, to enter into an agreement with Messrs. Herbert C. Hodges and C. O. Bastian, electrical engineers, to carry on in London and elsewhere the business of suppliers of electricity in all its branches, to construct, lay down, establish, fix and maintain all necessary cables, wires, lines, accumulators, lamps and works, and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity and manufacturers of and dealers in electrical apparatus and appliances. The first subscribers, with one share each, are :—J. Hayer, electrical engineer ; F. M. Staunton, electrical engineer ; C. O. Bastian, electrical engineer ; W. O. Bastian ; P. W. O. Hodges, civil engineer ; Herbert C. Hodges, electrical enginer, and W. R. Willcon.

**KIRLEW BROTHERS (LIMITED).**—This Company was registered on September 18th, with a nominal capital of £5,000, in £1 shares, to acquire the business carried on by Mr. Gilbert R. Kirlew, under the style of "Kirlew Brothers," and to carry on the business of electrical and mechanical engineers, electricians, machinists, tool makers, &c. The subscribers, with one share each, are :—G. R. Kirlew, agent, C. H. Broomhead, Miss E. M. Kirlew, Mrs. G. R. Kirlew, J. W. Hamill, M.D., R. L. Kirlew, engineer, and Mrs. J. Kirlew.

**RAINSFORD AND LYNES (LIMITED).**—This Company was registered on September 9th, with a capital of £20,000, in £5 shares, to carry on the business of manufacturers of and dealers in electric light fittings, chandeliers, brackets, lamps, pendants, and standards. The first Directors are :—Charles Rainsford, jun., Thomas Rainsford, and Wm. Lynes.

**TYNE CYCLE MANUFACTURING SYNDICATE (LIMITED).**—This Company was registered on September 18th, with a nominal capital of £15,000, in £10 shares, to carry on, amongst other things, the business of buyers, sellers, and dealers in dynamos, insulating material, accumulators, and other apparatus used in connection with the generation, distribution, supply, accumulation, and employment of electricity.

**P. R. JACKSON AND COMPANY (LIMITED).**—The annual return of this Company to May 18th has just been filed. The nominal capital is £120,000, divided into 6,000 Ordinary and 6,000 Preference shares of £10 each ; 5,041 Ordinary and 5,392 Preference have been taken up, and £65,300 has been considered as paid on 3,500 Preference and 3,900 Ordinary. The full amount has been called on 2,500 Preference and 2,000 Ordinary, and £7 per share on 2,891 Preference and 3,041 Ordinary.

**NEW PHONOPORE COMPANY (LIMITED).**—The annual return of this Company to July 2nd has been filed. The nominal capital is £150,000, divided into 100,000 Ordinary and 50,000 Preference shares of £1 each ; 90,000 of the former and 28,343 of the latter have been taken up, and 69,025 Ordinary and 10,380 Preference have been issued as fully paid. The full amount has been called on the remainder.

**OTIS ELEVATOR COMPANY (LIMITED).**—The annual return of this Company, to August 3rd, has been filed. The nominal capital is £50,000 in £10 shares. 2,000 of these have been taken up, and 650 have been issued as fully paid. The full amount has been called and paid on the remaining 1,350 shares.

**PRINTING TELEGRAPH RECORDER COMPANY (LIMITED).**—An agreement has been entered into by this Company with Mr. Walter S. Steljes for the acquisition of the rights in and benefits of Provisional Specification No. 15,445 (1895) for a type-writing telegraph recorder for £7,000, payable as to £1,000 in cash, £60 by the allotment as fully paid of 60 Founders' shares, and £6,000 by the allotment as fully paid of 6,000 Ordinary shares of £1 each.

**BURY, ROCHDALE AND OLDHAM TRAMWAY COMPANY (LIMITED).**—At the half-yearly meeting of this Company on Monday the Chairman stated that the subject of electric traction had been receiving the best attention of the Directors. They were endeavouring to keep abreast of the times, and if the inhabitants desired the substitution of electric for steam traction they would gladly co-operate with the local authorities in endeavouring to effect such a change.

## CITY NOTES.

**MEMORANDA**—Bank rate, 3 per cent. (Sept. 24, 1896). **Price of silver,** 30 7/8d. per oz. (Sept. 24th). Consols (2¾ per cent.) 109½—109⅝ for money, 109½—109⅝ for account; 2½ per cent. 104½—105 (Sept. 24th). Stock Exchange Settling Days: Consols, Oct. 1st ; Stocks and Shares Continuation Days, Sept. 28th and Oct. 13th ; Ticket Days, Sept. 29th and Oct. 14th ; Pay Days, Sept. 30th and Oct. 15th ; Mining Share Carry-over Days, Sept. 26th and Oct. 12th.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended September 20th were £871, against £831 in the corresponding week of 1895, an increase of £40. The total receipts for the half-year amount to £10,887, against £10,147 for the corresponding period of 1895, an increase of £740.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—This Company announce the payment, on October 15th next, of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum, on the Preference shares of the Company for the quarter ending 30th inst., and the usual interim dividend of 2s. 6d. per share on the Ordinary shares, free of income tax, in respect of profits for the quarter ended June 30th. The register of transfers will be closed from the 8th to 15th October inclusive.

**ELECTRICAL COPPER COMPANY (LIMITED).**—The statutory general meeting of this Company was held on Monday, Mr. H. M. Matheson presiding. In the course of his speech the Chairman said that 100,000 of the Preference shares had been allotted and paid up in full. The patents had all been transferred to the Company, and, though there had been applications both from Germany and the United States with reference to disposing of the patent rights for these countries, they preferred to await the results of the works which they were about to erect at Widnes before parting with any of these rights. They had secured suitable land at Widnes for the erection of the works, on a lease of 999 years. The plans of the works were nearly completed, engines and dynamos had been ordered, and they expected to be in operation early next year. The experimental works at Paris had been taken over by the Company. They were sufficient for the manufacture of commercial samples, and numerous such samples had been made and reported upon by experts both in England and on the Continent. Numerous tests of the copper had been made by Messrs. Kirkaldy and other experts. A complete series of these tests, as arranged by Messrs. Kirkaldy, was being carried on, and certificates would be issued which would enable engineers to judge of the suitability of the Company's copper for the purposes of their work.

**ENGINEERING AND GENERAL CONTRACT CORPORATION (LIMITED).**—The fourth ordinary general meeting of this Corporation was held on Monday, Mr. Henry Brown, F.C.A., presiding. In moving the adoption of the report and accounts the Chairman called attention to the fact that the Directors had come to the conclusion that the English patents and goodwill of the Hopcraft Furnace Company were valueless, and they had written off the sum of £70,845, which was the balance standing to the credit of that account. He said that asset was not the creation of the Directors, but was an old inheritance, and they had hoped against hope that something might be made of these patents, but they at length decided not to incur any more expenditure in respect of them. The report was, after considerable discussion, adopted.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 20th inst. amounted to £1,214. The amount for the corresponding week last year was £1,239. Decrease, £25.

**POSTAL TELEGRAPH CABLE COMPANY (OF NEW YORK).**—The Directors of this Company have declared another dividend of 1 per cent., making 3 per cent. for the year to date.

**PRETORIA LIGHTING COMPANY (LIMITED).**—At the special general meeting of the shareholders of this Company held at Pretoria, on August 28th, it was unanimously resolved, "that the redemption of the £40,000 Debenture issue take place on September 2, 1896, and interest paid thereon to that date." Holders of these bonds are requested to forward same to the Secretary of the Company at an early date.

**ROCKHAMPTON (QUEENSLAND) GAS AND COKE COMPANY (LIMITED).**—In their report for the half-year ended June 30th, the Directors state that the set of storage batteries which were referred to in the previous report have arrived and are in operation. The working expenses of the Electrical Department were somewhat less than the preceding half-year, while the returns were rather larger, the operations for the period showing a profit of £279. 7s. 2d., which has been appropriated towards the payment of the interest upon the Company's Debentures amounting to £300, leaving a deficiency of £20. 12s. 10d. The receipts from the sale of current amounted to £825. 4s., and from the rental on electric light fittings and sundries £100. 10s. 2d. The generation expenses came to £520. 0s. 2d., management £64. 1s. 6d., interest £300, and sundries £62. 5s. 4d. The reserve fund now amounts to £434. 15s. 3d.

**WILLANS AND ROBINSON (LIMITED).**—*The Statist*, the leading City organ, discussing the subject of eligible securities for small investors in its issue of the 19th inst., calls attention to the shares of this Company, and especially to the fact that the Ordinary shares have always received a dividend of 7 per cent. each half year, and that there is a reserve fund of £5,146. "The present price of the £5 shares about £8 would, on the basis of the 7 per cent. dividend hitherto paid, yield to investors 4¾ per cent. Should the dividend be increased to 10 per cent. the yield at the present price would be 6¼ per cent., and, so far as we can learn, this would be but a moderate estimate of the increasing prosperity of the Company. For investors who want a 'fixed' return, the 6 per cent. Preference shares, at £7 middle, are a moderately-priced industrial security, giving a yield at their present figure of rather over 4¼ per cent." The registers of transfers and members of this Company are closed, prior to the ordinary general meeting, till October 7th inclusive.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price September 16. | Price Wednesday, September 23. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Sept. 19. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | £ s. d. | | | |
| | | | **TELEGRAPHS.** | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 50 53 | 50 53 | 4 14 4 | Jan., Apr., July, Oct. | 52 | |
| £1,993,560 | Stock | 24/0 | Do. Preferred | 97 98 | 95½ 96½ | 5 3 8 | " " | 98½ | 96½ |
| £1,993,560 | Stock | 5/0 | Do. Deferred | 8½ 9½ | 8½ 9½ | .. .. | .. .. | .. | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 6 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ 9½ | 8½ 9½ | .. .. | .. .. | .. | .. |
| 180,000 | £10 | 3/0 | Brazilian Submarine | 15½ 15¾ | 15 15½ | 4 10 4 | Mar., June, Oct., Dec. | 15 7/8 | .. |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | .. — | .. — | .. | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ 13½ | 12½ 13½ | 5 13 6 | February and August | 13 | 12¾ |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20½ 21½ | 20½ 21½ | 4 13 .. | " " | — | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) xd | 3½ 4½ | 3½ 4½ | 4 8 11 | April and October | — | — |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. xd | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% 110% | 107% 110% | 4 2 7 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9¾ 10¼ | 9¼ 9¾ | 5 2 10 | Jan., Apr., July, Oct. | 9⅜ | .. |
| 400,000 | 10 | 5/6 | Eastern | 18 18½ | 18 18¾ | 3 10 3 | " " | 18⅝ | 18 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 19 20 | 18½ 19½ | 3 0 0 | " " | 19½ | 19 |
| £ .297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 3 0 6 | May and November | 132 | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 104 107 | 4 13 11 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 18½ | 18 18½ | 3 15 8 | Jan., Apr., July, Oct. | 18⅝ | 18 7/16 |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 5 | February & August | 132½ | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 4 17 1 | January and July | 101½ | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 16 2 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1900 (regd.) | 106 109 | 106 109 | 3 13 9 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% 114% | 111% 114% | 3 10 11 | May and November | .. | .. |
| 180,227 | 10 | 3 9 | Globe Telegraph and Trust | 11¼ 11¾ | 10¾ 11¼ | 3 15 7 | Jan., Apr., July, Oct. | 11⅜ | 11 1/16 |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 18 18½ | 17¼ 18½ | 3 5 9 | " " | 18½ | 18¼ |
| 150,000 | 10 | 5/0 | Great Northern | 24½ 25½ | 24 25 | 4 0 0 | Jan., April, and July | .. | .. |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 13 8 | March & September | 106½ | — |
| 17,000 | 25 | 37/6 | Indo-European | 53 56 | 53 53 | 4 9 3 | May and November | .. | .. |
| 37,518 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | — | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 109 112 | 5 7 5 | March & September | — | — |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 7 | — | .. | .. |
| 10,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | — | — |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 140 146 | 138 143 | 4 3 11 | " " | 143½ | .. |
| 15,600 | 10 | 6/0 | West African Telegraph | 5 6 | 5 6 | 5 0 0 | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 105 | 102 105 | 4 15 6 | March & September | 104 | .. |
| 30,000 | 10 | 2/0 | West Coast of America | 1 2 | ½ 1½ | .. .. | January and July | .. | .. |
| £150,000 | 100 | 8% | * Do. 8 per Cent. Debentures, 1902 | 99 104 | 99 104 | 7 16 1 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1½ 1¾ | 1⅜ 1⅝ | .. .. | .. .. | 1⅜ | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 12 | 5 0 0 | May and November | 11 1/2 | .. |
| 4,663 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | — | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 103 111 | 103 111 | 4 10 11 | June and December | .. | — |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8½ 9¼ | 8¾ 9¼ | 4 17 4 | May and November | .. | .. |
| 33,129 | 7½ | 3/0 | Do. 5 per Cent. Cumulative Preferred | 7 7½ | 6¾ 7¼ | 5 0 0 | — | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2¼ 2¾ | 2¼ 2¾ | .. .. | — | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 107 | 101 107 | 5 12 8 | February & August | — | — |
| £206,400 | 100 | 6% | Do. 6% Mort. Debs., Series "B" 1910 | 103 107 | 103 107 | 5 12 8 | " " | — | — |
| $1,177,000 | $1,000 | 7% | *Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 4 2 | May and November | — | — |
| £164,300 | £100 | 6% | * Do. 6 per Cent. Sterling Bonds (red.) | 1 0 105 | 100 105 | 5 14 6 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chill Telephone (fully paid) | 3½ 3¾ | 3½ 3¾ | 5 6 8 | — | — | — |
| 224,850 | 10/0 | 1¼d. | Consolidated Telephone Const. & Manufacturing | 1/16 3/16 | 1/16 3/16 | .. .. | .. .. | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅜ ⅝ | ⅜ ⅝ | 5 14 3 | Yearly | .. | .. |
| 484,597 | 5 | 2/6 | National | 7½ 7¾ | 7⅛ 7¼ | 3 1 0 | June and December | 7⅜ | 7 11/16 |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 19 | 17 19 | 3 3 2 | " " | .. | — |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 19 | 17 19 | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅞ 7⅛ | 6⅞ 7⅛ | 3 17 2 | — | 7⅛ | 7 |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 110 | 107 110 | 3 4 1 | January and July | 109½ | 107½ |
| 58,000 | 5 | 4/0 | United River Plate | 3½ 4 | 3½ 4 | 5 0 0 | July | .. | .. |
| £146,783 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 101 103 | 101 103 | 4 15 3 | January and July | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| .. | 5 | .. | Birmingham Electric Supply (fully paid) | 9 | 9 | .. | .. | .. | .. |
| .. | 5 | .. | Do. (£4 paid) | 6 | 6 | .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 16 17 | 16 17 | 2 18 10 | February & August | 16⅞ | 16½ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17½ 18½ | 17½ 18½ | 3 4 10 | January and July | .. | .. |
| £1 80,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 134 136 | 131 135 | 3 14 9 | June and December | 137 | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | — | .. | — |
| £30,000 | £5 | 2 6 | Charing Cross & Strand Electricity Supply Corp. | 9½ 9¾ | 9½ 10 | 2 15 0 | — | 9⅜ | .. |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — — | — — | .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8 9 | .. | — | .. | — |
| £10,000 | £10 | 5 4½ | Do. Pref. (fully paid) | 13¾ 14½ | 13½ 14½ | 4 4 3 | — | .. | — |
| 8,322 | £5 | .. | House-to-House Electric | — — | .. .. | .. | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | .. .. | — — | .. | January and July | — | — |
| 111,000 | 5 | .. | London Electric Supply | 1 1⅛ | 1 1⅛ | .. | — | — | — |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 13 14 | 12½ 13½ | 2 19 3 | — | 13 7/8 | — |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 120 124 | 120 123 | 3 13 9 | June and December | 1 ½ | 122 |
| 6,452 | £10 | 4 0 | Notting Hill Electric | 12 13 | 1 ½ 1 ½ | .. | — | — | .. |
| .. | .. | .. | Rand Electric | 1/16 1/8 | 1/8 1/4 | .. | — | .. | .. |
| 19,980 | £5 | 2 6 | St. James and Pall Mall | 11½ 12½ | 11½ 1 ½ | 3 2 0 | — | 1 ⅜ | — |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 11 | 10 1 | 3 6 8 | — | .. | .. |
| 59,900 | 5 | 3 0 | Westminster Electric Supply (fully paid) | 11 12 | 11 12 | 2 18 4 | — | 11½ | 11⅜ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1 1½ | 1 1¼ | .. | — | 1¼ | .. |
| 90,000 | 2 | 0 2 | Do. 6 per Cent. Pref. Non-Cumulative | 1½ 1¾ | 1½ 1¾ | .. | — | 1⅝ | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 110 113 | 110 113 | 3 19 8 | March & September | .. | — |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref | 2 2½ | 2 2¼ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/0 | Edison and Swan United ("A" Swan) (£3 paid) | 1¾ 2¼ | 1¾ 2¼ | 6 13 4 | February & August | — | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 5 9 | January and July | .. | .. |
| £30,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. — | — — | — | — | — | — |
| 110,000 | 2 | 0/0 | Electric Construction | 1½ 1¾ | 1½ 1¾ | 2 17 2 | — | 1½ | — |
| 12,845 | 2 | 0 0 | Do. 7 per Cent. Cumulative Pref. | 2½ 3 | 2½ 3 | 4 13 4 | September | 2½ | — |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ¾ 1 | ⅝ ¾ | .. | — | .. | .. |
| 20,000 | 5 | . | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. | — | .. | .. |
| 50,000 | 10 | 5/0 | Gutta Rubber, Gutta Percha, &c., Works | 21½ 22½ | 22 23 | 4 6 11 | February & August | 22¾ | 22 |
| £200,000 | 100 | . | * Do. 4 per Cent. Debentures | 107 110 | 107 1 0 | 3 12 9 | March & September | .. | .. |
| 20,000 | £5 | . | Manchester Edison-Swan "A" (£1 10s. paid) | ¾ ⅞ | ¾ ⅞ | .. | .. | .. | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 40 43 | 40 43 | 4 3 10 | March and July | 44⅜ | 41 |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 104 107 | 104 107 | 4 14 4 | January and July | .. | .. |
| £100,000 | 10 | 6/0 | W. T. Henley's Telegraph Works Ordinary | 18 19 | 18 19 | 4 10 1 | March & September | .. | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 11 10 | " " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 110 115 | 110 115 | 3 8 3 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1⅜% | City and South London Railway Con. Ordy. | 51 53 | 49 51 | 2 18 6 | January and July | 52 | 50 |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14⅞ 15½ | 14⅞ 15½ | 3 5 7 | " " | 15½ | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 138 | 136 138 | 2 18 0 | May and November | .. | .. |
| 37,500 | £10 | 2½% | Liverpool Overhead Railway | 13 3/16 13 5/16 | 13⅜ 13¼ | 2 4 6 | — | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 16⅜ 17⅜ | 16⅞ 17⅜ | 2 17 9 | — | .. | .. |
| 125,000 | Stock | 4% | Do. 4% Debenture | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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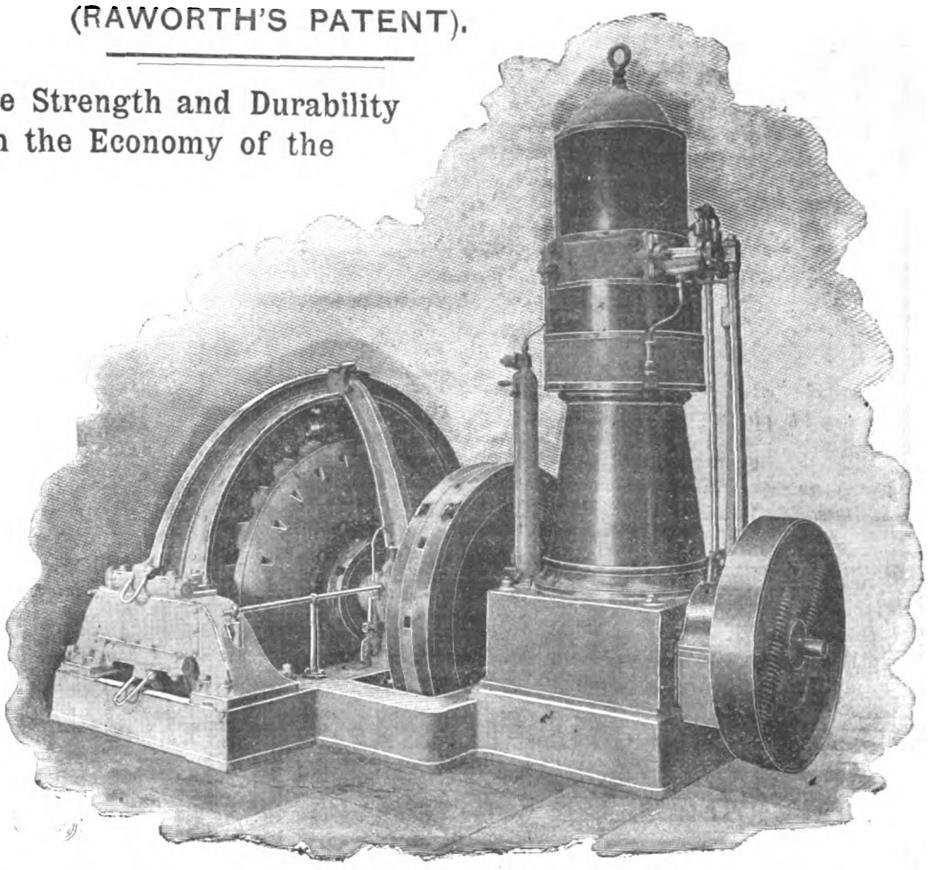
# THE UNIVERSAL ENGINE

(RAWORTH'S PATENT).



This Engine combines the Strength and Durability of the Corliss Engine with the Economy of the High Speed Engine.

••••••••••••••••

***Small Space,***
***Small Cost,***
***High Efficiency,***
***Perfect***
***Governing.***

••••••••••••••••

*For Prices and Particulars apply to*

THE

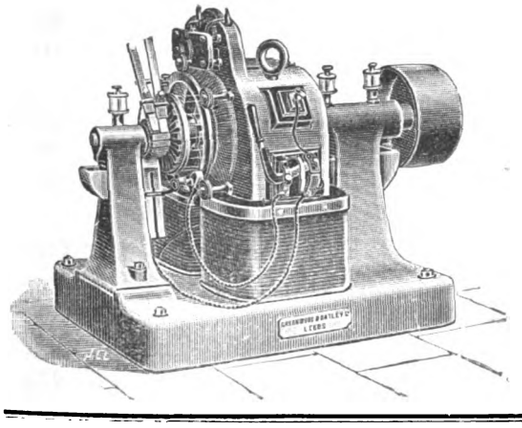
## BRUSH ELECTRICAL ENGINEERING CO.

LIMITED

49, Queen Victoria Street,

**LONDON, E.C.**

# GREENWOOD & BATLEY, Ltd.,



## ALBION WORKS, LEEDS.

## General Electrical Engineers.

MANUFACTURERS OF

**ALTERNATORS, INCANDESCENT and ARC-LIGHT DYNAMOS for ELECTRIC LIGHTING, ELECTRIC MOTORS for Tram Cars, MINING MACHINERY and as applied to Machine Tools.**

**FACTORY ENGINES and HIGH-SPEED ENGINES for Electrical and other Purposes.**

*MANUFACTURERS of SPECIAL and GENERAL TOOLS for ELECTRICIANS.*

London Office: 16, GREAT GEORGE ST., WESTMINSTER, S.W.

## UNDERGROUND MAINS.

# CALLENDER'S CABLE & CONSTRUCTION CO., LTD.

MANUFACTURERS OF

## ELECTRIC LIGHT CABLES, MAINS, CONDUITS AND ACCESSORIES.

**Engineers and Contractors. Ironfounders and Coppersmiths. Makers of Lead Tube and Pipes. Bitumen Refiners.**

**Head Office: 90, CANNON STREET, LONDON, E.C.**

Telephone No. 15133. Telegraph Address: "CALLENDER LONDON."

**Factory—ERITH MARSHES, KENT.**

**LIVERPOOL—Oldham Place, Renshaw Street.** **BIRMINGHAM—58, Water Street.**

**NOTTINGHAM—King John's Chambers, Bridlesmith Gate.** **GLASGOW—Great Western Road, Kelvinside.**

Also Contractors for underground Mains at ABERDEEN, COATBRIDGE, BURNLEY, LANCASTER, HUDDERSFIELD, SHEFFIELD, HULL, OXFORD, HANLEY CHELSEA, &c., &c.

The CALLENDER COMPANY is prepared to undertake the laying of Underground Mains, including all excavation and reinstatement of paving, building boxes, feeder points, or transformer chambers, erecting lamp posts, pillars and all other accessories required for the complete equipment of the distribution network of a Central Station, for either HIGH or LOW TENSION with CONTINUOUS or ALTERNATING CURRENTS:—

1. **With Vulcanised Bitumen Cables laid solid in Bitumen.**
2. **Or Drawn into CALLENDER-WEBBER or CALLENDER-RAWORTH Conduits, or into Pipes.**
3. **With Lead-Sheathed Cables either Single Conductor, Concentric, or Triple Concentric, armoured and laid direct in the earth.**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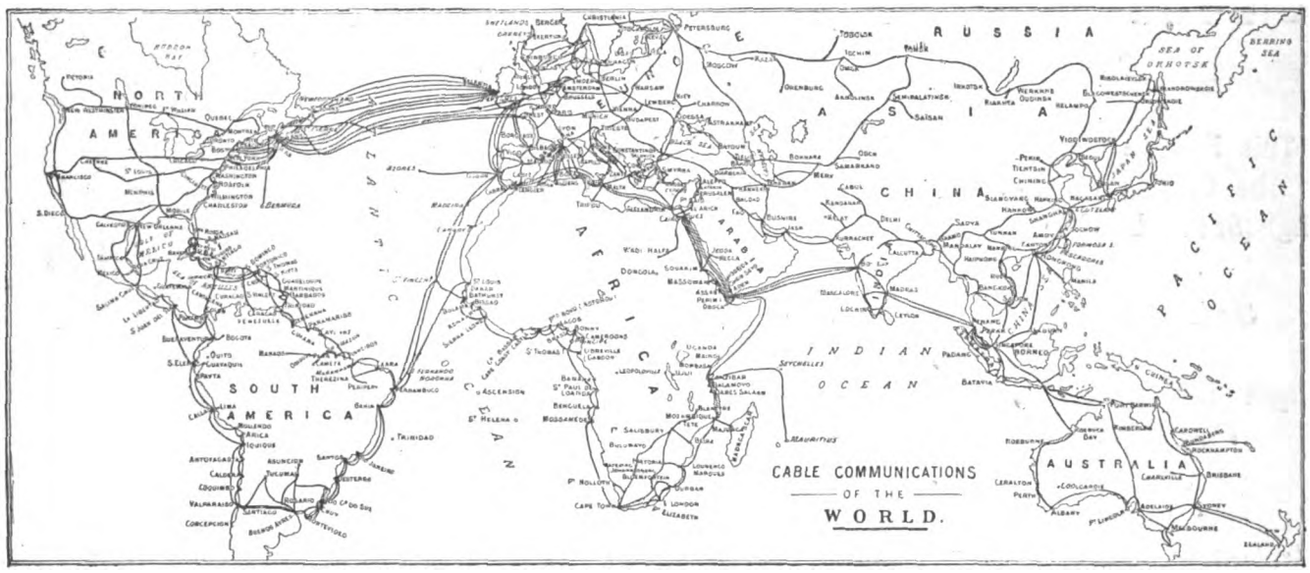
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

# EASTERN TELEGRAPH COMPANY

IN CONNECTION WITH THE (LIMITED),

EASTERN EXTENSION (AUSTRALASIA AND CHINA), BRAZILIAN SUBMARINE, EASTERN AND SOUTH AFRICAN, EUROPE AND AZORES, WEST AFRICAN AND AFRICAN DIRECT TELEGRAPH COMPANIES.

**By DIRECT TRIPLICATE CABLES, to Spain, Portugal, Gibraltar, Malta, Egypt, Aden, and India.**

**By DIRECT DUPLICATE CABLE ROUTES to Madeira, St. Vincent, Brazil, Argentine Republic, Uruguay, also to Peru, Chili, and other parts of South America; and to Suakin, Perim, Penang, Malacca, Singapore, Labuan, Java, Australia, New Zealand, Tasmania, New Caledonia, Bangkok, Cambodia, Saigon, Tonquin, Hainan, China.**

**By ALTERNATIVE CABLES to Zanzibar, Mombasa, Mozambique (duplicate), Lourenço Marques (Delagoa Bay), Durban and Capetown; Bathurst, Sierra Leone, Accra, Lagos, Bonny, Bolama, Bissao, Cameroons, St. Thome, Principe, Loanda, Benguella, Mossamedes, Conakry, Grand Bassam, and Gaboon.**

**By SINGLE CABLE to the Azores, Tangier, Tripoli, Cyprus, Seychelles, Mauritius, and Manila.**

Telegrams should be sent from the Company's Stations—

**LONDON—11, OLD BROAD STREET, E.C.; 8, LEADENHALL STREET; 3, GREAT TOWER STREET; 42, PARLIAMENT STREET, S.W.; 206a, WINCHESTER HOUSE, E.C.; 37, HOLBORN VIADUCT, E.C.; FOREIGN AUCTION HALL, COVENT GARDEN MARKET, W.C., and 449, STRAND, W.C.**

**MANCHESTER—20, Brown Street.** **LIVERPOOL—K13, Exchange Buildings.**

**GLASGOW—141, BUCHANAN STREET.**

COMPANY'S LEVANT SYSTEM:

**Odessa, Constantinople, Dardanelles, Tenedos, Salonica, Smyrna, Chio, Syra, Candia, Rettimo, Canea, Sitia, Rhodes, Trieste, Corfu, Zante, Patras, Corinth, Athens, Cephalonia, Santa Maura, Tinos, Andros, Zea, and all the Greek Islands.**

The Company's Cables are worked by Muirhead's DUPLEX principle upon all its Main Sections.

In sending Telegrams from Postal Stations care should be taken to mark them— "VIA EASTERN," these words being signalled gratuitously by the Postal Authorities.

Books of Forms and Tariffs forwarded post free on application at the Company's Chief Offices as above, or at

**37, RUE CAUMARTIN, PARIS; and HOTEL DES POSTES ET TELEGRAPHES, MARSEILLES.**

Winchester House, 50, Old Broad Street, E.C. By Order, GEORGE DRAPER, *Secretary*.

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TELEPHONE No. 15,077. TELEGRAMS: "INDICES LONDON."

**WHEATLEY KIRK, PRICE & GOULTY**

*(ESTABLISHED 1850),*

**Electrical Auctioneers, Valuers,**

**AND ARBITRATORS.**

**Average Annual Valuations exceed £1,500,000 Sterling.**

**49, QUEEN VICTORIA STREET, LONDON, E.C.**

## TENDERS INVITED.

### LANCASHIRE AND YORKSHIRE RAILWAY.

CONTRACTS FOR STORES.

The DIRECTORS are prepared to receive TENDERS for the SUPPLY of the Company's ordinary requirements of the following Articles during the twelve months ending 31st October, 1897 :—

No.
1. Brake Blocks.
2. Candles (Dip).
3. Canvas.
4. Carpeting and Rugs.
5. Cement.
6. Cloth (Bunting).
7. ,, (Cord and Moleskin).
8. Coach Fittings.
9. ,, Trimmings.
10. Coke (Best Durham).
11. ,, (Gas).
12. Copper Tubing.
13. Drysaltery.
14. Fire Bricks and Clay.
15. Fire Hose
16. Glass (Plate and Sheet).
17. Indiarubber.
18. Iron Castings (Hydraulic Pipes)
19. Iron Castings (Water Pipes).
20. Iron Hinges.
21. Ironmongery.
22. Smallwares, Trimmings, &c.
23. Soap.
24. Sponge Cloths.
25. Steel and Files.
26. Steel Plates (Siemens').
27. Straw.
28. Sundry Tools.
29. Timber (English or Welsh).
30. Transfers.
31. Wicking.

*Way Materials.*

32. Fence Rails (Larch).
33. Spikes.

Further particulars and Forms of Tender may be obtained on application at the Stores Department, Osborne-street, Manchester, where parties are requested to call and examine the samples before tendering. The sample room will be open for this purpose from the 28th September to the 10th October inclusive, between 10 a.m. and 4 p.m.; Saturday, 10 a.m. to 12 noon. Contractors cannot be allowed to tender to their own patterns, nor can the Company's patterns be sent away for inspection, all being sealed and exhibited at Osborne-street.

Tenders, properly endorsed and addressed to the Directors, must be lodged with the Secretary not later than Ten o'clock on the morning of MONDAY, the 12th day of October next; any received after that date will not be considered.

Separate Forms of Tender will be provided for each Contract; parties applying are therefore requested to state the particular Contract for which they propose to submit Tenders.

The Directors do not bind themselves to accept the lowest or any Tender.

C. W. BAYLEY, Secretary.

Hunt's Bank, Manchester, 25th September, 1896.

### THE METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).

NOTICE is Hereby Given that the TRANSFER REGISTERS will be CLOSED from SATURDAY, October 3rd, to SATURDAY, October 10th, both days inclusive, for payment of an interim dividend.

By order,
E. CUNLIFFE OWEN, Secretary.

29, Baker-street, London, W., Sept. 30th, 1896.

### THE EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (Limited).

The SHARE REGISTER of this Company will be CLOSED from the 7th to the 14th October, both days inclusive.

By order,
F. E. HESSE, Secretary and Manager.

Winchester House, Old Broad-street,
London, E.C., 30th September, 1896.

### TO CAPITALISTS AND ELECTRICAL ENGINEERS.—

FOR SALE, an old established ELECTRICAL CONTRACTING BUSINESS in London, with a high-class connection, and doing a large and profitable annual turnover.—Also a similar business in Glasgow. The two may be advantageously worked in conjunction. Full particulars on application to Messrs. EDWARD MOORE AND SONS, Chartered Accountants, 3, Crosby Square, London, E.C.

## THE GOLDSMITHS' INSTITUTE, NEW CROSS, S.E.

CHAIRMAN OF GOVERNORS:

THE PRIME WARDEN OF THE WORSHIPFUL COMPANY OF GOLDSMITHS.

**ELECTRICAL ENGINEERING.**

The Laboratory Appliances and Apparatus have been considerably improved and increased during the summer vacation.

FIRST YEAR COURSE.—Laboratory Work, Monday, Wednesday, or Thursday, 8 to 10. Lecture, Tuesday, 7:30 to 8.30 Course Fee, 12s. 6d. Reduced Fee (see special bills), 6s. 3d. Fee to Students attending the Lectures only in this Course, 7s. 6d. No Reduced Fees.

SECOND YEAR COURSE.—Laboratory Work, Monday, Tuesday, or Thursday, 8 to 10 Lecture, Wednesday, 7:30 to 8:30. Course Fee, 12s. 6d. Reduced Fee (see special bills), 6s. 3d.

**MAGNETISM AND ELECTRICITY.**

Elementary, Thursday, 7:30 to 8:30. Advanced, Wednesday, 8:45 to 9:45. Fee, 5s. each Course.

A SPECIAL COURSE of MATHEMATICS for Electrical Engineering Students will commence in November if a sufficient number of entries is received. Fee for Courses of Sixteen Lectures, 2s. 6d.

*CLASSES COMMENCE, MONDAY, SEPTEMBER 28th.*

J. S. REDMAYNE, B.A., Secretary.

**STANLEY** 2 Gold Medals.

Manufacturer of

**DRAWING and SURVEYING INSTRUMENTS**

Of Every Description, of the Highest Quality and Finish, at the most Moderate Prices

*— PRICE LIST POST FREE. —*

Address: **GREAT TURNSTILE, HOLBORN, LONDON, W.C.**

Telegrams, "Turnstile London." Telephone, 6518 8

## TECHNICAL CLASSES.

### UNIVERSITY COLLEGE, LONDON.

ENGINEERING AND ARCHITECTURAL DEPARTMENT,
Assisted by Technical Education Board of London County Council and by the Carpenters' Company.

SESSION 1896-7.

THE COURSES OF INSTRUCTION IN MECHANICAL, CIVIL, AND ELECTRICAL ENGINEERING AND ARCHITECTURE commence on OCTOBER 6th. They are arranged to cover periods of two and three years.

Particulars of the Courses, of Entrance Scholarships, of the Matriculation Examination, and of the Fees, may be obtained from the Secretary.

PROFESSORS:—

| | |
|---|---|
| Mechanical Engineering ..... | T. Hudson Beare, M.I.C.E. |
| Electrical Engineering ..... | J. A. Fleming, F.R.S. |
| Civil Engineering ..... | L. F. Vernon Harcourt, M.I.C.E. |
| Architecture..... | T. Roger Smith, F.R.I.B.A. |
| Physics ..... | G. Carey Foster, F.R.S. |
| Chemistry ..... | W. Ramsay, F.R.S. |
| Applied Mathematics ..... | K. Pearson, F.R.S. |
| Economic Geology ..... | T. G. Bonney, F.R.S. |
| Mathematics..... | M. J. M. Hill, F.R.S. |

The new wing of the College, opened by H.R.H. the Duke of Connaught in May, 1893, contains spacious mechanical and electrical engineering laboratories, workshops, drawing office, museum, and lecture theatres.

The laboratories are fitted with all the best appliances for practical work, and for research work of the most advanced character.

### DEPARTMENT OF SCIENCE AND ART.

ROYAL COLLEGE OF SCIENCE FOR IRELAND.

The NEXT SESSION will commence on OCTOBER 6th.

The Diploma of Associate is given in the Faculties of I., Manufactures (Chemical); II., Engineering; III., Mining; IV., Applied Physics (for Electrical Engineers, &c.); and V., Natural Science.

Two Royal Scholarships of £50 per annum, with Free Admission to the Courses, are competed for each year by first-year Students.

The Courses of Chemistry, Physics, Botany, Zoology, Geology, and Mineralogy qualify for the Examinations at the R.U.I. and elsewhere; Certificates are granted to Medical and other Students attending the Courses and Laboratories.

Special Courses to suit individual Students, and Research Work in all subjects.

Chemical, Physical, Botanical, Zoological, Geological and Mineralogical Laboratories open for Practical Work.

PROFESSORS:

| | |
|---|---|
| Mining and Mineralogy ..... | J. P. O'Reilly, C.E., M.R.I.A. |
| Physics ..... | W. F. Barrett, F.R.S.E., M.R.I.A. |
| Chemistry ..... | W. N. Hartley, F.R.S., F.C.S., F.R.S.E. |
| Zoology ..... | A. C. Haddon, M.A., M.R.I.A., F.Z.S. |
| Botany ..... | T. Johnson, D.Sc., F.L.S., M.R.I.A. |
| Geology..... | J. A. J. Cole, M.R.I.A., F.G.S. |
| Applied Mechanics and Mechanism ..... | W. McF. Orr, M.A. |
| Descriptive Geometry and Engineering .. | J. Lyon, M.A. |

Fees for Associate Students from £10 to £22 per Session according to Faculty and year.

Non-Associate Students' Fees for Lectures, £2 per Session (except Mathematics £3), Laboratory Fees from £2 upwards.

All the Courses are open to Ladies.

Directory of the College with List of Fees and all other information on application personally, or by letter.

NOTE.—Entrance Examination for Intending Associates will be held on TUESDAY, 6th OCTOBER. Subjects—Mathematics and Elementary Practical Geometry.

G. T. PLUNKETT, Lieut.-Col. (late R.E.), Director.

### CITY AND GUILDS OF LONDON INSTITUTE.

TECHNICAL COLLEGE, FINSBURY, E.C.

EVENING CLASSES, SESSION 1896-97.

The NEW SESSION begins on MONDAY, October 5th, at 6 p.m. Lectures and Laboratory work: Mechanical and Electrical Engineering; Industrial and Technical Chemistry; Applied Art, including Lectures on Domestic Furniture and Practical Instruction in Enamels and Art Metal Work, Drawing, Painting, &c.; Special Trade Classes in Cabinet Making, Carpentry and Joinery; Metal Plate work and Plumbing.

The Programme may be obtained at the College, Leonard-street, Finsbury, or at the Head Office, Gresham College, E.C.

SILVANUS P. THOMPSON,
Principal of the College.

JOHN WATNEY,
Honorary Secretary of the Institute.

### SAMUEL MORLEY MEMORIAL COLLEGE,

(For Working Men and Women)

WATERLOO BRIDGE ROAD, S.E.

SESSION 1896-7 begins OCTOBER 5th. Evening Classes. Fees from 1s. 6d. per term of three months, with 1s. Entrance Fee payable once for all by New Students.

English History, Foreign Languages, Logic, Experimental Electricity and Physics, Building and Machine Construction, Physiology, Botany, Wood-carving, Violin, Part-singing, Shorthand, Latin, Greek, Book-keeping, Dressmaking, Cookery, Elocution, &c,

Lectures on the Care of Horses, specially suited to Stablemen, &c., on Saturdays, by Prof. Pritchard, M.R.C.V.S. University Extension Lectures on "The Earth and its Luminaries," by F. Wornack, M.B., B.Sc. (Wednesday).

Scholarships to Summer Meeting of the University Extension Society at Oxford and Cambridge.

Gymnasium both for Men and Women.

Library, Debating Society, and various Clubs. Particulars at the College any evening.

EMMA CONS, Hon. Sec.



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## APPOINTMENTS VACANT.

### COUNTY BOROUGH OF HUDDERSFIELD.

**ELECTRICIAN-IN-CHARGE.**

The Electric Lighting Committee are prepared to receive APPLICATIONS for the post of Electrician-in-charge in the Electric Supply Station, where there are two vacancies.

The duties consist of taking charge of the running plant and switchboard during the shift of eight hours per day including Sundays, and such other work as the Borough Electrical Engineer may direct.

Applicants must have held similar positions in High-Tension Alternating Stations. Salary £2 per week.

Applications on foolscap paper stating age, experience, and accompanied by copies of not more than three recent testimonials (which will not be returned) must be sent to me not later than Saturday, the 10th October, 1896, endorsed "Electrician in Charge."

By order,
F. C. LLOYD, Town Clerk.

Town Hall, Huddersfield, 30th September, 1896.

### NORTHAMPTON INSTITUTE.

CLERKENWELL, LONDON, E.C.

The following APPOINTMENTS will shortly be made :—

ENGINEERING WORKSHOP ASSISTANT (good fitter and machinist) at £120 per annum. DRAWING OFFICE and MECHANICAL LABORATORY ASSISTANT (one used to making lecture diagrams preferred) at £120 per annum. CARPENTER and TEACHER of CARPENTRY, &c., at £2 per week. TRAINED MECHANIC (used to brass finishing, &c.). 35s. per week. ENGINE DRIVER, 32s. per week. STOKER, 25s. per week. BUILDING CONSTRUCTION LECTURER (four evenings a week) £60 per session. PATTERN MAKER (one evening a week) £15 per session. SMITH (one evening a week) £15 per session.

Applications, stating age and qualifications and accompanied by single copies of not more than three testimonials, to be made not later than 10th October to

R. MULLINEUX WALMSLEY, D.Sc., Principal.

## SITUATIONS VACANT AND WANTED.

AGENCIES WANTED.—St. Edmund's Electric Works, Salisbury. Sole Agents for West of England for Dr. Lessing's Dry Batteries (just awarded R.C.P.S. First-Class Bronze Mdeal).

DRAUGHTSMAN WANTED.—Thoroughly acquainted with general electrical work.—Age, references, salary.—BRUSH COMPANY, Loughborough.

IMPROVER WANTED, from Technical College. Must give six months in lieu of premium.—GILBERT AND CO., 35, High-street, Kensington.

THE firm of FABIUS HENRION, Nancy, France, require an ENGINEER-IN-CHIEF for their Works, to superintend the construction of Polyphase Dynamos and Motors.

WANTED, for an estate in the country, a YOUNG MAN to take entire charge of Crossley Oil Engine and electric light install ation. Must have had previous experience, and thoroughly competent. Must be good rough carpenter. Wages 30s. week, with cottage, light, vegetables, &c.—Apply, by letter only, to "W.," care of J. W. Vickers, 5, Nicholas-lane, E.C. None but thoroughly competent and trustworthy men need apply.

WANTED, good ARMATURE WINDERS, used to Ring and Drum Bar Machines, good wages to first-class men.—Wage and particulars to "K.R.," *Electrician* Office, Salisbury-court, Fleet street, E.C.

WANTED at once, some competent electrical WIREMEN, also some Junior hands. Applications must be accompanied by full particulars of previous experience, also wages.—CURTIS BROTHERS, 10, Suffolk-Street, Dublin.

ENGINEER (24), with good general electrical and mechanical experience, seeks SITUATION to take charge of an installation or otherwise.—"ELECTRODE," *Electrician* Office, Salisbury-court, Fleet-street, E.C.

ENGINEER, seven years' experience of electrical and mechanical engineering, also French and German, seeks SITUATION or PARTNERSHIP.—Address No. 2,284, *Electrician* Office, Salisbury-court, E.C.

TELEGRAPHIST wants PRIVATE TUITION in higher branches of telegraphy. Must be in London. Liberal payment.—Write "A.B.," 47, Fleet-street, E.C.

PRACTICAL EVENINGS.—Electricity, Running Engine, and Dynamo. Mondays, Wednesdays, Fridays.—ELECTRICAL ENGINEER, 51 Sinclair-road, West Kensington.

**ELECTRICAL PATENTS.**

**Mr. J. G. LORRAIN,** M.Inst.E.E., M.Inst.M.E., Fellow of the Chartered Institute of Patent Agents,

**NORFOLK HOUSE, NORFOLK STREET, STRAND, LONDON, W.C.**

"PATENTEES HANDBOOK," post free on application, gives Full Information to Inventors and upon all the chief points of the Patent Law.

(*Telegrams: "Lorrain London."*)

## WANTED, and FOR SALE.

FOR SALE.—116 GLASS ACCUMULATOR BOXES, in perfect condition, length, 11¾in.; breadth, 11in.; depth, 12¼in.; internal sizes.—Write offers to JOHN RANKIN, Secretary, Kirktonhill Electric Light Company, Dumbarton.

PLATINUM UTENSILS, SCRAP, LAMP TOPS.—Best prices given by Derby and Co., 44, Clerkenwell-road, London, E.C. N.B.—Platinum sold

ACCUMULATOR CHARGING.—C. H. CATHCART and CO., having plant specially adapted for this purpose, Charge Cells of all sizes promptly, thoroughly and cheaply. Terms on application. Accumulators on Hire for temporary lighting, experimental uses, &c.—3, Dorset-buildings, Salisbury-square, Fleet-street, E.C. (Telephone No. 65,266.)

ELECTRICIANS.—NOTICE to EMPLOYERS.—Please note we have a number of First-Class ELECTRICAL MEN upon our Books. Kindly send us particulars of any VACANCIES you may have. We can introduce you, free of charge, to the best men now at liberty.

Address, CHAS. RICHARDSON and CO., Engineers' Bureau, 342, Strand, London, W.C

PARTNERSHIPS.—ELECTRICAL ENGINEERS and others WANTING PARTNERS, or wishing to SELL, can be introduced to Clients with Capital; and GENTLEMEN Seeking Investments can obtain personally (or through their solicitors) particulars of bona-fide OPENINGS. Strictest confidence observed.—Address, CHAS. RICHARDSON and CO., 342, Strand, London, W.C.

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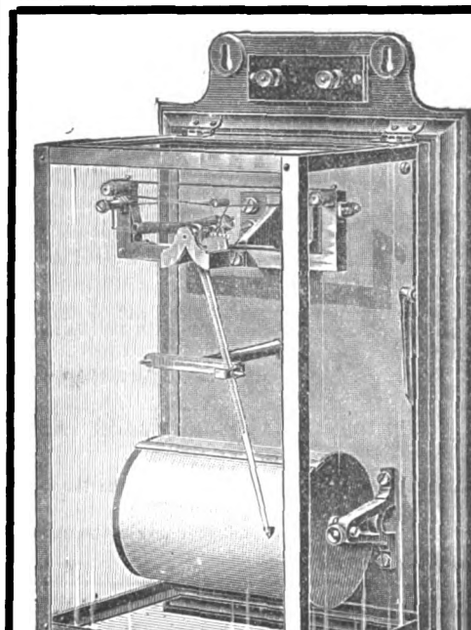
Manufacturer of
**ELECTRICAL AND PHYSICAL INSTRUMENTS,**
**44, HATTON GARDEN, LONDON.**
CATALOGUES FREE.

TRADE MARK

SPECIALISTS IN
**VENTILATING**
By Electrical or any other Motive Power.
**BLACKMAN VENTILATING COMPANY LTD.**
**63, Fore Street, LONDON, E.C., & Branches.**



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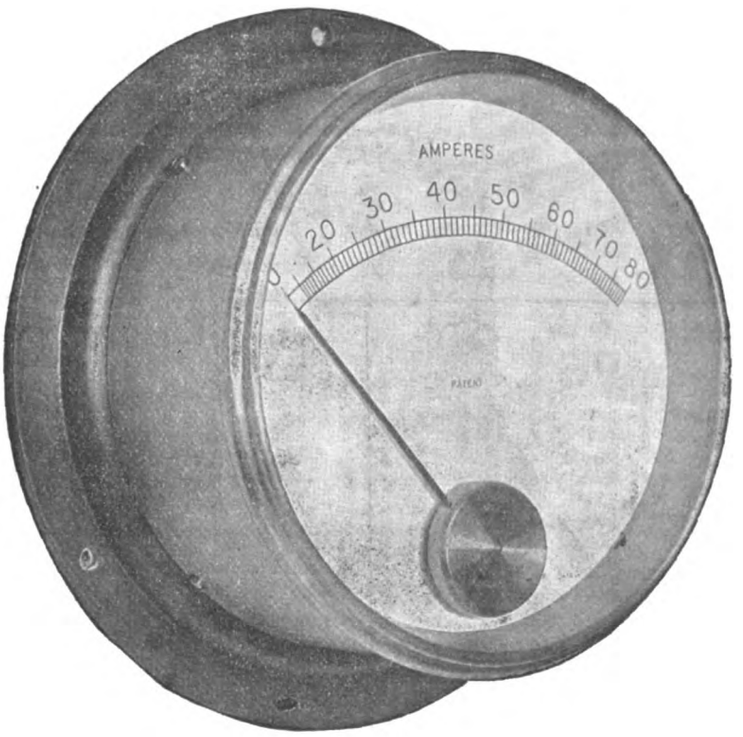


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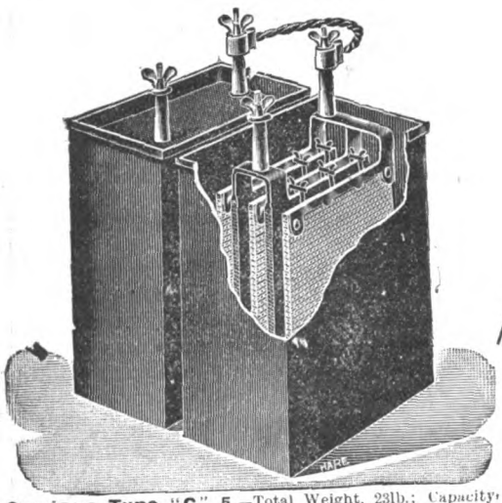

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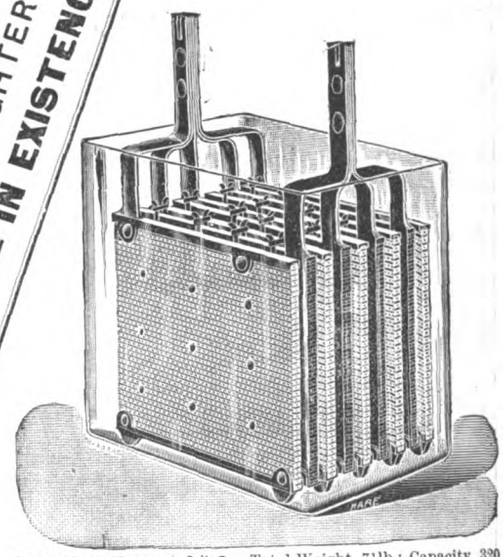

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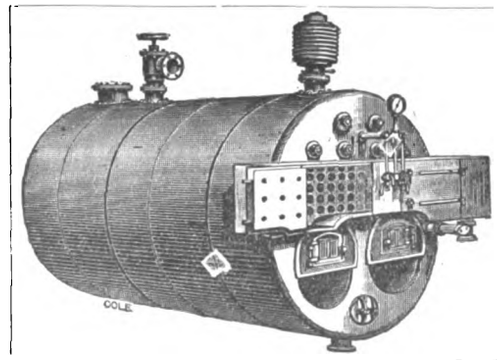

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A WEEKLY ILLUSTRATED JOURNAL OF

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ESTABLISHED 1861–1878.

No. 959. [Vol. XXXVII. No. 23.] FRIDAY, OCTOBER 2, 1896. PRICE SIXPENCE.

## NOTES.

WE print this week the form of the resolutions as to a new thermal unit provisionally approved by the Electrical Standards Committee of the British Association, at the recent meeting at Liverpool. These resolutions, if sent as intended to representative bodies throughout the world, may serve as a basis for international agreement in calorimetry. Hitherto units of heat have been standardised in terms of the thermal properties of water; and the statement of the dynamical value of a thermal unit has been identical with the statement of the value of the specific heat of water in dynamical measure. It is now proposed to make the dynamical value of the thermal unit be independent of thermometry, and of the properties of water, by defining a rigid value of the 42 million ergs. This value is chosen because it is equal to one water-gramme-degree in the convenient neighbourhood of 9·5° to 10·5°C., the specific heat of water in thermal measure being unity.

MR. PREECE'S Paper on submarine cables, read before the British Association last week, has revived the question—Are long submarine telephone cables a possibility? The question was first considered in a practical way by Prof. SILVANUS THOMPSON at Chicago in 1893, when he described various methods of counterbalancing the high capacity of cables by distributing self or mutual induction along them by means of a series of artificial inductive faults placed at intervals along the line. Since then the subject has hardly been mentioned until Mr. PREECE read his Paper. We have the following means at our disposal to decrease the retarding effect of the capacity of a cable:—(1) To increase the mutual induction between the two conductors; (2) to decrease the capacity itself; (3) to decrease the insulation resistance. The applicability of this third method seems to have been rather ignored. It is a well-known fact that low insulation, *if it be evenly distributed* along the cable, tends to increase the speed of working. In the case of many of the earlier cables, it was noticed that, while the insulation resistance was decreasing from day to day, the possible speed of working steadily increased until the cable broke down.

During the last few years paper has been used extensively as insulation in trunk telephone cables of low capacity; and manufacturers have found that they can obtain by its means insulation resistances varying from a few hundred ohms to several thousand ohms per mile, and capacities of about a quarter those of gutta-percha insulated cables. The insulation resistance depends entirely on the dryness of the paper. If a paper-insulated cable is made up and lead-covered, without being dried by artificial means just before it is lead-covered, its insulation resistance will be very low—a few hundred ohms per mile. In experiments made in 1894 by the French Telephone Administration it was found that, by blowing dry air through a cable from one end to the other, the insulation resistance could be increased from a dead earth to the highest limit. It seems reasonable to suppose that by careful experiments a method of manufacturing cables could be founded somewhat on these lines. The two copper cores for the telephone circuit could be paper-covered, as the wires of the existing telephone cables are, and then laid up parallel—not cabled—so as to combine low resistance with a certain amount of mutual induction. A few loose braidings of cotton or jute might then be put on, so as to reduce the capacity between the conductors and earth, and the whole could be lead-covered. Then a current of air passed through the lead tube would enable the insulation resistance to be brought up to some fixed low value, the cable being connected to the testing instruments all the time.

SUCH a cable would possess, to a much greater extent than any existing gutta-percha covered cables, all the three properties required for high-speed working. Paper-and-air insulation has a very low specific inductive capacity, and the two wires would have low insulation and high mutual induction. The insulation resistance being evenly distributed all along the cable, there would be no difficulty in localising faults. Two more things on which the details of the construction of the cable would depend would also have to be determined experimentally. (1.) Would the lead covering resist the action of the sea water? If this were not so it would have to be covered with rubber or gutta-percha, which would also be useful in increasing the resistance between the conductors and earth. (2.) Would the deep-sea portions of such a cable, when armoured, withstand the pressure of the water? To lay a cable designed for telephony might not really be so risky a speculation as at first sight might appear. If it did not do for telephony it could, at any rate, transmit telegraph signals at speeds greatly exceeding those that at present obtain in submarine work.

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In an article we reprint this week Mr. H. E. Campbell states the case in favour of built-up steel flywheels, as against flywheels of cast iron. The energy of a flywheel is, of course, entirely kinetic; so that to obtain a high plant efficiency it is necessary to run the wheel, as Mr. Campbell puts it, "with very little surplus of strength." We remember to have seen, some time ago, a small, rigid cast-iron flywheel, in which an efficiency of nearly 100 per cent. was obtained by the simple expedient of connecting the flywheel to the engine shaft by a variable reduction gear controlled by the governor. The flywheel varied enormously in speed, while the engine shaft varied in speed only a slight amount. The arrangement worked very well, and had the advantage of giving to a comparatively light wheel the capacity of a much heavier and stronger wheel arranged in the usual way. But such an arrangement, unfortunately, is only possible in a model, owing to the well-recognised difficulty in handling large amounts of power with variable reduction gear. The practical engine builder, therefore, has no other resource at present, when the capacity is to be increased, than to build larger and faster flywheels, and to look to it that the choice and disposal of the materials forming the wheel are such that the severe stresses are properly met.

**Royal College of Science for Dublin.**—The next session commences on 6th inst. Further particulars are given in our advertisement columns.

**A Municipal Light.**—A member of the Tonbridge Urban District Council has unburdened himself of the remark that "electric light would undoubtedly *soon be* the light of the future."

**Telegraphists' Strike in Canada.**—Traffic is greatly affected on the Canadian Pacific Railway by the strike of the telegraph operators on that railway. On all parts of the system goods trains have been shunted on to the sidings.

**University College, London.**—The courses of study in electrical engineering at University College, London, under the direction of Prof. J. A. Fleming, D.Sc., F.R.S., are now commencing for the winter session. The laboratories for practical electrical engineering form a department of the spacious and admirably equipped new engineering laboratories.

**Cable Interruptions and Repairs:—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique | Dec. 19, 1895 | — |
| Monte Alegre—Santarem | May 5, 1896 | — |
| Bahia—Rio de Janeiro | Sept. 4, 1896 | — |
| Penang—Medan | Sept. 7, 1896 | — |
| Loanda—Benguela | Sept. 13, 1896 | Sept. 28, 1896. |
| Zanzibar—Mombasa | Sept. 23, 1896 | Sept. 26, 1896. |

**Morley Memorial College.**—The winter session of the Morley Memorial College, S.E., will commence on the 5th inst. The recreative evening classes at this Institution are in a variety of useful and healthful subjects, and are open to working men and women. We are in sympathy with the efforts of the promoters of this Institution to provide healthy mental and physical recreation for the labouring classes. Further particulars are given in our advertising columns.

**Electric Tramways on the Continent.**—In a Paper recently read by Mr. Kolle before a German Society of Engineers and Architects he stated that the electric tramway lines in Germany represent a capital of £5,000,000. In 1895 Germany had 256 miles of electric tramways, France 82 miles, and Great Britain and Ireland only 67 miles. During 1895 the number of electric tramways in Germany increased from 70 to 111, and the engine power from 17,000 to 30,000 kilowatts.

**Condemnation of the Standard Candle.**—The *Journal of Gas Lighting* announces that a Sub-Committee of the American Institute of Electrical Engineers, appointed in 1893 to investigate the subject of a suitable standard of light for photometric purposes, has recently issued a preliminary report. Of all the standards thus far used, they find the candle the least reliable. It is thought that the difficulties attending the use of a flame standard may be overcome by the adoption of one consisting of some surface electrically heated to a standard temperature.

**Advanced Science Evening Classes.**—In conjunction with the Technical Education Board of the London County Council, the Councillors of University College and King's College, London, have arranged for evening courses of instruction in mechanical and electrical engineering, practical chemistry, civil engineering, architecture, experimental and practical physics, and pure mathematics. The classes are limited to students who have made some advance in the knowledge of the subjects. These classes form a new departure in the work of the Colleges.

**Business of the United States Patent Office.**—The United States Commissioner of Patents has submitted his report on the business of the Patent Office for the year ending June 30, 1896. It shows 48,105 applications and caveats received; 24,585 patents granted and trade marks, labels and prints registered; and 15,580 patents withheld and patents expired. Receipts from all sources during the year were $1,307,090, and expenditures $1,097,368, leaving a surplus of $209,721. The balance in the Treasury of the United States on account of the patent fund on June 30, 1895, was $4,566,757, making a total, with 1896 surplus, of $4,776,479.

**The Telegraph Jubilee in Belgium.**—An exhibition, entirely due to private enterprise, was opened in Brussels on Sept. 9th. The exhibition is intended to celebrate the fiftieth anniversary of the introduction of the electric telegraph into Belgium. The first line, which was opened on Sept. 9, 1846, and connected Brussels with Malines and Antwerp, was a financial failure. A model of the original Cooke and Wheatstone instruments used on this line is shown, as well as the various types of apparatus in use at different times, down to the Morse sounder and Hughes printing instrument of to-day. All the exhibits are seen actually working.

**Finsbury Technical College.**—The autumn courses in the laboratories of the Technical College, Finsbury, open on Monday next. The advanced lectures on Monday evenings by Prof. Silvanus Thompson will be on construction and theory of dynamos and alternators; but the opening lecture on October 5th will deal with the newest work in the production of special qualities of iron and steel for dynamos and magnets. In the elementary course on electrotechnics on Wednesdays, Prof. Thompson and Mr. O'Keeffe, or Mr. F. R. Flew, will deal with practical electrical measurements, and with electromagnets. Mr. Flew undertakes the Physics lectures on Friday evenings, and Mr. B. Wedmore the laboratory instruction in Heat. Further particulars are given in our advertisement columns.

**Telegraphy in Europe.**—The following table has been compiled by the Austrian Ministry of Commerce. The numbers refer to the year 1894:—

| Country. | Inland charge for ten words (pence). | No. of sq. miles per telegraph office. | No. of inhabitants per telegraph office. | Total number of paid telegrams per 1,000 inhabitants |
|---|---|---|---|---|
| Austria and Hungary | 7·2 | 36 | 6,083 | 428 |
| Germany | 6·0 | 10 | 2,483 | 649 |
| Great Britain and Ireland | 6·0 | 13 | 3,969 | 1,894 |
| France | 4·8 | 18 | 3,382 | 1,017 |
| Italy | 5·6 | 22 | 6,023 | 293 |
| Russia | 5·6 to 22·4 | 2,034 | 28,663 | 102 |
| Sweden | 6·7 | 140 | 3,917 | 404 |
| Norway | 6·7 | 310 | 4,990 | 884 |
| Denmark | 6·7 | 36 | 5,324 | 809 |
| Holland | 5·0 to 6·2 | 15 | 5,628 | 929 |
| Belgium | 4·8 | 10 | 5,487 | 871 |
| Switzerland | 5·2 | 10 | 1,848 | 1,250 |
| Spain | 9·6 | 143 | 12,876 | 243 |
| Portugal | 8·0 | 88 | 10,863 | 310 |

**Bristol Electric Supply Station.**—Mr. J. R. Blaikie, Assistant Electrical Engineer to the Corporation of Bristol, read a Paper at the Western Counties Meeting of the Association of

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Municipal and County Engineers, at Bristol, on Saturday, descriptive of the Bristol Central Electric Lighting Station. The station was fully described in *The Electrician* of March 6th last (Vol. XXXVI., p. 613. In the subsequent discussion on the Paper Mr. J. Lobley, of Hanley, asked whether they had tried rectifiers in Bristol. They were a very great advantage, because they saved working an entire set of engines after midnight during the long, dark hours of the winter. They had had rectifiers in use in Hanley for a month or two, and had found a considerable saving in coal. Mr. Blaikie said they were rather endeavouring to use alternating current-lamps with a small reflector hung up over the arc. Rectifiers might act very well in Hanley, but he understood they did not act in Cardiff. Mr. Harper, of Cardiff, said he should not like it to go forth that rectifiers did not act well in Cardiff. As representing Cardiff, he could say they were an unqualified success.

**Electric Light on the "Fram."**—The *Elektroteknisk Tidsskuft* publishes some interesting particulars regarding the use of electricity on the "Fram." According to this article, the electric light gave great satisfaction, and general regret was expressed when, in May, 1895, Lieut. Sverdrup and Mr. Nordahl decided that it must be dispensed with, owing partly to the wearing out of the gearing of the cogwheel in the windmill which worked the dynamo, after the vessel had entered the ice, and partly to the fact that portions of the apparatus were required for making snow-shoes and runners. Mr. Nordahl took advantage of every puff of wind to charge the accumulators, and until May last year the electric light was always available. In the severe cold the accumulators froze right through, but the acid-blended ice, we are told, proved an excellent electrolyte, and the frost did not interfere with the working of the accumulators. Electricity was also used for other purposes besides lighting, the mining shots which set the "Fram" free from the grip of the ice being fired by means of a cable attached to six Leclanché cells.

**Cable Steamer in a Cyclone.**—The cable steamer "François Arago," the renamed "Westmeath," has recently had a narrow escape. She sailed from Cape Haytien, Hayti, on September 3rd, for Halifax, Nova Scotia. She had been engaged in repairing a break in the insulation of a cable between Porto Plata and Cape Haytien, and was bound by way of Halifax to repair cables near St. Pierre, Miquelon Islands, when she was struck by a storm. On the morning of September 6th, in latitude 28.50, longitude 77, a storm set in from the south south-east, and constantly increased in fury, until the vessel was found to be in the centre of a cyclone. The captain kept the ship in the vortex of the cyclone until its fury had abated, before attempting to move toward the outer circle. In the height of the storm the steamer was continuously flooded by mountainous seas, which broke over her from all directions, carrying everything before them. One of the great waves struck her on the port-bow and carried away the second quartermaster. Nothing was afterwards seen of his body. The port and starboard lifeboats went by the board with the same sea, and both steam and hand steering gear were disabled. The decks were swept of everything movable, and when the vessel emerged into smoother water she was so badly disabled that it was decided to bear away for Philadelphia for repairs. She arrived at that port on September 12th.

**International Submarine Telegraph Memorial.**—In addition to those whose names have already been published, the following have agreed to join the committee which is being formed for the furtherance of the above object:—Lord Charles Beresford, Lord Rayleigh, Sir David Salomons, Sir Thomas Sutherland, M.P., Sir James F. Garrick, Q.C., Sir Charles Todd (Postmaster-General of South Australia), Sir Donald Currie, Sir Alfred Dent, Sir Julius Vogel, Sir Roper Lethbridge, Sir A. Wilson, His Excellency Ernst Dániel (Hungarian Minister of Commerce), Mons. E. A. Floyer (Inspector-General of Government Telegraphs, Egypt), Mr. Alfred de Rothschild, Mr. H. C. Fischer, Mr. B. T. Ffinch, General Thomas T. Eckert (U.S.A.), Colonel H. M. Hozier, Commodore Suenson, D.R.N., Mr. A. H. Baker, Mr. Charles Burt, J.P., Mr. Frank Dawes, Mr. Alexander Elder, Herr Emil Guilleaume, Herr Max Guilleaume, Herr Theodore Guilleaume, Mr. John W. Mackay (U.S.A.), Mr. Abram S. Hewitt (U.S.A.), Mr. W. Claude Johnson, Mr. Thomas McKie, Mr. T. R. Tufnell, Mr. W. Worby Beaumont, Mr. H. C. Burdett, Mr. W. H. Burman, Mons. J. Depelley, Mr. J. T. Crowe, Mr. G. C. Jack, Mr. J. Lockie, Mr. W. R. Lyne, Mr. A. R. H. Mackay, Mr. W. H. Maw, Mr. F. Moll, Mr. F. C. C. Nielsen, Mr. J. Pendred, Mr. T. H. S. Pullin, Mr. Benjamin Smith, Mr. W. O. Smith and Mr. G. B. Stacey. The first meeting of the Committee formed for the purpose of promoting the above object will be held in Room 174, Winchester House, Old Broad-street, London, E.C., on Tuesday next, October 6th, at 2:30 p.m. An Executive Committee will then be appointed, and it is expected that Lord Kelvin will explain his views as to the most appropriate object to which the bulk of the Fund should be devoted.

**Technical Education.**—Our esteemed contemporary the *Engineer* has joined in the revived battle now raging around the standard of Technical Education; and, as was only to be expected, it refuses to be frightened by the "bogey" of German competition, or to be converted in a moment of panic to the technical education creed:—

"The German does not, after all, possess better machinery or turn out better work than the Englishman. His technical education has not taught him to build better locomotives or marine engines than we have; his spinning machinery and his steel castings are in no sense or way better than ours; his flour is not more excellent, nor his cotton goods, nor his cutlery, nor his watches, his boots, or his agricultural implements. It would seem from this either that his much-boasted technical education is a failure or that conditions exist which prevent him from putting into practice what he learns in the schools. The English manufacturer asserts that he is continually undersold by the German, because the German sells inferior goods for little money; and it is notorious that, in spite of technical education, professors and colleges, Germany can only keep many of her industries alive by the help of protective tariffs or by bounties. All her training in chemistry has not enabled the German housewife to buy sugar for less than 4d. a pound. On the other hand, our ignorant and benighted manufacturers get on fairly well without any help of the kind. We regard with very grave doubt the tales which we hear of successful German competition. We cannot have the whole trade of the world; but it does not appear that less would satisfy some people. We ask—and, so far at least, in vain—for some tangible, trustworthy evidence that Germans are getting more than the legitimate share of trade which any active, quiet and intelligent manufacturing community ought to enjoy. One strike such as that just averted on the Clyde can do more harm than the closing of every technical school and engineering college in this country for ten years. But conceding, for the sake of argument, that Germany is beating us, is it true that her victory is due to the professor and the technical college? This is a point on which absolute silence exists. What does the German do as a result of technical education that we do not do? A few facts on this point would be of inestimable value. We are told, for example, that Germany is beating us in the steel trade. One man says that this is the case, because of technical education; another tells us that technical education has nothing to do with it; that it is brought about by low wages, steady labour and long hours. We turn to the German manufacturer himself, and find that the whole statement is a myth. It is all he can do, he says, to make a living in the face of the fierce competition of all-powerful England. What we ask is the truth. Perhaps, after all, if we could but handle this bogey of German competition, we should find that it is not nearly so terrible as the professors would have us believe."

**Modern Discoveries and Research.**—The present position and prospects of chemical science, says the *Chemical News*, justify a few words of advice to students: "Discoveries have been lately made of a novel character, such as may possibly modify the course of future research. Thus it is very probable that argon and helium are not merely isolated bodies hitherto unknown, but that they are the types of a new class of elements which may seriously modify our general views. Hence they must require careful examination from every conceivable point of view. Technically, indeed, these elements may be of little direct moment, but their indirect bearings may be for the present beyond our ken. The grand question of the elements as modifications of protyle, or as mere desultory and ultimate essences, has not been advanced any nearer to a definite solution, but our suspicions of their modifiable character are certainly becoming more justified. Young chemists who have time at their disposal might very advantageously employ it in this direction. The failure of Dr. S. Brown to effect a mutual conversion of carbon and silicon should not, we think, discourage us from future attempts in this direction. It seems that the advance which we have already accomplished in chemical and physical

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science, instead of narrowing, actually expands the fields which remain for us to occupy. If science means the interpretation of the universe, its scope must widen with our comprehension of the almost infinite nature of its task."

**No. 0000 Trolley Wire.**—"It has generally been the custom in American practice," says the *Electrical World* of New York, "to use No. 00 B. and S. gauge trolley wire in electric railway construction, but of late the size has been increased on some interurban roads to No. 000, and in a few cases to No. 0000. This change has been brought about principally for the reason that a better contact may thus be obtained between the trolley wheel and wire, a solution necessitated by the use of the larger motors with which the heavier interurban cars are equipped. There are, however, several other advantages to be gained by adopting a No. 0000 wire, and the question naturally arises why this change has not been brought about on a more extensive scale in ordinary street railway construction. Among the several reasons favouring the use of No. 0000 wire may be mentioned that it is stronger than the ordinary trolley wire, and is not as liable to break, due to pitting produced by the arcing near the ears and switches. It is also more easily grasped by a mechanical clip, and, in fact, such a clip could be designed so as to hold a No. 0000 trolley wire far better than a soldered ear. The better contact rendered between the trolley wheel and wire is not an unimportant point. Moreover, the installation of the heavier wire reduces the amount of insulated copper, and on short roads having a light service the insulated feeders could be done away with altogether. Of course, many cases will arise where its installation will be unwise; but there is no doubt that its judicious use in most equipments could not fail to be both more economical and render more efficient service than the present practice."

**A French Municipality's Dispute with its Gas Company.**—*L'Industrie Electrique* tells the following amusing story. The little town of Lodève pays the local gas company £600 a year for illuminating its streets badly. It is under contract to continue to pay this sum for the same amount of illumination until the year 1909. In the agreement there is the clause so common in France, and which reads as follows:—

"If, during the duration of the enterprise, a system of public and private lighting other than by hydrogenous gas should, in consequence of the advances made by science, be adopted at Nimes, at Montpellier, or any other town in France of similar importance, and prove more economical, the grantees undertake, on the demand of the municipal authority and after a general application of the system for two years in one of the above towns, to allow the town of Lodève to possess this system until the end of the contract time, at the same price and upon the same conditions as in the above towns; always allowing, however, for the differences which might result from the application of this system of illumination at Lodève and the comparative importance of the consumption of gas and the net cost of manufacture."

The municipal administration of Lodève claimed that according to this clause they were entitled to have electric light substituted for gas, and put its case before the Conseil de Préfecture about three years ago, although the contract was only entered into in 1892. The Conseil de Préfecture has just given its decision, having weighed the evidence from both sides with care and impartiality, and without undue haste. The estimate of the gas company's expert of the cost of changing the system from gas to electricity was £20,880; the estimate of the expert employed by the Municipality, £8,000; while the Conseil de Préfecture's expert estimated £12,000. As two out of the three experts drew conclusions unfavourable to the Municipality's case, the latter were non-suited and had to pay costs.

**Institution of Electrical Engineers.**—A small party of students of the Institution of Electrical Engineers recently returned from a ten days' tour in Switzerland, where they visited a number of places of electrical interest. The party left London on the evening of Saturday, August 29th, by the Hook of Holland route, and arrived at Bâle on the following evening. On the morning of the 31st the Bâle electric tramway was inspected, and in the afternoon the students went on to Neuhausen, where they saw the Falls of the Rhine. The next morning the party saw the wire-rope and electric-power transmissions at Schaffhausen, and in the afternoon was shown over Sulzer Brothers' large engine works at Winterthur, where Mr. Sulzer himself very kindly welcomed the party. The next two days were spent at Zürich, where the central station and two electric tramway stations were inspected. Very interesting visits were also made to the works of Messrs. Brown, Boveri and Co., the Maschinenfabrik Oerlikon, and Escher, Wyss and Co. The party was also shown over the Physical Department of the Zürich Polytechnic, and saw the installation at the Tonhalle, where a battery of accumulators is charged during the daytime off the alternating supply mains by means of a motor-generator, and is used for lighting the concert hall by night. The Dolden cable railway, worked by an electric motor run off a private lighting plant, was also visited. The next day (Friday) the party went to Lucerne. The Stanserhorn cable mountain railway, which is driven by electric motors, the electric power being transmitted from a water-power station near the foot, was ascended. On the Saturday the students proceeded to Geneva, stopping for a short time at Berne on the way, where the Mekarski compressed-air tramway was inspected. At Geneva three days were spent in visiting the National Exhibition, the works of the Cie. de l'Industrie Electrique (Système Thury), the Mont Salève electric rack railway, and the electric light stations, including the new water-power two-phase station at Chèvres, on the Rhone, where 18,000 H.P. is eventually to be utilised. On Wednesday, September 9th, the party left Geneva, and went to Lausanne by the lake, and the next morning most of the party left Bâle for England, after a most interesting and enjoyable trip.

**Contemporary Electrical Science.**—The current number of *Wiedemann's Annalen* (No. 9) contains some valuable papers on electric radiation and discharge, on magnetic properties of amalgams, and on photographic photometry.——E. WARBURG explains the influence of light upon the spark discharge, and proves that if the discharge potential is gradually applied, illumination has practically no effect upon it. It is only with sudden applications or alternations of potential that illumination has a facilitating effect. Jaumann suggested last year that this effect is not direct, but secondary. There is some process, at present unknown, which precedes discharge, and it is this process which is shortened by illuminating the cathode. When the potential is gradually raised, this process has time to develop itself, and light has no further effect. Another point observed was that the range of potentials at which discharge may or may not take place in the dark is much narrowed by illumination. Hence a telephone in circuit with a spark gap will give an impure note in the dark, whereas under the influence of light the note will be higher and purer, owing to the increased regularity and frequency of the oscillations. This explanation, based upon careful experiments, is extremely suggestive, and should lead to further advances.——P. DRUDE has found that there is such a thing as electric dispersion in water, although his first experiments led him to the opposite conclusion. The square of the refractive index at 17°C. has been found to vary from 80·60 at a frequency of $1·5 \times 10^8$ to 83·6 at $8 \times 10^8$ oscillations per second. This dispersion is normal. Dilute aqueous solutions behave like pure water. But solutions of cane-sugar show anomalous dispersion and absorption, increasing with the concentration.——The behaviour of dilute iron, nickel, and cobalt amalgams is the subject of a Paper by H. NAGAOKA. That eminent Japanese physicist has found that the magnetic intensity of amalgams shows a maximum at their melting points, and that during the process of melting there is a sudden change, which is not observed during solidification. The amalgams, which oxidise very readily, were enclosed in vertical ellipsoidal bottles, and their surfaces were covered with linseed oil.——H. T. SIMON describes a new process of photometry, which is to avoid the difficulties of accurately comparing the luminosities of two nearly equal surfaces, and to give a permanent record of the measurement. The principle employed is that of photographing a cube as employed in the usual photometers, but in such a manner that only a narrow horizontal strip across both surfaces is photographed at one time. One source is moved from a position which is too near for equality to a position too far away, and by a link work the camera is moved so as to take a succession of impressions at all the stages. The line on the negative which crosses the region of equal brightness is determined by a specially designed comparator.

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# THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 627.*)

*Loop Methods.*—The methods 9 and 10, described in the preceding chapter, may be used during working with only a slight, but important, modification.† The test should be made at the time of lightest load. All the feeders except one are disconnected from the 'bus bars (if the load is not small enough to be taken by one feeder, two must be left on, but the accuracy of the test suffers). The connections are made between two adjacent feeders, as in Fig. 34. This is followed by the test indicated by Fig. 35, if necessary, and by the test in the street, Fig. 36 or 37. The tests are proceeded with exactly as previously described, except for this one important difference: *The galvanometer key is depressed first, and the balance is taken to false zero.* And this makes the difficulty in carrying out the localisation. On depressing the galvanometer key, a relatively large current will pass through the galvanometer, and the spot or needle will usually fly to the end of the scale and stay there. It may be brought back towards the middle of the scale by shunting the instrument, or by a controlling magnet. The latter means cannot be used with instruments of the d'Arsonval type; but with other instruments it is to be preferred, as shunting the galvanometer naturally reduces its sensibility. The controlling magnet may be put in such a position that it just counterbalances the current without reducing the sensibility. It must, however, be borne in mind that the current may be strong enough to damage the coils of the galvanometer, if all were allowed to flow through them. Then shunting must be resorted to, unless the disturbing E.M.F. be balanced by an opposing E.M.F. inserted in series with the galvanometer, as will be explained presently. In any case, a very fine fuse should be in series with the galvanometer to protect it. This is not the only trouble in connection with the "false" zero. When the galvanometer needle is brought back towards the centre of the scale, so that it can swing in either direction, one finds that the disturbing current is not a constant one, but continually varies. It is thus necessary to balance to a false zero that is constantly changing. Although this is troublesome it is yet possible to balance to a fair degree of accuracy under these conditions.

The battery will probably not be needed, and it can be replaced by a resistance, such as a lamp or two lamps in series. Even if it is necessary to use a battery, it is well to have a lamp in series with it. This prevents a large current from flowing through the coils or stretched wire if the fault breaks down. If the fault has by itself a high resistance, and it is not wished to still further increase the resistance of the "battery arm" by having a lamp in it, a lower resistance, or even a thick piece of wire, may be used for the connections between the bridge and battery or earth; but then it is advisable to insert a very fine fuse in series with it, and also to keep a sharp look-out that the coils or stretched wire show no signs of heating.

The galvanometer key may be left down throughout the test.

The method 9 is a modification of a method published by Dr. Richard Hieke, of Vienna, in 1892.‡ Dr. Heike connected his bridge as on Fig. 51. A battery $B_1$ was connected between the two adjacent feeders, and a resistance box, *a b*, between the ends of their test wires $P_3$ and $P_4$. The galvanometer connection divided this resistance into two parts. One pole of another battery $B_2$ was connected to the other galvanometer terminal. This second battery was bridged by a stretched wire with a sliding contact, E, connected to earth. On "making" the galvanometer circuit there is a deflection as before, but now the sliding contact E is moved until the galvanometer needle returns to zero. The arrangement simply forms a potentiometer, by means of which the disturbing E.M.F. is neutralised by an opposing E.M.F., which can be regulated to a nicety. The pole of $B_2$ to be connected to the galvanometer end of the stretched wire must be determined by trial. $B_2$ can be a few cells of a secondary battery, in which case the stretched wire must be of high resistance or must be replaced by adjustable resistance coils, else the cells will send more current than is good for them. In Dr. Heike's original trials he used Bunsen cells for $B_2$, and a wire wound on two cylinders constituted his potentiometer. This manner of neutralising the disturbing galvanometer current, instead of diminishing it by a shunt or neutralising its effect by a controlling magnet, can be applied just as well to Fröhlich's method. It enables the galvanometer to be in its most sensitive condition, and it also avoids the risk of burning the galvanometer coils incurred when the deflection is neutralised by a controlling magnet. Its disadvantage is evident; it complicates the method, as it includes an extra battery and slide wire with their connections.

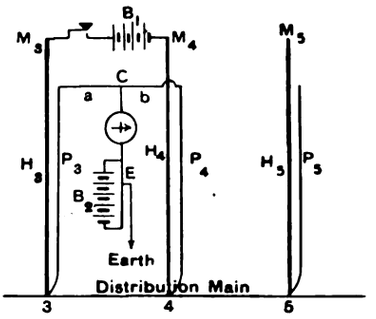


FIG. 51.

The galvanometer key can now remain down, and the bridge is brought to balance by adjusting the slider C until the deflection is the same, whether the battery key is open or closed. If the position of C for balance is at the end of the stretched wire, the next feeders and their test wires in the direction indicated are substituted for the first ones, just as in Fröhlich's method (method 9) already described. Thus, if balance is only obtained when C is at the extreme right-hand side of the stretched wire, the apparatus is changed over to $M_4$, $M_5$, $P_4$ and $P_5$. Supposing now, with these connections, balance is obtained at the extreme left-hand position, the fault will be either in the feeder $H_4$, or at the feeding point 4. The connections are then changed to Fig. 52, so that the feeder $H_4$ is included in the loop. (If a stretched wire be used for *a b* instead of a resistance-coil bridge, this latter mode of connection must always be employed; for, as the resistance of the stretched wire will not be high compared with that of the test wires, this latter resistance could be neglected.)

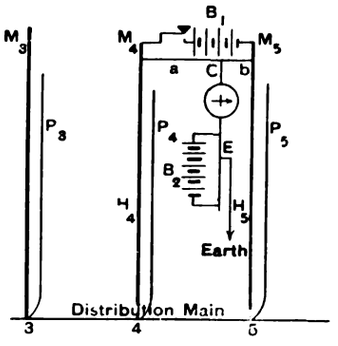


FIG. 52.

The position of the fault is calculated as from any other test with a "Murray loop." If the connections are as Fig. 51, the distance of the fault from the point 3 is $\frac{a}{a+b} l$, where $l$ is the length of the piece of distributor 3, 4. If the connections are as Fig. 52, the equivalent length of the loop,

* From a forthcoming work to be published by *The Electrician* Printing nd Publishing Company. All rights are reserved.

† These two methods of localising during working were described by Dr. O. Fröhlich, of Berlin, in a Paper read before the Elektrotechnischer Verein in December, 1892. See *Elektrotechnische Zeitschrift*, January 27, 1893, or *The Electrician*, February 24, 1893.

‡ *Elektrotechnische Zeitschrift*, September 30, 1892.

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in terms either of the distributing or one of the feeding cables, must be taken for $l$, and then $\frac{a}{a+b}\,l$ is the equivalent distance of the fault from $M_4$, the station end of the feeder.

To decide whether to use Dr. Hieke's or Dr. Fröhlich's connections for the bridge we must compare Figs. 51 and 34, and consider in which instance the disturbing current through the galvanometer will be less variable. In Fig. 51 the fault is in the galvanometer arm, so that as its resistance and E.M.F. have unsteady values, the galvanometer needle will be continually on the move. In Fig. 34 the fault is in the battery circuit, and so has no effect on the false zero. But in this case, the galvanometer being connected between two points on a distributing main, the false zero will change every time lamps are switched on or off. But the test will naturally be taken at a time of light load, and if lamps are switched on or off it means a large relative change in the load each time. This will occasion now and then a decided change in the false zero; but there will not be that unsteadiness of zero which ensues when the fault is in the galvanometer circuit. Thus Dr. Fröhlich's modification is always to be preferred, unless the test has to be taken on a fairly heavily-loaded section of main, on which, as usual, the number of lamps between adjacent feeding points is constantly changing. But the means Dr. Hieke employs to neutralise the disturbing E.M.F. in the galvanometer circuit may be made use of in either case.

The loop tests have one distinct advantage over the induction method, and Latch's fall of potential method, to compensate for their requiring more apparatus. They are carried out on the faulty main, and the other main is not interfered with. In the other methods it is always necessary to earth

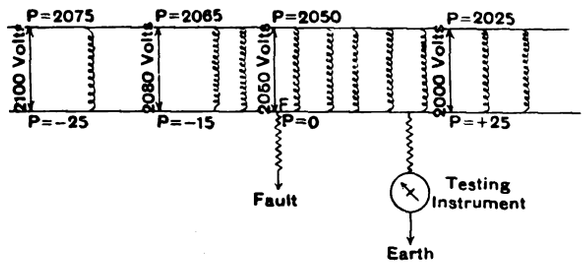


Fig. 53.

the healthy main in such a way that a considerable leakage current shall flow through the fault. Of course, this earthing may be only instantaneous, but it still will have to be done a number of times to get a useful result. The loop tests may also be used on alternating-current networks. As the alternating current will not directly cause a deflection of the galvanometer needle, one must be doubly careful that it does no damage to the instrument or to the resistance coils or stretched wire; fine fuses must be used as already directed.

On high-pressure mains the loop methods could also be used if a special independent switchboard be constructed for the purpose. The board would have to be arranged so that the connections either of Fig. 34 or 35 could be made simply by switching, and no loose wires should be used nor connections made by hand when any bare metal on the board is "live." The sliding contact on the stretched wire $a\,b$ would have to be provided with a well-insulated handle, and also with a sort of guard to prevent the hand from coming in contact with the bare stretched wire, and all the switches and fuses would have to be of the high-pressure pattern. The induction methods are not applicable to high-pressure networks during working. Neither are loop methods in the street recommended, as they would be too dangerous.

A clue as to the whereabouts of a fault in a high-pressure main may also be obtained in the following manner. If one point of a network makes contact with earth, through a fault whose resistance is small compared with the fault resistance of the rest of the network, its absolute potential is 0. This is shown in Fig. 53, which represents a pair of mains conveying current to transformers distributed at various points along the line. (The potential at the points marked P = −25, −15, &c., is opposed to that at the other points marked.) Now, if a voltmeter or a galvanometer whose resistance is high compared with the resistance of the fault be connected in turn between different points of the faulty main and earth, it will give a lower reading the nearer it is to the faulty point. The instrument must have a high resistance chiefly because it is not advisable to send a large current through the fault for considerations of safety, but also because the resistance of the circuit, F, earth-testing instrument, G, must not be relatively very much altered by a change in the resistance of the fault during the walk from one testing point to another. On account of the current through the main constantly varying by the switching of lamps in and out of the secondary circuits, misleading tests will occur, but near to the faulty point hardly any current will be obtained through the testing instrument. Great care must be taken that the hand does not come in contact with the main; the instruments and connecting wire should be insulated as against high pressures. Omitting the possibility of connecting on to the wrong main, the pressure of the faulty main may rise to above the safe limit for handing by the fault getting momentarily sealed up, or by another fault occurring on the opposite main. Before connecting the instrument to the main a vacuum tube may be

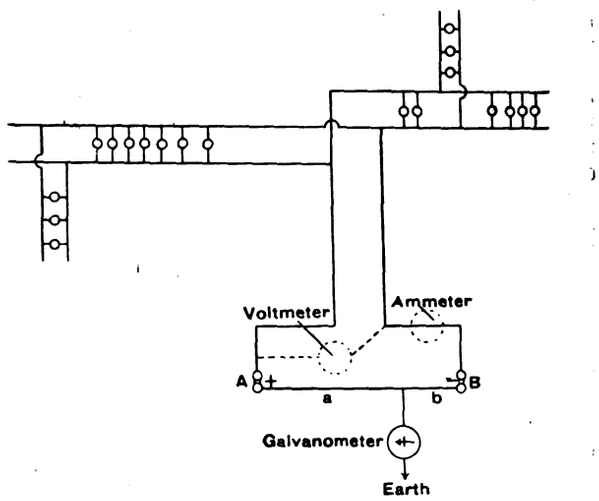


Fig. 54.

held against the latter. The main of higher potential will cause the tube to glow; the main which is wanted will not. For completeness' sake a method of localising faults on low-pressure networks, recently suggested by Mr. J. Pigg, of Liverpool,* must be mentioned. It may be found to give useful results on small networks fed from only one pair of feeders from the station, as on such networks the loop methods already described cannot be used. The connections are shown on Fig. 54. A and B represent the + and − ends of a pair of feeders at the station. The stretched wire or resistance coil bridge is connected between them, and the sliding contact, or the middle terminal of the resistance box, is connected through a galvanometer to earth. This diagram of connections is the diagram for a loop test, the cable loop being formed by the + cable, lamps and − cable.

If the position of the slider or the values of the resistance coils be adjusted until no current flows through the galvanometer, we have the usual equation,

$$\text{Resistance from A to the fault} = x = \frac{a}{a+b} \times (\text{resistance of loop}).$$

The resistance of the loop is got by taking simultaneous readings of the voltage between A and B, and the current passing through the feeders at the moment balance is obtained. These readings are given by the switchboard instruments. Calling them V and C respectively we have

$$x = \frac{V}{C} \cdot \frac{a}{a+b},$$

or $y$ (the resistance from B to the fault) $= \frac{V}{C}\,\frac{b}{a+b}$.

* See *The Electrician*, August 30, 1895.

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If the lower of these two values be taken, the resistance per yard of the cable being known, the distance of the fault from the station can be calculated. For further particulars the reader is referred to the original article.

The reason this method can seldom be accurate is that the current through the feeders is constantly changing, and therefore the values of $a$ and $b$ necessary for balance are also changing. Besides, the accurate reading of the station ammeter at a particular moment is a matter of difficulty, and the percentage error in this reading will cause the same percentage error in $x$ or $y$. At times of a fairly steady load of a few hundred lamps the test might be relied on to indicate whether the fault were in the feeder or in the distributor.

*(To be continued.)*

## MAGNETIC HYSTERESIS IN A ROTATING MAGNETIC FIELD.*

BY R. BEATTIE, B.SC., AND R. C. CLINKER.

The subject of the following investigations was the measurement of the hysteresis loss in iron in a rotating magnetic field. The rotating-field method has been employed by several experimenters for quickly testing transformer iron in the workshop. The method consists either in measuring the torque exerted upon the specimen to be tested, when placed in a rotating magnetic field, or that exerted on the magnet producing the field by the rotation of the specimen. The first mode of measuring the torque has been used by Prof. Elihu Thomson and Mr. Holden in America, and also in England by Mr. Baily. The first two of these experimenters balanced the torque on the specimen by means of a spring previously calibrated, whilst Mr. Baily measured the force required to keep the specimen rotating against this torque. The second mode has been applied by Prof. Ewing in his well-known hysteresis tester. In his instrument the specimen (in the form of strips clamped together) is spun between the poles of a pivoted C-shaped permanent magnet, the restoring force on which is gravity. The deflection of this magnet is nearly proportional to the hysteresis. The instrument is calibrated by means of two standard specimens whose hysteresis losses have been previously determined ballistically. All these experimenters seem to have used specimens of the same form and size, usually built up of thin discs or strips cut from transformer sheet. At the suggestion of Dr. Fleming, and with his assistance, an apparatus was designed for experimenting on any sample of iron, whether in the form of discs, wires, or filings. The sample to be examined was placed in a cylindrical bucket of non-conducting material, which was suspended in the magnetic field by a wire from a fixed support. The deflections were read by the usual lamp mirror and scale arrangement, and the wire being calibrated by a vibration experiment with a bar of known inertia moment, the torque exerted corresponding to any deflection was thus known in absolute measure. If W be the energy dissipated in hysteresis alone the ergs per c.c. of sample per cycle, V be the volume of sample and $n$ be the number of cycles per second: the total work done per second = W V $n$.

Again, if T = torque exerted on the wire, the total work spent on the sample

$$= 2\pi n \mathrm{T}$$
$$= 2\pi n \mathrm{K\,D},$$

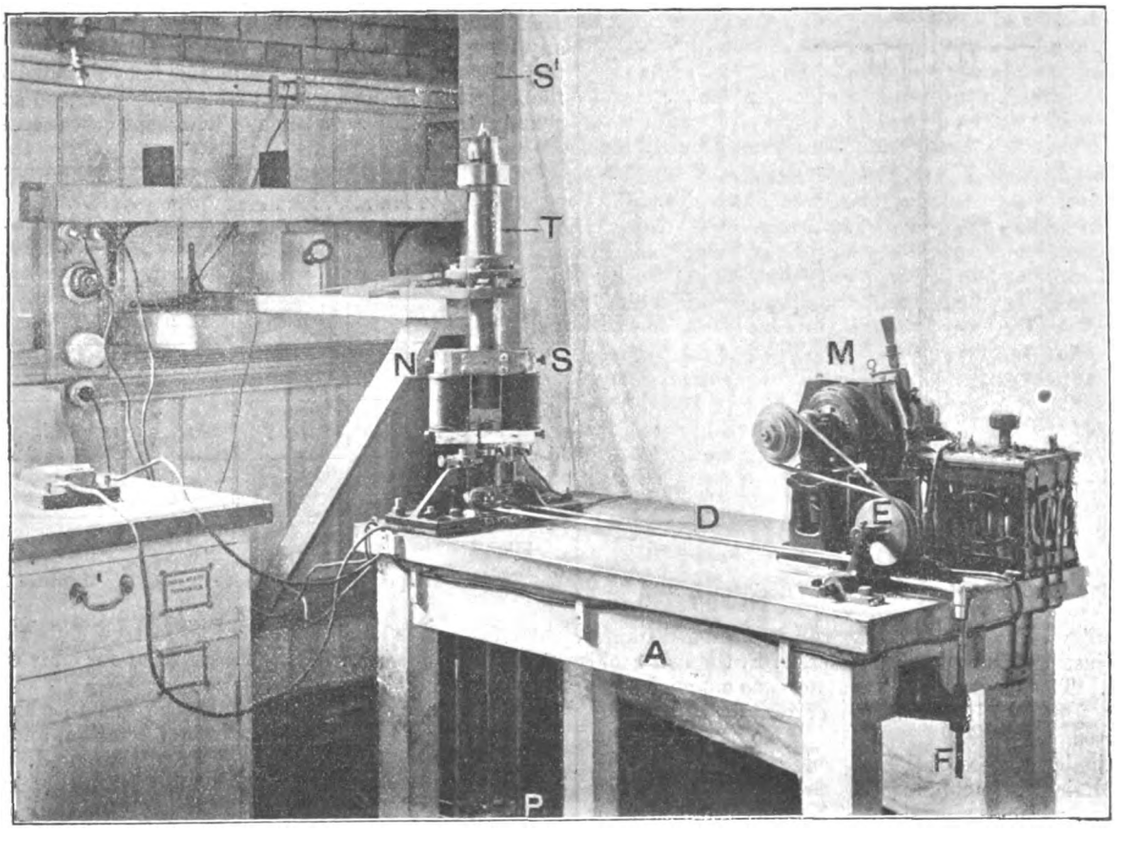


FIG. 1.—General View of the Apparatus for Testing Iron in a Revolving Magnetic Field.

where T = K D, D being the observed deflection and K the constant determined from the vibration experiment.

Hence $$\mathrm{W\,V}\,n = 2\pi n k\,\mathrm{D}$$

or $$\therefore \mathrm{W} = \frac{2\pi k}{\mathrm{V}}\,\mathrm{D}.$$

This, of course, assumes no dissipation by eddy currents. As the deflection due to eddy currents increases proportionally to the speeed, their presence could be readily detected by varying the speed. By laminating the specimen, however, this effect could be reduced to a negligibly small quantity.

*Description of Apparatus* (*see* Fig. 1).—N S is the electromagnet used to produce the field. It is mounted on a vertical steel spindle, which runs in gunmetal bushes in a strong cast-iron frame, bolted to a massive table, A. The coils of the magnet were each wound with 800 turns of No. 18 wire, the

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current being led in by insulated contact rings and brushes. The pole faces are flat, and have each an area of about 34 sq. cm., their distance apart being 6·5cm. They are prevented from flying asunder by two thick brass plates (one on each side), which are screwed to the iron. A current of three amperes in the coils produces a field of about 550 C.G.S. units. This low value of the field is due to the large air-gap which was necessary, owing to the size of the tube, T, used to shield the bucket from air currents. The weight of the magnet (about 25lb.) is taken up by a collar on the spindle resting on the upper bearing. Between this and the lower bearing the spindle carries a V-grooved pulley, with two speeds for driving purposes. In order to ascertain the speed at which we might be working, a centrifugal pump, P, was constructed, and connected by a light rod with the lower end of the spindle. This pump forced coloured liquid up a glass tube fixed against a vertical scale, S′, which is divided into centimetres. The height of this column can be shown to be proportional to the square of the speed of rotation. This speed indicator, being very sensitive, especially in the higher parts of the scale, afforded a ready means of regulation. The magnet was driven by a ½ H.P. motor, M, through a belt, D, which passes around

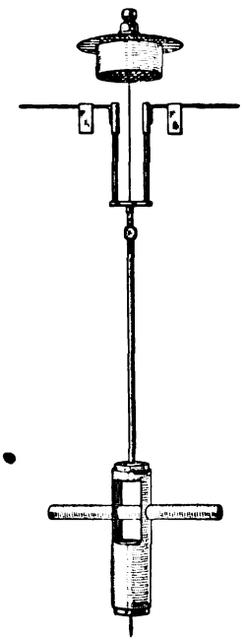

FIG. 2.—Mode of Suspension of the Bucket.

two jockey-pulleys, E. These pulleys run in a hinged frame, so that by adjusting the nuts on the screw, F, the belt could be tightened. The current for the motor was supplied from accumulators, from which the exciting current for the magnet was also derived.

Owing to the large mass of the magnet, and the high speed at which we desired it to run, careful balancing was necessary to make it run without vibration. This was attained after repeated trials by means of a piece of sheet lead, cut the right size, screwed on under one of the brass plates joining the pole-pieces.

Fig. 2 is a diagram showing the mode of suspension of the bucket, which was supported and shielded from air-currents by a fibre tube. The tube was fixed, by means of a wooden ring and levelling screws, to a rigid support. This support, being independent of the table, could transmit no vibration from the latter to the suspended bucket. The tube is closed at the top by a torsion-head, which, by means of a wire, supports the bucket. This bucket, made from a fibre tube, is 1in. inside diameter, and $\frac{5}{16}$in. thick. It is closed by an ebonite bottom, which fits tightly, but can be removed for the insertion of a specimen. A brass pin was fitted into the centre of the bottom. The lower end of the large tube was closed by a boxwood bung, through the centre of which a glass tube was tightly fitted. This was contracted at its upper end, so as just to allow the brass pin to slip into it. This arrangement was found necessary owing to the instability of a piece of iron freely suspended between the poles of the magnet. An annular dashpot (*see* Fig. 1) was constructed to check the vibrations of the bucket. Two vanes (*see* Fig. 2) were made to dip into oil contained by the dashpot. Suitable slots in the tube allow the wires carrying the vanes free play, and also allow the bucket to be removed.

The advantage of the method of suspension by a wire is that the absolute value of the couple exerted on the wire can be calculated from the deflection when the constant of the wire is known. This constant was obtained experimentally in the following way:—The time, $t$, of one complete vibration of the suspended system was taken and noted. A cylindrical bar of known moment of inertia (I) was then placed through the bucket in a horizontal position, with its centre in a line with the axis of suspension (*see* Fig. 2), and the time of vibration ($t'$) again taken. Then, if $C_0$ be the couple required to twist the wire through one radian, it can be shown that

$$C_0 = \frac{4\pi^2 I}{t'^2 - t^2}.$$

Hence, if in any experiment T be the torque, and D the deflection in *degrees*, we have

$$T = \frac{4\pi^2 I}{180\,(t'^2 - t^2)} \cdot D.$$

This gives the hysteresis loss in terms of observable quantities.

Although by this method the hysteresis loss in specimens of any form can be determined, yet the difficulties introduced by the effects of eddy currents, and the irregular distribution of the induction in most cases, make it necessary to adopt some symmetrical shape. Without giving the specimen any particular form, it is possible to obtain the true deflection due to hysteresis alone by applying a correction for eddy currents to the observed deflection.

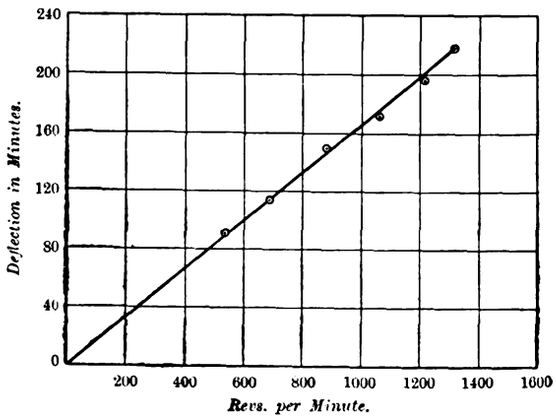


FIG. 3.—Torque on Brass Cylinder in Rotating Magnetic Field.

The latter consists of two parts, one due to eddy currents, which is proportional to the speed of rotation, and the other to hysteresis, which is independent of the speed. That the effect of eddy currents on the observed deflection *is* proportional to the speed, has been proved conclusively by Guthrie and Boys for the case of discs of different metals. We also found this to be true when experimenting on a brass cylinder placed in the suspended bucket. On plotting the deflections against the corresponding speeds, it was found that the observed points lay on a practically straight line passing through the origin (*see* Fig. 3). If, then, $d$ be the increase in deflection due to unit increase in speed, the part of the total deflection arising from eddy currents will be $= n\,d$, where $n$ is the speed. The other part of the deflection due to hysteresis being constant, and equal to $D_h$, say, the total deflection $D_n$ must be the sum of these two, or,

$$D_n = D_h + n\,d.$$

Similarly, at another speed $n'$,

$$D_{n'} = D_h + n'd,$$

and from these equations we get

$$D_h = \frac{n' D_n - n\,D_{n'}}{n' - n}.$$

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In general, however, we have avoided the introduction of any very large correction, by using specimens well laminated, and by working at as low a speed as possible. Under these conditions the correction was often negligible, rarely amounting to more than a few per cent.

Since with a specimen of nondescript form the induction is neither uniform nor easily measured, we were obliged to confine our attention to specimens of a cylindrical shape, as the most likely to lead to a uniform distribution of induction. But in general, however, with a cylindrical specimen magnetised transversely it is difficult to obtain a large enough value of the induction. In an indefinitely long cylinder of large permeability, $\mu$, it is well known that the induction **B** is approximately equal to twice the applied field **H'**.

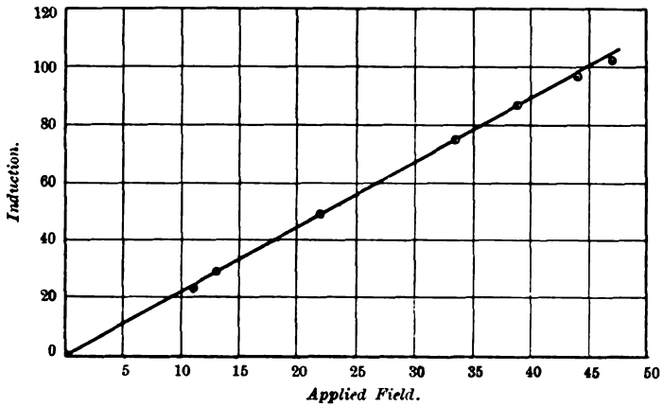


FIG. 4.—Relation between Applied Field and Induction in Steel Cylinder Magnetised transversely.

Measurements made by us of the values of **B** and **H'** in the case of a short steel cylinder, 3·8cm. long and 2·2cm. in diameter, showed that the ratio $\frac{B}{H'}$ was still constant, and had a value of about 2·24. (*See* Fig. 4.) As the maximum field between the poles of the revolving magnet was about 770 lines per square centimetre (with a current of 10 amperes in coils), the highest induction obtainable in such a cylinder was $770 \times 2{\cdot}2 =$ about 1,700. It will be noticed from this, however, that as the length of the

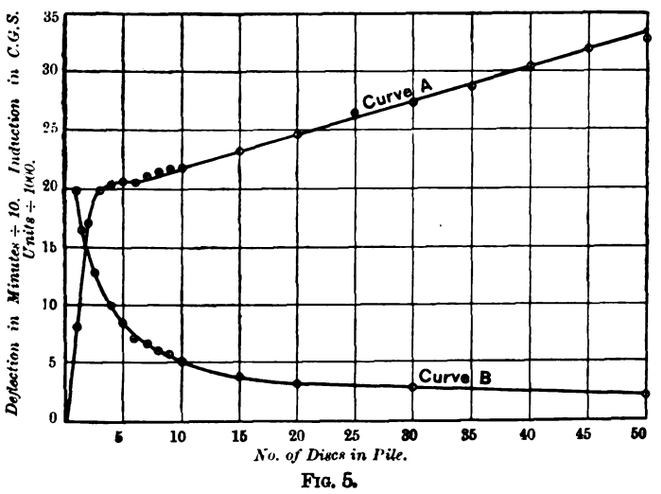


FIG. 5.

cylinder is decreased in proportion to its diameter, that **B** increases for a given value of **H'**; and it has been shown by Maxwell that when the length of the cylinder is small compared with its diameter, the demagnetising force becomes very small compared to the field, and **B** therefore becomes approximately $\mu$ **H'**. In this way, by using a thin disc of sheet iron, we have been able to raise **B** to a value of nearly 25,000 C.G.S. units. Some interesting results obtained by Prof. Ewing, and embodied by him in the form of a curve, show that the deflection obtained on his instrument is not proportional to the number of strips in the revolving bundle. As the number of strips is increased, the curve at first rises to a maximum, and then falls to a very flat minimum, with about six or seven strips, afterwards rising slowly with the number of strips. We thought it would be interesting to see if the shape of the curve would be the same for circular discs as for strips; and, if possible, to arrive at a satisfactory explanation. For this purpose we obtained a number of circular discs stamped from transformer-sheet, 1·9cm. in diameter, and 0·041cm. in thickness. The deflections were then read, when different numbers of these discs were built up into a cylinder. Curve A, Fig. 5, shows that the general shape of the curve is much the same as that given by Prof. Ewing. There is the steep part (which in our curve reaches nearer the origin), then a part where the curve is horizontal for a short distance, and beyond that a gradual rise. The explanation of the general character of the curve may be as follows: As the number of strips is diminished, **B** continues to increase, until at length a point is reached where the effect upon the mass of removing a strip is exactly counterbalanced by the increase of induction, so that the total work spent per cycle, which is proportional to the mass and to some power of the induction, remains unchanged. If we go on removing strips, however, the influence of the decrease of mass begins to preponderate, and the curve to drop. This explanation is probably correct for the particular shape of specimen employed in the tester, viz., a bundle of strips 3in. long and $\frac{5}{8}$in. wide; and we wished to see if the same explanation held good for a pile of discs, by examining how the induction varied with the number of discs in the pile, and so finding out whether the effects of mass and induction sufficiently accounted for the observed phenomena.

In order to measure **B**, piles of 1, 2, 3, 4 and so on up to 50 discs were made, and each provided with a coil of some 10 or 15 turns of fine wire, the whole being solidified by dipping in shellac varnish. These coils were successively joined in circuit with a ballistic galvanometer, and then the bundle and its coil pulled sharply out of the field. This we afterwards found not to be the best method, as it gives the induction rather too high a value, and it is better to turn the bundle through 180 deg. in the field, so as to reverse the magnetisation. But though it must be borne in mind that the values given are slightly too high, this will not affect the validity of the explanation given below. The results of these measurements are given in Fig. 5, A and B, the numbers from which these curves are plotted, being the means of a large number of observations. Curve A shows the variation of deflection with the number of discs, and curve B the variation of **B** with the number of discs. An examination of curve B shows that decreasing the number of discs below about 10 causes **B** to rise very rapidly until the induction through one disc becomes 20,000.

*Table showing the Effect on Deflection and Induction of Varying the Number of Discs forming a Circular Pile.*

| No. of discs. | Deflection in minutes. | Induction in C.G.S. units. | No. of discs. | Deflection in minutes. | Induction in C.G.S. units. |
|---|---|---|---|---|---|
| 1 | 80 | 19,860 | 8 | 212 | 5,970 |
| 2 | 170 | 16,400 | 9 | 216 | 5,600 |
| 3 | 198 | 12,750 | 10 | 217 | 5,000 |
| 4 | 203 | 9,900 | 15 | 232 | 3,720 |
| 5 | 206 | 8,250 | 20 | 245 | 3,140 |
| 6 | 205 | 7,080 | 30 | 273 | 2,800 |
| 7 | 209 | 6,640 | 50 | 325 | 2,100 |

Before leaving this part of the subject it may be of interest to notice that from the fact that at a certain point the hysteresis loss is independent of the number of discs, it is possible to deduce the relation between the hysteresis-loss and the corresponding induction. So long as **B** does not exceed some 10,000 lines per sq. cm., we may assume that the hysteresis-loss **H** is proportional to some power of the induction **B**; *i.e.*, $H = \eta B^x$, where $\eta$ is the hysteretic constant. Suppose **H** to be the energy dissipated per unit mass of the metal. Then, if $n$ be the number of discs, each of mass $\mu$, the expression for the whole work W spent in the pile per cycle will be

$$W = \mu H = \mu \eta n B^x.$$

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Considering $n$ as the independent variable

$$\frac{d\,W}{d\,n} = \mu\,\eta\,\mathsf{B}^x\left(1 + \frac{x\,n}{\mathsf{B}} \cdot \frac{d\,\mathsf{B}}{d\,n}\right).$$

At the horizontal part of the curve $\frac{d\,W}{d\,n}$ vanishes, and as $\mathsf{B}^x$ is not zero, we have $x = -\frac{\mathsf{B}}{n} \cdot \frac{d\,n}{d\,\mathsf{B}}$.

The table above (from which the curves of Fig. 5 are plotted), shows that from $n = 5$, to $n = 6$, the loss is invariable. At the point where $n = 5{\cdot}5$, we find from the curves that $\mathsf{B} = 7{,}750$, and $\frac{d\,n}{d\,\mathsf{B}} = -\frac{1}{1{,}000}$ as nearly as possible.

Accordingly, $x = \frac{7{,}750}{5{\cdot}5 \times 1{,}000} = 1{\cdot}4$.

Though it is doubtful whether this method of arriving at the value of $x$ is susceptible of any great degree of accuracy, still the value just found is sufficiently close to that usually adopted (1·6), to be at least noteworthy.

Throughout the foregoing experiments, the magnetising current was, of course, maintained constant. This is equivalent to saying that the *applied* field was constant, and it is at least probable that with an applied field of a different strength, we should have found the horizontal part of curve A (Fig. 7) shifted so as to occur at some value of $n$ different from 5·5. We have not had time, however, to examine this point.

From these two curves (in Fig. 5) was deduced a third curve connecting the hysteresis loss per disc with the corresponding induction (*see* Fig. 6). This curve shows that at a value of B of about 16,000 or 17,000, the hysteresis loss

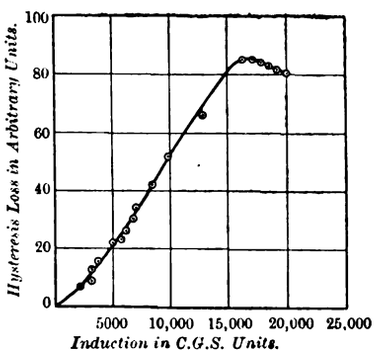


FIG. 6.—Dissipation of Energy in a Rotating Magnetic Field.

reaches a maximum, and for higher values of B actually decreases. This, in fact, is a confirmation of Mr. Baily's discovery that in a rotating field the hysteresis begins to disappear with a sufficiently high induction. This effect, therefore, also plays a part in determining the shape of curve A, at its commencement. The fact that with a single disc of iron values of B could be reached which exceed that at which the hysteresis commences to decrease, led us to try a disc of less thickness, and of as large a diameter as possible, in the hope of reaching still higher values of B. This disc was cut from a sheet of ordinary tinned plate, and measured 0·16cm. in thickness and 4·77cm. in diameter. It was suspended in the ordinary way, with its plane horizontal. On revolving the magnet, and increasing the magnetising current step by step, the deflection rose to a maximum and then quickly fell, showing a disappearance of about 80 per cent. of the maximum deflection. The highest value of B reached in this disc was about 24,000. Accurate observations were made of the deflections for different values of magnetising current. The inductions through the disc for different currents were calculated from the throw of a ballistic galvanometer, produced by turning the disc, with a coil wound upon it, through 180deg. in the field between the magnet poles. Curve A (Fig. 7) shows these results. The ordinates of this curve represent the actual deflections of the specimen, and are therefore proportional to the total loss per cycle, inclusive of that due to eddy currents. The latter is small at low values of the induction, but increases very nearly proportionally to the induction, so that at high values of B it becomes greater than the loss due to hysteresis alone. We found in this case that the curve connecting deflection and speed was not a straight line. This is, no doubt, due to the effect of the eddy currents in partly screening off the induction from the iron, and consequently diminishing the hysteresis loss. This rendered it difficult to apply any correction for eddy currents; but by diminishing the speed to as low a value as possible, consistent with a steady deflection, we succeeded in reducing the deflection to 5 per cent. of its maximum value. Curve B (Fig. 7) shows the results obtained by correcting as far as possible for eddy currents, the last two deflections being very doubtful. Both curves, however, exhibit a tendency to turn off as they approach the axis of no hysteresis. Another method, which overcomes the difficulty arising from eddy-currents, is to turn the magnet step by step through 360deg., first in one direction and then in the other, and taking readings at every step. Half the difference between the deflections obtained when the magnet is brought to the same position, first in one way and then in the other, is evidently proportional to the hysteresis. Applying this method to the same disc, we obtained a curve very similar to curve B, Fig. 7.

A comparison of these two methods, viz., the "step" method and the "spinning" method for well-laminated

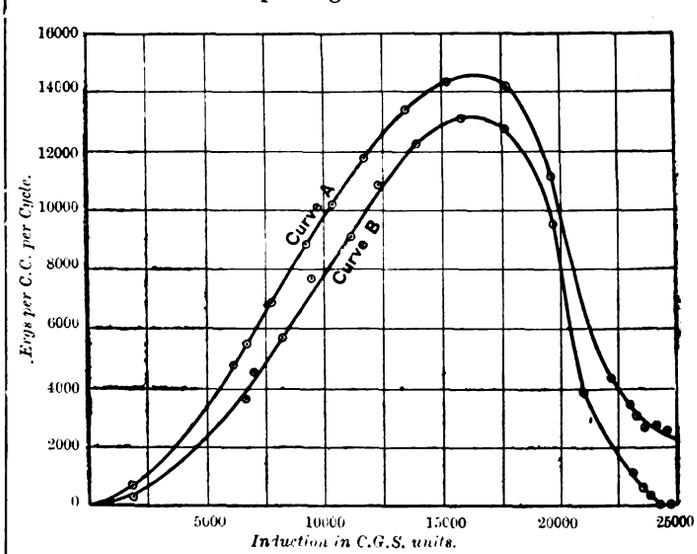


FIG. 7 —Dissipation of Energy in Iron in a Rotating Magnetic Field.

specimens in which the eddy-current loss was negligible, showed a pretty close agreement, as will be seen from the following table.

| Kind of specimen. | Deflection by "step" method. | Deflection by "spinning" method. |
|---|---|---|
| Bundle of steel wires ..... | 10·2° | 9·4° |
| Pile of soft iron squares ... | 1·15° | 1·33° |
| Iron filings ..... | 10·9° | 11·25° |
| Bundle of soft iron wires (1) | 4·55° | 4·45° |
| Bundle of soft iron wires (2) | 8·75° | 8·9° |
| Single strip of soft iron ... | 0·21° | 0·18° |

In the experiments so far described, with the specimen in the form of a cylinder, and magnetised at right angles to the axis, the material is subjected to a true rotating field, which remains constant in magnitude, but varies in direction. In such a rotating field it is only necessary to get a sufficiently high induction in order to cause the hysteresis to diminish; but when a specimen is subjected to an alternating field always in the same direction, but varying in magnitude from $a+$ to $a-$ maximum, it is known that at high inductions no *diminution* of hysteresis takes place. The next part of our investigations consisted in modifying the shape of specimen used, so that when placed in the rotating field it should be subjected to magnetising forces varying in a manner as nearly as possible the same as those in an alternating field. We can do this, at least approximately, by employing a thin wire as the specimen; for as long as the length of wire is great in com-

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parison with its diameter, the magnetisation is almost entirely in the direction of the axis, and as the field is revolved, this force will vary between + and − limits, in a manner analogous to an alternating field. We should expect to find, in consequence, that under these conditions, the hysteresis does not decrease at high inductions.

The results of experiments made with hard drawn wire fully bear this out, the hysteresis-induction curve going steadily upwards and showing no tendency to turn over, even with an induction of 24,000 lines per square centimetre. The curve is given in Fig. 8. We obtained similar curves for strips of transformer-iron placed with their planes both vertically and horizontally. In the latter case the length of the strip was only four times its breadth, yet the hysteresis loss continued to increase up to the highest induction reached. It is easy to see that this will continue to be true so long as the maximum induction at any part of the revolution falls below 16,000 or 17,000 lines per square centimetre—the value at which hysteresis begins to diminish in a rotating field. Other experimenters have found that the hysteresis loss of soft iron in an alternating field tends to become *constant* at high inductions, while steel exhibits no such tendency. The actual values for the hysteresis loss for the wire mentioned above are so high as to indicate that it had more of the nature of steel than of soft iron, and therefore its hysteresis loss would not be expected to reach a constant value.

In an experiment with wire of a softer character, made specially to investigate this point, we found that the hysteresis induction curve showed no tendency to become horizontal.

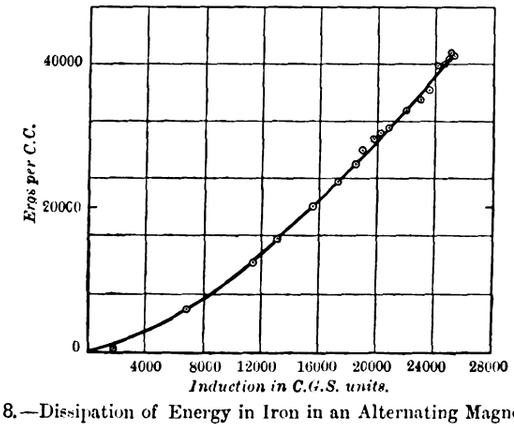


FIG. 8.—Dissipation of Energy in Iron in an Alternating Magnetic Field.

The concluding part of our investigations related to the comparison with one another of the results of hysteresis measurements made by the rotating field and the ballistic methods. In making this comparison we confined our attention to two kinds of iron. The first was what is usually known as transformer-strip; and the results of many experiments on a ring of this iron, made by students at University College, London, proved that at an induction of 2,500, and 100 cycles per second, the hysteresis loss amounted to about 0·3 watt per pound. The second kind was a chemically pure iron in the form of wire, about 0·01in. in diameter. This was made up into a ring, wound over with primary and secondary coils, and then tested by the ballistic method. It was found that this wire had a mean hysteresis loss of 0·57 watt per pound at $B = 2{,}500$, and 100 cycles per second. In both these cases the hysteresis was found to be very strictly proportional to the 1·6th power of the induction.

To test the transformer strip by the rotating field method, a short length of it was cut off and suspended between the poles of the magnet. This piece measured about 4cm. long, 1·3cm. broad, and 0·031cm. thick, and weighed 1·38 grammes. In making this experiment it was found necessary to load the arms carrying the vanes, by this means increasing the moment of inertia, and so uniting into a steady deflection the separate impulses which the specimen received. In the experiments first made the coil wound upon the specimen to determine the induction extended over some two-thirds of its length. Experiments were made with the plane of the strip both horizontal and vertical, the only difference being that the correction to be applied for eddy currents was considerably greater in the latter case than in the former. The value for the hysteresis obtained in these first experiments coincided almost identically with the value obtained from the ballistic tests. This coincidence was, however, soon found to be accidental, and to depend upon what proportion of the length of specimen was wound with the exploring coil when measuring the induction. With a short coil of a few turns wound round the centre of the test-piece, we found that for any given induction the hysteresis obtained by the rotating field method was invariably less than that by the ballistic method. With a coil distributed over the whole length the value obtained approached nearer to the ballistic value, but was still too small.

The induction through a strip of iron, when placed in a uniform field, is not at all uniform, being much greater in the centre than towards the ends. The result of this is that if we take the induction at the *centre* to be the working induction, we refer the observed hysteresis to a higher value than is proper; and it is evidently equally wrong to take the mean value of the induction along the strip, which, in effect, is what we do when we wind the coil over the whole length. It would, of course, be right to take the mean value if the hysteresis were simply proportional to the induction, which it is not, being proportional to the 1·6th power.

Now if the induction through the strip were uniform and of such a value as to be equivalent to the variable distribution

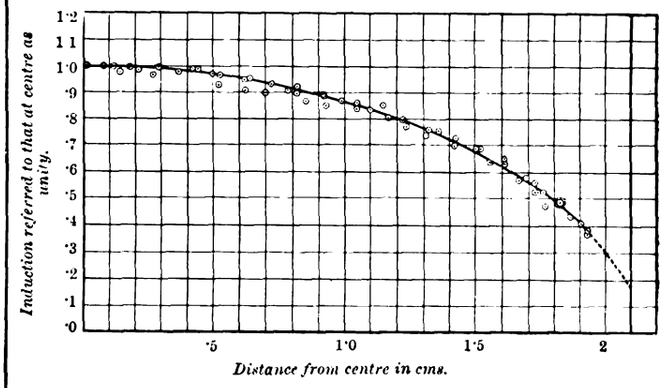


FIG. 9.—Distribution of Induction along Strip of Iron in uniform Magnetic Field.
Length of strip = 4·2 cms.

of induction actually existing, it would give rise to the same hysteresis loss. It will be evident that we may arrive at this "equivalent" induction by taking the 1·6th root of the mean of the 1·6th powers of the inductions taken at a number of equal intervals along the strip. In order to do this it is necessary to know the distribution of induction between the middle and ends of the specimen. Experiments were made to determine this distribution in the case of the strip, by winding a little coil of a few turns round it, so that it could be slid along. This coil being placed at a known distance from the end, the strip was turned through 180deg. in the field, and half the throw of a ballistic galvanometer in circuit, taken to represent the induction at the middle of the little coil. In this way the curve in Fig. 9 was obtained, which shows the induction at different points in the strip, referred to that at the centre taken as unity. There are really *three* different sets of points in this curve, each set corresponding to a different value of the field-strength; but they all lie closely about the same line, which shows that in this case the law of distribution does not vary with the induction. From the curve thus obtained, another was constructed by raising each ordinate to the 1·6th power. The 1·6th root of the mean ordinate of this latter curve was then taken to represent the equivalent induction, the actual induction at the centre being unity. In this way a factor was obtained for reducing the induction as measured at the centre, to the true "equivalent" induction. The value of this factor for the particular test-piece referred to above was found to be about 0·8, and the



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equivalent uniform induction was, therefore, 0·8 times the maximum. On applying this correction we obtained values for the hysteresis agreeing closer with the results of the ballistic tests, as will be seen from the following table :—

| Equivalent induction in strip. | Watts per pound by ballistic method. | Watts per pound by rotating-field method. |
|---|---|---|
| 1,568 | 0·142 | 0·169 |
| 5,896 | 1·183 | 1·013 |
| 6,768 | 1·476 | 1·330 |
| 7,680 | 1·807 | 1·722 |
| 8,320 | 2·053 | 2·039 |
| 10,260 | 2·873 | 3·005 |

We next experimented on the iron wire previously tested by the ballistic method. A little bundle of some 20 short lengths of it was made up, about 4cm. long. In precisely the same way as for the strip, the distribution of induction was determined for the bundle, and the results are shown in Fig. 10. The factor to be employed in obtaining the *equivalent* from the *maximum* induction (at the centre) was in this case 0·82. Two sets of experiments were made to determine the hysteresis. In one set the *maximum* induction was measured, and the *equivalent* induction found by multiplying by 0·82. In the other set the *mean* induction was measured (by a coil wound the whole length), and the *maximum* induction obtained by

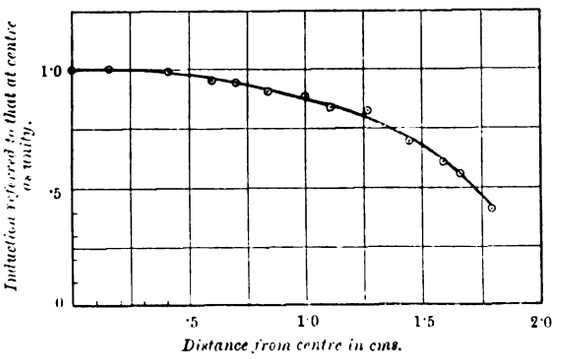


FIG. 10.—Distribution of Induction along Bundle in uniform Magnetic Field.

dividing by the length of the mean ordinate of the curve in Fig. 10 (0·79). This maximum induction, when multiplied by 0·82, gave the equivalent value thus :—

$$B_{max} = \frac{B_{mean}}{0{\cdot}79}$$

$$\therefore B_{equiv} = 0{\cdot}82 \times B_{max} = \frac{0{\cdot}82}{0{\cdot}79} \cdot B_{mean}.$$

The results are given in the following tables :—

(Value of hysteresis determined ballistically = *0·57 watts* per pound at $B = 2{,}500$ and 100 $\sim$ per second.)

**Table I.**

| Induction at centre (max.). | Equivalent $B = B_{max} \times 0{\cdot}82$. | Watts per pound at 100 $\sim$ per sec. | Watts per pound at $B = 2{,}500$, and 100 $\sim$ per sec. (calc. by 1·6 law). |
|---|---|---|---|
| 9,000 | 7,410 | 3·60 | 0·63 |
| 9,950 | 8,200 | 4·32 | 0·65 — mean 0·64. |
| 11,200 | 9,200 | 5·23 | 0·65 |

**Table II.**

| Mean induction. | Equivalent $B = B_{mean} \times \frac{0{\cdot}82}{0{\cdot}79}$ | Watts per pound at 100 $\sim$ per sec. | Watts per pound at $B = 2{,}500$, and 100 $\sim$ per sec. (calc. by 1·6 law). |
|---|---|---|---|
| 6,150 | 6,448 | 2·60 | 0·57 |
| 8,000 | 8,387 | 4·22 | 0·61 |
| 9,450 | 9,906 | 5·72 | 0·63 — mean = 0·62. |
| 10,200 | 10,690 | 6·35 | 0·62 |
| 10,970 | 11,500 | 7·24 | 0·63 |
| 11,400 | 11,950 | 7·71 | 0·63 |

The above values for the hysteresis loss in watts per pound at $B = 2{,}500$, and a frequency of 100 $\sim$ per second, agree fairly well together, the mean being 0·63 watts per pound, somewhat greater than the value obtained from ballistic tests (0·57). This difference may be very well accounted for when it is considered that as the hysteresis varies from point to point, the value obtained from measurements in a small specimen may not be the same as measurements in a large one. Besides, the mere cutting up of the wire and tying it up in a bundle might give rise to differences as great as those observed—for it should be remembered that the wire was not annealed before testing.

Though the rotating-field method of measuring the absolute value of hysteresis in iron is at first sight a very simple one, it loses much of that simplicity on account of the difficulty of obtaining the true induction, especially in small specimens. The results we have so far obtained, however, lead us to believe that with a fuller knowledge of the distribution of induction in small specimens of different forms placed in a uniform field, the method could be made much more expeditious and quite as accurate as the ballistic method. Probably with such a knowledge a single measurement of the induction made at the middle of a specimen of given shape would by the application of a simple factor be sufficient to determine the equivalent uniform induction. Want of time has prevented our making the lengthy investigations necessary to establish such a rule; but it appears that in our apparatus, and with a thin cylindrical specimen about 4cm. long, an approximate value of the equivalent induction can be obtained from the maximum by multiplying by 0·8.

These experiments have been conducted under Dr. Fleming, in the Electrical Laboratory of University College, London. To Dr. Fleming we are under great obligation for help rendered in many ways, more especially for his kindness in providing the necessary apparatus, and for his ready advice.

## MODERN FLY-WHEELS.*

BY HARRY E. CAMPBELL.

The one part of an engine which does not in recent years appear to have received the attention that its importance seems to warrant is the flywheel. The wheels under construction to-day are the same in all essential features as those put on engines five or ten years ago. The cast-iron wheel has undoubtedly reached the limit of development, and that no further improvements can be looked for in it is universally acknowledged by engineers. The many accidents caused by the bursting of cast wheels prove that such wheels are unsafe and unreliable, and unfortunately the larger and heavier the wheels are built, the smaller is the factor of safety employed. All other parts of an engine are designed so as to safely withstand a much greater speed than the normal, but the flywheel has usually very little surplus strength. The consequence is that when the engine speeds up from any cause, the flywheel is almost invariably the first to give way under the strain. Fig. 1 shows a section of a modern flywheel, and from the careful study of 14 large wheels the writer has decided this to be one of the best cast wheels in use. This wheel is well designed and constructed, making 80 revolutions. At 94 revolutions the strain becomes 1,000lb. per square inch in the flanges of the rim. In this calculation it is assumed that the arms will carry one-third of the stress due to centrifical force, and that the other two-thirds are resisted by the rim. This makes the factor of safety one-sixth. This wheel is a good illustration of the weakness of cast-iron in flywheel construction. Perhaps it may be said that the tensile strength of cast-iron is over 1,000lb. per square inch. This is generally true, but the writer believes it to be the utmost limit of safety in cast wheels.

All foundrymen know that it is impossible to get uniform results from cast-iron; and of two castings, put up by the same man, moulded from the same pattern and poured from the same ladle of iron, one may prove to be perfect, while the other, looking equally well on the face, may be honeycombed in such a manner as to make it worthless. The proof of this can be found in every scrap pile. The weakest point in a built-up wheel is undoubtedly in the connections of the rim. This is due to the angles and possibly to shrinkage strains. Where the arm and section of rim are cast together, as seen in some well-known wheels, the junction of rim and spoke must necessarily be a weak point due to the shrinking of the iron away from this part of the casting. When the shrinkage of iron is from one-eighth to one-twelfth of an inch to the foot, and some parts of a casting are chilled while others are yet molten,

* From *Cassier's Magazine.*

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the tendency of the iron to shrink away from angles can readily be seen. The churning of iron in the mould as a remedy for this, as advanced by some writers, is of little importance, as the riser is always too small to remain molten long enough to be of much value in heavy castings. That shrinkage strains have much to do with flywheel accidents has been often proved.

That castings change their form after having the scale removed is well known too, and this, undoubtedly, has much to do with the wobble in many wheels. A wheel is jointed, bolted together and turned true on face and edges, and after it is taken apart and again erected in position on the shaft it is seldom found to run perfectly true, showing that there must be unequal strains on some of the connections due to the castings changing their form. The arms, if hollow, may be defective by the core rising in the mould, leaving one side heavy. If a green sand mould is used, uneven ramming may injure a casting.

The mixture of iron is also an important factor in flywheel construction. Very few large wheels are balanced, many builders depending on the different sections weighing the same, as they are

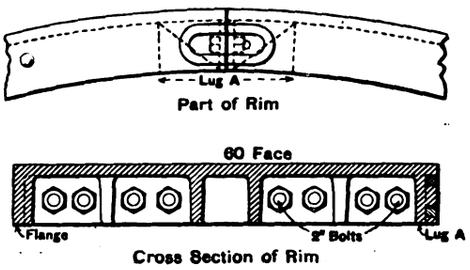


Fig. 1.—A Modern Fly-wheel Detail.

moulded from the same pattern. This, however, should not be relied upon, as castings from the same pattern are liable to vary greatly in weight. The well-known formulas for computing the weight of flywheels are defective when used in all cases. In one case a wheel was replaced by another of one-half its rim weight and regulated the engine perfectly. In electric power stations weight is always an important factor as a means of securing steadiness in running. It is not unusual to find a wheel of 50in. face, with a hub bearing of only 24in. This may not be important when the hub is shrunk on the shaft and the wheel is new; but after a few years of service the wheel is certain to begin to work on the shaft, and when the main bearings are worn a side thrust will develop which will throw an enormous side strain on a wheel. This it may not have been designed to withstand.

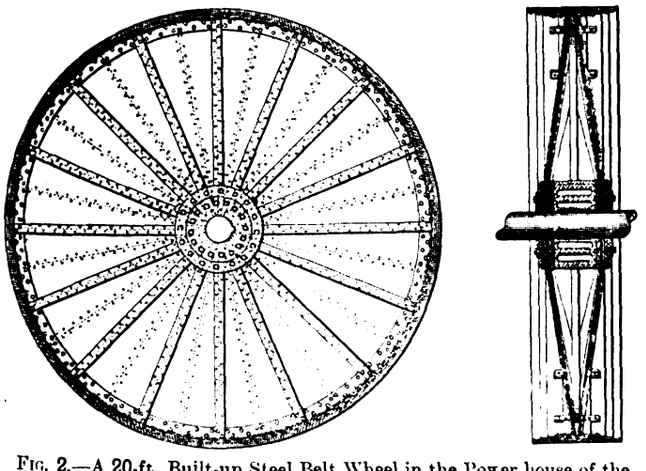

Fig. 2.—A 20-ft. Built-up Steel Belt Wheel in the Power-house of the Albany Railway Company, Albany, N. Y., U.S.A.

For small wheels cast-iron is probably the cheapest and best material, but the tendency to-day is toward larger and more powerful engines. That the wheel of the future will be of other material than cast-iron is, undoubtedly, the case, and on account of the great tensile strength and cheapness of steel, that material may be used.

The writer, in conjunction with Mr. Thomas E. Murray, consulting engineer of the Albany Railway at Albany, N. Y., U.S.A., has designed a 20-foot steel belt wheel which has been erected and is now running in the power house of the Albany Railway Company. This wheel replaces a cast-iron wheel of the same diameter which burst last fall and caused much damage. The engine is one of a pair, and a second wheel is now under construction for the other engine. These engines are of the Cooper-Corliss type, 500 H.P. tandem compound, 20in. by 36in. by 48in., and are belted to a 500 kilowatt Edison multipolar generator. The speed is 72 revolutions per minute. The new wheel is built entirely of steel, except two cast-iron fillers, as shown in Fig. 3, and weighs complete about 27 tons. The steel used has a tensile strength of 60,000lb. The hub consists of 20 ⅜in. steel plates and a cast-iron filler. The plates are put together in four sections, and each section is held together by ¾in. countersunk rivets. The sections are placed one against the inside and one on the outside of each disc, and the cast-iron separator is between them. The illustrations show this arrangement plainly. The hub fits closely on the shaft, and is held together by 32 steel bolts, which pass through from side to side. The discs consist of 32 sectors of ¼in. steel plate, riveted together in two layers with ⅜in. rivets, the joints broken and the outside joints covered by 5in. by ¼in. steel bars, thus making a continuous web. The two discs are set at an angle to each other, on the principle of the bicycle wheel. This arrangement of the webs is one of the most important features of the wheel, as it prevents all vibration and side motion, and makes the wheel run steady and true. At the rim again the discs are separated by a cast-iron filler ring. The rim consists of four layers of steel plates, and is connected to the discs by two lines of 6in. by 6in. by ½in. angles, one on each side of the web. The outer layer of plates is 50in. wide by ⅜in. thick; the next is 50in. by ⅜in.; the next 40in. by ⅜in., and the innermost is 32in. by ½in. The inner plates, being narrower, give a better opportunity for riveting. The rim ends of the 5in. by ¼in. bars are bent over, and two 1¼in. rivets pass entirely through the rim and the ends of each bar, thus making a very strong connection. The weight of the rim is about 15 tons. This wheel ran for some time without being turned; but that has since been done. While the nominal speed is but 72 revolutions, the wheel is guaranteed to run 250 revolutions, and it is calculated that it will run over 350 revolutions per minute safely and without bringing an excessive strain on any part, and without danger of bursting.

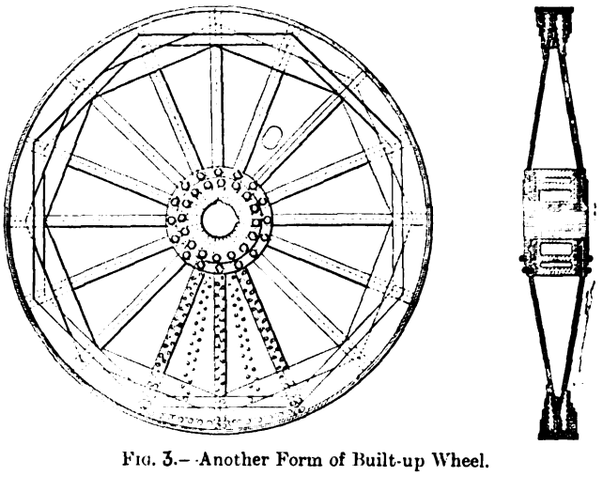

Fig. 3.—Another Form of Built-up Wheel.

The writer has also designed recently a 20-foot steel flywheel proper which is to weigh 100,000lb. and which is intended for use on direct connected engines for electric power plants. The hub and web are essentially the same as in the wheel just described, except that instead of the twenty ⅜in. plates ten 1in. plates are used, and the radial bars on the discs will be increased in size from 5in. by ⅜in. to 6in. by 1in. The rim consists of two outer plates 1in. thick. A 1in. plate 18in. wide and sheared at the circumference of a circle 19ft. 8in. in diameter is inserted between the discs, and projects 6in. beyond them. The angles between are filled with cast fillers, and the whole is securely fastened together. To this plate are riveted two rings of 6in. by 6 by ½in. angles, and to these angles the two outer plates are connected as shown above. These plates are also connected to the 6in. by 1in. bars in the same manner as in the belt wheel. On each side of the web the angle is filled with an iron casting, and outside of this eight 1in. plates, sheared into segment shape, are fastened, four on each side. These plates are of different sizes, and the smallest are on the outside. The whole is held firmly together by bolts and rivets, making the whole rim virtually one solid piece. The wheel is moderate in cost, and, practically speaking, cannot burst from centrifugal force.

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## TESTS OF GLOW LAMPS.

The Paper read by Mr. PREECE before Section G at the British Association at Liverpool, and an abstract of which we publish this week, gives us the results of prolonged and careful tests made by him on various types of incandescence lamps on the market. The Paper will derive additional importance in the eyes of the public, from the fact that it is in a sense an official pronouncement, and that the experiments were undertaken by the author of the Paper as a means of arriving at a specification and test for glow lamps, which will be considered as a species of Government test, as it is actually the proposed present test for the Post Office. In short, the Post Office specification for glow lamps is liable to be regarded by many as embodying the highest and final experience in the matter of glow lamp testing. Under these circumstances it is only natural that it should be somewhat carefully examined, and glow lamp makers will, above all, be interested in its conditions, having in view their responsibilities under it. Regarding the actual experiments carried out and recorded in the Paper, there is not much opportunity for critical remark, although at the same time it is exceedingly useful to have absolutely unbiassed tests published on the behaviour of various classes of lamps, seeing that many figures have been published in the past which are, on the face of them, unreliable. Mr. PREECE admits that he does not claim much novelty for the facts elucidated. The Papers by Prof. AYRTON and Mr. MEDLEY previously published gave to the public precise information on a number of matters with which incandescence lamp manufacturers were already perfectly familiar. The gradual decadence in the light giving power of the lamps when kept at constant voltage, the decrease in efficiency, the changes in resistance

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and surface emissivity of the filament, as well as the initial rise in candle-power of certain types of lamps, are now well-known facts, acquaintance with which is no longer confined to specialists, but extends even to the ordinary non-technical householder. Mr. PREECE made a large collection of lamps from various makers, and he embodies the results of his tests in various useful curves. Some may be surprised to note that Mr. PREECE still has faith in the so-called standard candle as a practical unit of illuminating power, and in the Rumford shadow tests as a means of photometric comparison. He perhaps shares Mr. DIBDIN'S expressed opinion that the candle is more sinned against than sinning; but, though backed up by a Parliamentary definition, the candle is but a candle still, and everyone who has used it knows what an elastic standard it is. The fact of the matter is, that we are still employing an antiquated and ill-defined unit as our standard of comparison in measurements of light, and one which is almost on a par with the "barleycorn" as a standard of length. The Berlin Reichsanstalt has been making serious efforts lately to grapple with this problem, and to improve and define the platinum standard into a means of establishing a unit of illuminating power which shall be more on a level with the accuracy of modern electrical measurements. Are we to wait until an improved standard has been "made in Germany" before an adequate effort is put forth in England to overcome the difficulties of this subject? We may assume, however, that some future date will see a standard of light more scientific than the spermaceti candle honoured with legal authority and definition. Meanwhile we must be content to express photometer measurements in candle-power, whatever that may be understood to mean. What is really important is, however, that every glow lamp factory should be consistent with itself and with other rivals. A 16 candle-power lamp should always mean the same thing, by whoever made; and it is to enforce this uniformity that a specification of test is necessary.

This brings us to the really important matter in Mr. PREECE'S Paper—viz., the proposed Post Office specification for glow lamps, on which we desire to offer one or two criticisms. The clauses on "Terminals," "Marking" and "Defective Lamps" call for no remark. The fourth clause deals with the proportion of lamps to be selected for test. Here it has to be remembered that glow lamp testing is not like dynamo or boiler testing, because the particular article tested in the case of lamps is spoilt in the act of testing it and cannot afterwards be retested, in event of dispute. This is not so with a dynamo. If the dynamo manufacturer disputes the tests of one expert he can engage another one to repeat them, and perhaps refute the first. Hence it is exceedingly important in the case of lamps that the selected samples should be a fair average. But glow lamps are like human beings; some come into the world with congenital defects which foredoom them to an early death; and it may be open to question whether in the case of an order for 3,000 lamps or over, one per cent., as stated in the specification, is a sufficient number to test when the failure to pass the tests of more than eight lamps out of thirty so chosen is to be sufficient to condemn the whole lot. This would mean that the manufacturer will have to safeguard himself by careful pre-measurements. He may find it necessary on that account to quote a higher price. We then come to the section on "Tests," which is the kernel of the whole specification. The specification states that all selected lamps are to submit to a photometer test, to determine the candle-power of the new lamp at its standard pressure. Nothing is said about the position of the lamp in the photometer. Is it to be placed with axis vertical or horizontal? Is the candle-power to be a single measurement in one direction, or a mean spherical candle-power? How is the loop of the filament to be placed with regard to the plane of the photometer? No mention is made of these details, yet they may affect the stated candle-power value to the extent of 30 per cent. Then again, in Subsection 5, we are told that the candle-power of all lamps must be in terms of the English standard candle, and yet a note a few lines below tells us that the Post Office tests will be made either with the Vernon-Harcourt or Hefner-amyl-acetate standard. We are not told, however, whether by the Vernon-Harcourt standard is meant the air-gas standard or the Pentane lamp. Moreover, the option between a standard giving a distinctly reddish light like the Amyl-Acetate lamp and the whiter light of the Vernon-Harcourt standard opens up a fruitful source of dispute. Let anyone try the experiment of measuring the candle-power of a given glow lamp against these two standards, first when the glow lamp is at an efficiency of 4 watts per candle-power, and then when it is at an efficiency of 2·5 watts per candle-power, and he will be at once convinced that to give the option of two such different standards is very much like saying that payment will be made in a given number of shillings *or* francs. Under such an imperfectly-defined test as the above, lamps selected at random from the same batch might be passed in Glasgow and condemned in London, and a manufacturer would have no sort of security that differences of opinion between himself and the official testing would not arise as to the meaning of the above clause, and result in his receiving his consignment on his hands again. Photometry is not altogether a matter of instruments. Very much depends on the photometrist, and, as SAM WELLER said with regard to the spelling of his own name, a good deal depends on taste and fancy. The use of a reddish standard like the amyl-acetate renders it most difficult to get agreed opinions when testing glow lamps at 2·5 watts a candle.

Sections 2 and 3, under the head of "Tests," prescribe a test in which the lamp is gradually submitted to a raised pressure and then tested again at the ordinary pressure. This is proposed as a test for endurance. The question then arises whether the imposition of this 170-volt test on 100 or 110-volt lamps is the best means of deciding what the normal behaviour of these lamps will be under the fluctuations of pressure actually met with in practice. The object of testing the lamps is to decide the probable fate of the average lamp under average circumstances. May not such a test press too hardly on a thin filament lamp? The 170-volt pressure is considerably outside the range of ordinary variations on 100-volt circuits. Does it follow that because a lamp fails to pass this 170-volt test it will therefore necessarily be a worse lamp in ordinary use than a lamp which does pass? We confess we should have liked more proof of this contention. A man with a weak heart may live as long and as usefully as a man with a strong one, and meet the usual vicissitudes of life; but he must not attempt to climb Mont Blanc. On the other hand, not a few tests in engineering consist in subjecting a structure to an abnormal load, and inferring therefrom what its behaviour in normal conditions is likely to be.

The fourth section prescribes an alternative to tests (2) and (3). Concerning this it may be said that a lamp might protect itself against the effect of over-pressure by running up in resistance. It is a matter of common experience that lamps on a constant-voltage circuit will, if they succeed in increasing their resistance beyond a certain point, go on living an indefinite time. The increase of resistance so decreases the current that all danger of overheating is prevented. As regards tests (2) and (3) the final result of the candle-power

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measurement would depend very much on the way in which the increased pressure was applied, and, generally speaking, it has yet to be shown that short-time tests are capable of bringing out all the qualities of a lamp when used in a normal manner. To set a man to run a hundred yards at top speed is not the best way of finding out his staying qualities for a long-distance walk, and the same criticism may apply to tests of glow lamps. Viewing this specification as a whole, we are inclined to the opinion that it might well be held in suspense for a time until some of these questions have been further discussed. We want first a better primary legal standard of illuminating power to replace the candle with all its sins. Secondly, we want an agreed method of constructing and comparing secondary or working standards of light. Dr. FLEMING mentioned at Liverpool that he had been using special large-bulb incandescent lamps for this purpose. In the next place any specification for glow lamp tests should be most precise as to the details of the light standard, the form of the photometer, the position of the tested lamp and the process of the test, leaving as little as possible to the option of the observer. We want further information on the results of tests at super-pressure, and the relation of the behaviour of a lamp at these higher pressures to its behaviour at its marked pressure, and such a mode of selection of lamps for test as shall secure that those tested truly represent the average of the batch under inspection. A vague specification is sometimes worse than none at all; and it is a question which deserves serious consideration, whether so important a specification as that for glow lamps should not be further discussed with those most interested in it before it is made final.

## REVIEWS.

**The Story of Electricity.** By John Munro. Illustrated. (London: George Newnes, Ltd.)

This little book makes a very good attempt to relate the story of electricity in 190 very small pages, adorned with 100 illustrations. None but an intrepid Scotchman would have undertaken this feat; and we congratulate him on the amount of success he has attained. It is, however, a matter of some doubt to whom the book is really dedicated. Is it the "general reader," or the "young person" who is considered always to be thirsting after knowledge? Or perhaps it is intended that schoolboys and mechanics shall read it in their leisure hours. We find already on the second page a reference to Cræsus, King of Lydia, Cyrus the Great of Persia, and the renowned Solon; and we are made acquainted with the fact that the original discovery of electricity was contemporaneous with the battle of Megiddo, where Necos, King of Egypt, defeated Josiah, King of Judah, and that Necos dedicated the corslet he had worn during the battle to Apollo Didymæus in the temple of Branchidæ, near Miletus. This is certainly a light relief in a book on electricity, and we personally prefer it to the heavy jocularity usually found in books of this type. But we are inclined to think that the "general reader" would not form much idea of the state of the wires at the back of a telephone switchboard by reading that they were "concentrated like the nerves in a ganglion."

The book commences with a description of the phenomena of frictional electricity—renamed, without any reason, "the electricity of friction." Following this is a chapter headed, presumably for a similar reason, "The Electricity of Chemistry," in which some forms of primary and secondary batteries are described. By a printer's error the titles under the diagrams of cells in series and cells in parallel have been interchanged. We are also told that "batteries known as secondary immagasine the current." "The Electricity of Heat" is the title of a chapter on thermopiles; and this is followed by a chapter entitled "The Electricity of Magnetism," which gives at some length the history of the loadstone, describes the chief magnetic and electromagnetic phenomena, and ends with descriptions of the induction coil, transformer and dynamo, mentioning alternating currents *en passant*. This is 20 pages; it takes one's breath away. We had hoped the blocks representing the original form of the Edison dynamo had all long ago been destroyed, as we had not seen the picture for so long; but in Fig. 43 the long-limbed thing is brought to our notice as the Edison type of dynamo. Chapter V. is on "Electrolysis," Chapter VI. on the "Telegraph and Telephone." In the latter chapter are described the needle and Morse instruments, Bain's chemical and Prof. Hughes' type-printing telegraph, several forms of telautograph, the submarine cable, Lord Kelvin's mirror galvanometer and siphon recorder, besides the principles of telephony, and types of receivers and transmitters; the chapter ends with a recommendation to artists to try their hand at painting "a bevy of English girls working a telephone exchange." The electric bell is not included here, but is described near the end of the book among the minor uses of electricity. Atmospheric electricity is considered partly under this heading and partly in Chapter I. We are told that "a good lightning conductor should not have a higher electrical resistance than 10 ohms, including the earth contacts. Exceptionally good conductors have only about 5 ohms;" and also, "Sometimes it (the lower end of the conductor) is merely soldered to the water mains of the house." This latter practice is not condemned. Arc and incandescent lamps are described in Chapter VII. on "Electric Light and Heat," wherein are also diagrams of series, parallel and three-wire systems of distribution. Tesla's work is mentioned and illustrated with diagrams, and there are pictures of an electric kettle, frying pan, flat iron, and of a cigar lighter. The chapter on "Electric Power" is clearly written, though there is rather a tedious history of the development of the Niagara scheme, beginning with the statement that in 1678 "the science of electricity was in its early infancy." The last chapter includes a very nice little description of the phonograph; but this can hardly be considered an electrical instrument. This chapter ends with X-rays, so that it is brought completely up to date. There is also an appendix devoted to "Units of Measurement," taken from Munro and Jamieson's Pocket Book.

**Jordan's Tabulated Weights of Iron and Steel.** Fifth Edition. (London: E. and F. N. Spon.)

This book, which is of the usual pocket-book size, contains very complete tables of the weights and dimensions of angle, tee and bulb iron and steel, but very little else; so that it is only really useful to naval architects and shipbuilders. These gentlemen, no doubt, find the book very valuable, seeing that it is already in its fifth edition. After some 500 pages, exclusively devoted to tables of weights and sectional areas, some very handy tables of decimal equivalents are given, covering 25 pages, and a table giving the breaking strains of iron wire of standard wire gauge. The various sections of the book are printed on different coloured paper, but we should have preferred an alphabetical index.

**Induction Coils.** By H. S. NORRIE. (New York: Spon and Chamberlain.)

This book is of the usual type of those dedicated to amateurs. There is little new or original in it. A book with this title, published at this time, ought to contain some practical hints on the arrangement of apparatus for X-rays; but although a chapter is devoted to "The 'Roentgen' Rays and Radiography," its contents are so meagre that we are led to doubt whether the author has himself repeated the experiments he describes. The method of coil construction the author recommends is one described in Mr. F. C. Allsop's book on Induction Coils. While acknowledging this he unkindly mis-spells that gentleman's name. After the reader has been taught how to build up his coil and how to make a condenser, the usual show experiments are described. Several forms of primary battery useful for working induction coils are explained, and instructions are given for making an amateurish storage battery. Mention is made of Hertz's resonator, and the construction of a Tesla coil and spark gap is described; but the reader is referred to Tesla's published works for an account of the

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experiments that can be made with the coil. We are informed that "the main use to which the Tesla currents have been put is that of artificial illumination." Nothing is said in the book as to the use, and possible abuse, of the induction coil in medicine and surgery, nor even of the employment of Röntgen rays for any practical purpose. The author states in the Preface that he avoids, wherever not absolutely imperative, any discussion of abstruse electrical theories. We cannot find the places where it has been imperative, and we are thankful.

## PROPOSED UNITS OF HEAT.*

The Standards Committee of the British Association have provisionally approved the following propositions with the view of opening international discussion of the question. They propose to send the propositions to representative bodies throughout the world, with a letter stating that they have been provisionally approved, inviting further discussion, and asking those bodies to take steps which seem to them most desirable in order to secure international agreement on the matter.

PROPOSITIONS.

I. For many purposes heat is most conveniently measured in units of energy, and the theoretical C.G.S. unit of heat is 1 erg. The name Joule has been given by the Electrical Standards Committee to $10^7$ ergs.

For many practical purposes heat will continue to be measured in terms of the heat required to raise a measured mass of water through a definite range of temperature.

If the mass of water be 1 gramme and the range of temperature 1°C. of the hydrogen thermometer from 9·5°C. to 10·5°C. of the scale of that thermometer, then according to the best of the existing determinations the amount of heat required is 4·2 Joules.

It will, therefore, be convenient to fix upon this number of Joules as a secondary unit of heat. This secondary thermal unit may be called a "Calory."

Accordingly, for the present a second proposition is :—

II. The amount of heat requisite to raise the temperature of 1 gramme of water 1°C. of the scale of the hydrogen thermometer at a mean temperature which may be taken as 10°C. of that thermometer is 4·2 Joules.

If further research should show that the statement in II. is not exact, the definition could be adjusted by a small alteration in the mean temperature at which the rise of 1deg. takes place. The definition in I. and the number (4·2) of Joules in a Calory would remain unaltered.

## A NEW USE FOR SILICON CARBIDE.

Hitherto silicon carbide (carborundum) has been utilised not on account of its chemical composition, but because of its possession of a particular physical property, viz., extreme hardness. It is now proposed by Herr F. Lürmann, writing in the *Zeitschrift für Elektrochemie*, that silicon carbide should be employed as a source of silicon in the manufacture of steel. Among certain makers and users of steel of tolerably hard grade, such as that commonly used for railway tyres, there has been lately an alteration of opinion in favour of silicon as a desirable constituent; many, however, still maintain that it is an objectionable impurity. The discussion of this question is not our immediate purpose, and it is sufficient to say here that there exists a considerable demand for steel containing about 0·2 per cent of Si. To produce steel of this quality, the addition of ferro-silicon is generally adopted. Ferro-silicon is made with a content of about 11 per cent. of silicon, and its price is 78 marks for 1,000 kilos, *i.e.*, about £4 per ton. It is, of course, necessary that ferro-silicon used in the production of steel castings should be free from harmful impurities, *e.g.*, phosphorus, and indeed this element is usually present in proportion not greater than 0·1 per cent., so that the increase in the percentage in the finished steel ingot is inappreciable. Assuming that the value of the steel before treatment is 67 marks for 1,000 kilos, and that a product containing 0·2 per cent. of silicon is required, a simple calculation shows that the extra cost due to the addition of ferro-silicon is 2 marks for a 10-ton charge, *i.e.*, approximately 2½d. per ton.

Now it is clear that if silicon carbide is to replace ferro-silicon as a source of silicon in steel castings, it is necessary to show either that its use is cheaper or that it presents independent advantages. It may first be noted that an actual trial has been made, as long ago as November, 1894, at the Phœnix works at Laar, and that nearly pure silicon carbide (containing 67·5 per cent. of Si and 32 per cent. of C.) has been proved to be soluble in molten steel. It is also of some commercial importance to find that a subsequent attempt to patent the use of silicon carbide for the deoxidation of oxides contained in ingot iron or steel has been frustrated by the decision of the German Patent Office. With regard to the cost of silicon carbide, a simple calculation indicates that for the production of steel containing 0·2 per cent. of Si at the same expenditure as is necessary when ferro-silicon is employed, the carbide must be obtainable for 54·3 pfennige per kilo—say 3d. per pound. Against this somewhat onerous condition for the success of the new material, must be set the fact that silicon carbide can be introduced into the steel precisely when and how it is required, and moreover that it is free from impurities likely to be injurious to the steel. That a considerable trade in silicon carbide might arise if the steel maker were persuaded that it would be better than ferro-silicon for this purpose, is evident on considering that the consumption of ferro-silicon for a steel works of moderate size may be set down as 1,440 tons, and that, counting the number of works in Germany using the open-hearth basic process, the total consumption would reach 15,000 tons, corresponding with 2,414 tons of SiC. This represents the substantial sum of 1,327,092 marks, *i.e.*, £66,000.

Silicon carbide, for use as a grinding material, is a highly crystalline substance, which has presumably undergone fusion; it is possible enough that the substance may be formed at a temperature somewhat lower than that necessary to melt it and cause it to crystallise. In this case, the cost of manufacture would be sensibly reduced; and, seeing that the product of an electric furnace is always highly heterogeneous, it is reasonable to suppose that amorphous SiC, unfitted for abrading purposes, may be found a profitable bye-product as a carburetting and siliciding agent. Carbides, silicides, nitrides and borides of manganese, magnesium and aluminium, suggest themselves as possible products for the common profit of the steel-maker and the electro-metallurgist, and some at least among them may come to be ordinary articles of commerce before the end of the century.

## ELECTRIC GLOW LAMP TESTS.*

BY W. H. PREECE, F.R.S.

So much has been written on glow lamps, and so ably did Prof. Ayrton and Mr. Medley treat the subject in a Paper read before the Physical Society, on December 14, 1894, and on January 25, 1895, that it is now somewhat difficult to discuss any new question of commercial and scientific interest. However, as I have been investigating the quality of various glow lamps since the Edison-Swan patents collapsed, in order to establish a fair and reasonable specification for the Post Office requirements, and to find, if possible, an expeditious as well as reliable way of testing the efficiency and durability of lamps submitted in competition and delivery, I thought the results obtained would not be unwelcome to the members of the British Association.

My experiments were conducted on the following lines :—

1. To find the efficiency and life of 100 and 105 volt 16 and 8-c.p. lamps in a trial of 2,000 hours' duration when kept alight continuously (night and day) at a constant voltage, and the filaments at an approximately uniform temperature.

* Resolutions as to a thermal unit provisionally approved by the Electrical Standards Committee of the British Association, September 18, 1896.

* Abstract of Paper read before the British Association at Liverpool, in Section G.

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2. To ascertain the efficiency and life of lamps when similarly maintained at constant potential, but lighted for several consecutive hours daily, as in an ordinary installation.

3 and 4. Similar to 1 and 2, except that the duration of trial was limited to 1,000 hours.

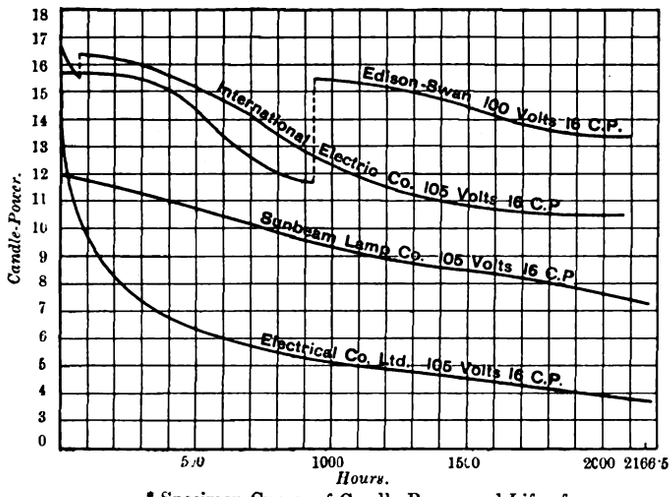
5. To find the mean breaking voltage of filaments by gradually increasing the voltage for each lamp at about the same rate.

6. To see what the effect would be on similar filaments after being raised to three-fourths of their mean breaking voltage, as found by 5.

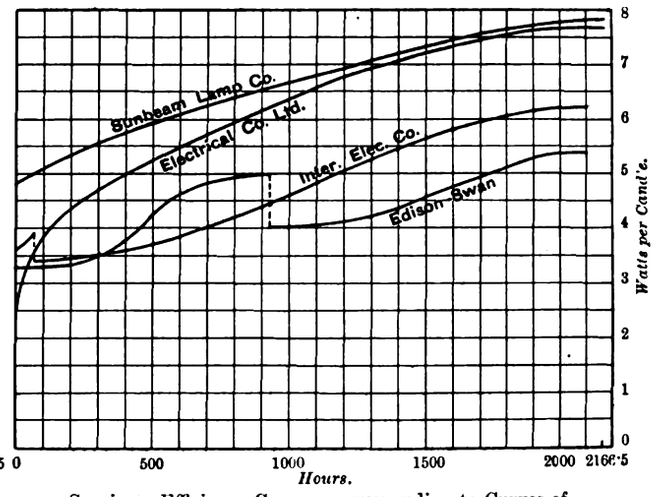
The whole of the following tests were carried out with a continuous current.

All the electrical measurements of voltage and current were made with a Hartmann and Braun voltmeter, in conjunction with an Ayrton and Perry twisted strip ampere meter, and each instrument was frequently verified against a standard d'Arsonval galvanometer. A few secondary cells were used to regulate the dynamo potential on the 105-volt circuit, and adjustable resistances were employed to maintain the required potential at the ends of the respective lamps.

For the continuous lighting experiments each lamp was fitted in a proper lamp holder, attached to which was a short length of flexible twin conductor, and until the lamps were wanted for measurements they hung on hooks outside the photometer in positions marked to correspond with the lamps. To ascertain the caandle power of any one of the lamps, it was passed through a small door into the photometer space, and suspended from a clip on a carriage which could be moved over a graduated photometer bar. The illuminating power of the lamp was balanced against Messrs. Sugg and Company's standard candles on Rumford's shadow principle, and to ensure the greatest possible accuracy the mean value of the following three observations was recorded as the result :—(1) Through green glass ; (2) Through red glass ; and, (3) Without any vitreous medium while the two lights were carefully shaded from the observer's eyes.




* Specimen Curves of Candle-Power and Life of Group A, 16 candle-power lamps.




Specimen Efficiency Curves, corresponding to Curves of Group A, 16 candle-power lamps.

As several distinct series of experiments have been made by me since the end of 1894, it would perhaps be advisable to deal with each group separately.

Between the months of February, 1894, and April, 1895, the following lamps were tried :—

| Experiment. | Lamps. Volts. | Lamps. C.P. | Supplied by |
|---|---|---|---|
| 1 and 2 | 105 | 16 | Messrs. The Edison-Swan Co. |
| | 100 | 16 | " |
| | 105 | 16 | Messrs. Siemens Brothers. |
| | 100 | 8 | " |
| | 100 | 16 | The Brush Co. |
| | 100 | 8 | " |
| | 105 | 16 | Laing, Wharton and Down. |
| | 100 | 8 | " |
| | 105 | 16 | Stearn. |
| | 100 | 10 | " |
| | 105 | 16 | The International Electric Co. |
| | 100 | 8 | " |
| | 105 | 16 | The Bishop's Cluster Co. |
| | 100 | 8 | " |
| | 105 | 16 | The Electrical Co., Ltd. |
| | 105 | 8 | " |
| | 105 | 16 | The Sunbeam Lamp Co. |
| | 100 | 8 | " |
| 3 and 4 | 100 | 16 | The Electrical Co., Ltd. |
| | 105 | 8 | " |
| | 105 | 16 | Barclay and Son. |
| | 105 | 16 | Sturm and Co. |
| | 105 | 8 | " |
| | 105 | 16 | P. Walters and Co. |
| | 105 | 8 | " |
| | 105 | 16 | Conze and Simon. |
| | 105 | 8 | " |
| | 105 | 16 | General Electric Co. (Robertson). |
| | 100 | 8 | " |
| | 105 | 16 | Lowcock, Hill and Co. |
| | 105 | 8 | " |
| | 105 | 16 | J. Shaw (Gem). |
| | 105 | 16 | Rose and Bird. |
| | 105 | 8 | " |
| | 105 | 16 | Mackey, Mackey and Co. |
| 5 and 6 | 105 | 16 | The Edison-Swan Co. |
| | 105 | 16 | General Electric Co. (Robertson). |
| | 105 | 16 | G. Straus. |
| | 105 | 16 | Sturm and Co. |
| | 105 | 16 | Conze and Simon. |
| | 105 | 16 | Lowcock, Hill and Co. |
| | 105 | 16 | P. Walters and Co. |
| | 111 to 119 | 11 to 16 | As now supplied by the Crystal Electric Lamp Co. |

[*Owing to the multiplicity of the curves given by the Author, and the confusing way in which they cross and recross, we have selected in each case the two best and also two other curves with peculiar characteristics.—Ed. *E.*]

Between the months of February, 1894, and April, 1895, the following lamps were tried :—

Two lamps out of 24 of each make were selected at random, one 16-candle power, and one 8-candle power, of 105 and 100 volts. The potential marked on the lamps was kept constant, and the current and candle power were carefully measured once in every 24 hours. If a lamp collapsed within the pre-arranged 2,000 hours' trial, its life was noted, and another lamp substituted without delay. From the results obtained, the following curves, A, B, C and D, of "candle-power and life" and "watts per candle and life" have been prepared for 16-candle power and 8-candle power lamps, comprised in Groups A and B.

In addition to the above curves, the summaries for Groups A and B show, at the end of 1,000 hours candle-power and efficiency, percentage drop in candle-power ; and the "comparative efficiency," calculated on the assumption that an Edison-Swan 105-volt nominal 16 candle-power lamp, taking 3·75 watts per candle, is 100 per cent. efficiency. From the corresponding curves the behaviour of any one lamp at intervals of 100 hours can easily be obtained if required.

Group A.—*Summarised Behaviour of Nominal 16 c.p. Lamps in 1,000 hours.*

*Note.*—The numbers I., II., &c , indicate number of lamp in trial.

| Firm. | Initial c.p. | Percentage drop in 1,000 hours. | Percentage efficiency of constancy in c.p. | Percentage efficiency comparative electrical. | Mean of columns 4 and 5. |
|---|---|---|---|---|---|
| Edison-Swan. 100 volts(II.) | 15·5 | 13·1 | 86·9 | 71·6 | 79·25 |
| International Electric Co. 105 volts (II.) ..... | 16·3 | 26·6 | 73·4 | 79·8 | 76 60 |
| Stearn. 105 volts (I.)*... | 16·9 | 31·3 | 68·7 | 77·0 | 72·85 |
| Siemens Bros. 105 volts (III.) ..... | 18·35 | 35 9 | 64·1 | 73·0 | 68·55 |
| Edison-Swan. 105 volts... (I.)† ..... | 16·9 | 39·0 | 61·0 | 69·5 | 65·25 |
| Electrical Co. 105 volts. (I.) | 15·0 | 65·3 | 34·7 | 59·1 | 46·9 |

* Only run 962 hours.

† 1st 105-volt lamp tested. The second 105-volt behaved more like the 100-volt lamp referred to above.

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**The following four lamps started considerably below the stated 16-c.p., and are therefore regarded as of no comparative value.**

| Firm. | Init'al c.p. | Percentage drop in 1,000 hours. |
|---|---|---|
| Bishop's Cluster Co. 105 volts (I.) ..... | 14·0 | 11·9 |
| Laing, Wharton & Down. 105 volts (II.) | 13·1 | 22·5 |
| Brush Co. 100 volts (I.) ..... | 13·0 | 7·8 |
| Sunbeam Lamp Co. 105 volts (I.) ..... | 12·0 | 22·6 |

GROUP A.—*Summarised Behaviour of Nominal 8-c.p. Lamps in 1,000 hours.*

*Note.*—Numbers I., II., &c., indicate number of lamp in trial.

| Firm. | Initial c.p. | Percentage drop in 1,000 hrs. | Percentage efficiency | | Mean of columns 4 and 5. |
|---|---|---|---|---|---|
| | | | of constancy in c.p | comparative electrical. | |
| Sunbeam Lamp Co. 100 volts (I.) ..... | 9·0 | 14·4 | 85·6 | 75·3 | 80·45 |
| International Electric Co. 100 volts (II.) ..... | 9·08 | 25·9 | 74·1 | 78·6 | 76·35 |
| Siemens Bros. 100 volts (I.) | 10·0 | 34·0 | 66·0 | 81·5 | 73·5 |
| Laing, Wharton and Down. 100 volts (II.). | 9·2 | 57 6 | 42·4 | 66·0 | 54·2 |
| *Stearn. 100 volts (I.)... | 10·3 | 61·9 | 38·1 | 65·8 | 51·95 |

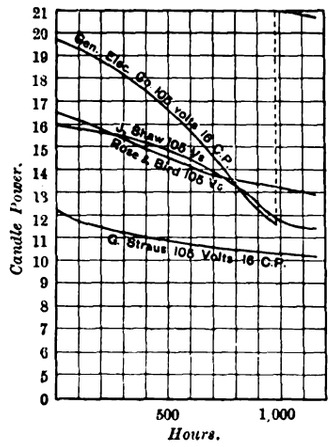
* Nominal 10 c.p.

**The following three lamps started considerably below the stated 8-c.p., and are therefore regarded as of no comparative value.**

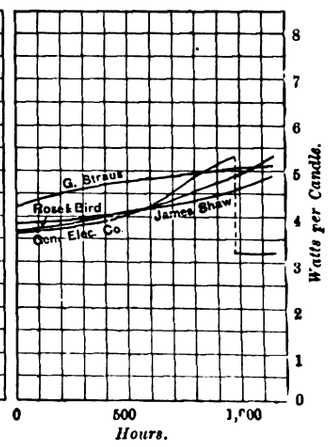
| Firm. | Initial c.p. | Percentage drop in 1,000 hours. |
|---|---|---|
| Brush Co. 100 volts. (II.) ..... | 6·6 | 5·42 |
| Electrical Co. 105 volts. (I.) ..... | 6·4 | 49·4 |
| Bishop's Cluster Co. 100 volts. (I.) | 3·5 | 13·7 |

**The curves A, B, C, and D seem to indicate four classes of lamps :—**

**1. Those that start at about their nominal candle-power at a high efficiency, but very quickly show a decided falling off in candle-power and efficiency, and become practically useless in four or five hundred hours.**




Specimen Curves of Candle-Power and Life of Group B, 16 c.p. Lamps.

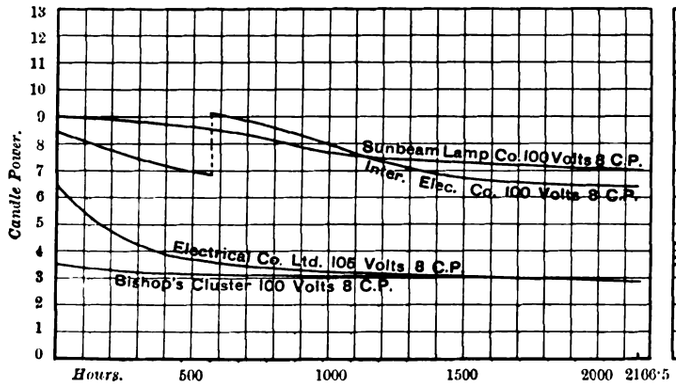



Specimen Efficiency Curves, corresponding to Curves of Group B, 16 c.p. Lamps.

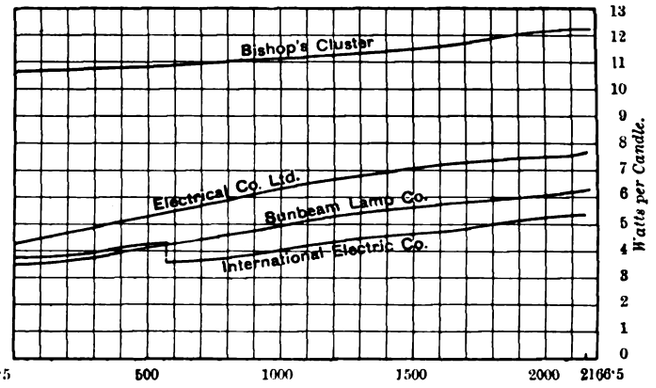
**2. Those that start off at about their nominal candle-power, give a useful light for about a thousand hours, and then burn out.**

**3. Those that start off like 2, but do not break ; and**

**4. Those that start off with a candle-power below their nominal value, and keep it up fairly steadily for 2,000 hours, or more.**




Specimen Curves of Candle-Power and Life of Group A, 8 c.p. Lamps.




Specimen Efficiency Curves, corresponding to Curves of Group A, 8 c.p. Lamps.

GROUP B.—*Summarised Behaviour of Nominal 16-c.p. Lamps in 1,000 hours.*

| Firm. | Initial c.p. | Percentage drop in 1,000 hrs. | Percentage efficiency | | Mean of columns 4 and 5. |
|---|---|---|---|---|---|
| | | | of constancy in c.p. | comparative electrical. | |
| Rose and Bird. 105 volts. 16 c.p. ..... | 16·5 | 20·0 | 80·0 | 81·2 | 80·6 |
| James Shaw. 105 volts. 16 c.p. ..... | 16·0 | 22·5 | 77·5 | 78·5 | 77·0 |
| Electrical Co. 105 v. 16 c p. | 15·6 | 19·9 | 80·1 | 73·5 | 76·8 |
| Barclay and Son. 105 volts. 16 c.p. ..... | 15·2 | 30·3 | 69·7 | 77·3 | 73·5 |
| Conze and Simon. 105 volts. 16 c.p. ..... | 15·7 | 35·7 | 64·3 | 72·8 | 68·5 |
| *General Electric Co. 105 volts. 16 c.p..... | 19·7 | 41·1 | 58·9 | 71·7 | 65·3 |

* Only lasted 982 hours.

**The following four lamps started considerably below the stated 16-c.p., and are therefore regarded as of no comparative value.**

| Firm. | Initial c.p. | Percentage drop in 1,000 hours. |
|---|---|---|
| *Sturm and Co. 105 volts. 16 c p. | 14·5 | 26·9 |
| P. Walters and Co. 105 volts. 16 c.p. | 14·1 | 21·9 |
| †Lowcock, Hill and Co. 105 volts. 16 c.p. ..... | 14·0 | 18·6 |
| G. Straus. 105 volts. 16 c.p..... | 12·1 | 14·9 |

* Only lasted 895 hours. † Only lasted 945 hours.

With Class 1 lamps, frequent renewals will evidently be necessary to keep up a satisfactory light on any installation of considerable magnitude; but, as will appear later on, it would seem that my old prediction of a "short life and a merry one" is not to be disregarded. Classes 2 and 3 are apparently the most promising lamps for practical use, while those in Class 4 scarcely admit of fair comparison with the others in that they never reach their nominal candle power.

Throughout the prolonged tests of "continuous lighting," it will be seen from the data supplied, that the candle power of each lamp gradually dropped from the start to finish, and the watts per candle rose.

The next experiments were conducted between April, 1895 and February, 1896, and the results are shown in Group C, summary, and corresponding curves. In this group (C) I met with several lamps which supported Prof. Ayrton's investigations, that is, the candle power increased at first, and then diminished.

A so-called 100-volt 8-c.p. Gabriel and Angenault lamp began at 5½ candles, and remained practically constant during the first 400 hours. It then gradually rose 10 per cent. (6·18 candles) to the 800th hour, after which the light slowly diminished to the starting luminosity, but the watts per candle were then higher than at the beginning of the trial.

A Lotz Abbott lamp, 100 volts, 16 c.p. (No. 2) rose from 13·3 to 14 candles in 400 hours, and then fell continuously. A Lotz Abbott lamp, 100 volts, 8 c.p., began at 7 and increased to 7·9 candles in 500 hours, and then dropped gradually. In 1,400 hours the candle power was the same as at the commencement of the test. The watts per candle varied from 5 at the start to 4·71 at the 1,400 hour point.



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Two other lamps, as made by Stearn and the Crystal Electric Lamp Company, slightly increased in candle power up to 200 hours, and then slowly diminished.

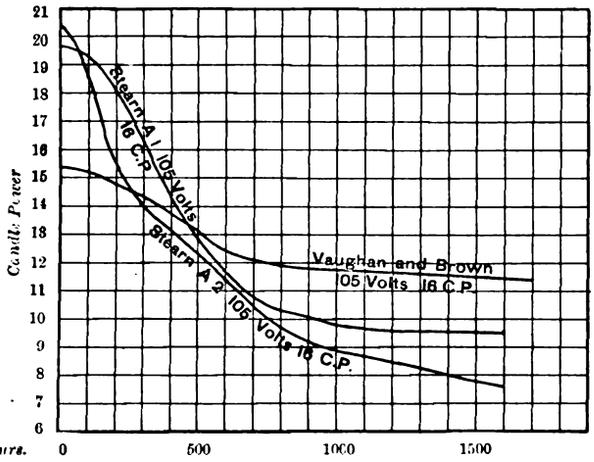
GROUP C.—*Summarised Behaviour of Nominal 16-c.p. Lamps in 1,000 hours.*

| Firm. | Initial c.p. | Per-centage drop in 1,000 hours. | Percentage efficiency | | Mean value of 4 and 5. |
|---|---|---|---|---|---|
| | | | of constancy in c.p. | comparative electrical. | |
| Stearn (A 1). 105 v. 16 c.p. | 19·7 | 50·25 | 49·75 | 60·4 | 55·07 |
| Stearn (A 2). 105 v. 16 c.p. | 20·2 | 55·69 | 44·31 | 55·2 | 49·75 |
| Vaughan & Brown. 105 v. 16 c.p. ..... | 15·3 | 22·9 | 77·1 | 69·0 | 73·1 |

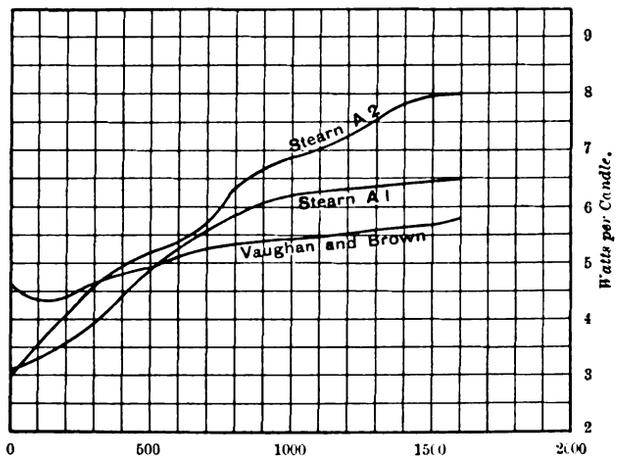
The following five lamps started considerably below the stated 16 c.p., and are, therefore, regarded as of no comparative value.

| Firm. | Initial c.p. | Per-centage dr p in 1,000 hours. | Percentage efficiency. | | Mean value of 4 and 5. |
|---|---|---|---|---|---|
| | | | of constancy in c.p. | comparative electrical. | |
| *Gabriel and Angenault. 105 volts. 16 c.p. (1) | 12·4 | 32.99 (793 hrs.) | 67·01 | 92·6 | 79·82 |
| Gabriel and Angenault. 105 volts. 16 c.p. (III.) | 9·7 | 10·3 | 89·7 | 91·5 | 90·6 |
| Stearn (1). 105 v. 16 c.p. | 13·3 | 30·1 | 69·9 | 58·3 | 64·1 |
| Stearn (2). 105 v. 16 c.p. | 14·1 | 34·1 | 65·9 | 57·6 | 61·7 |
| †Lux. 100 volts. 16 c.p. | 12.0 | 5·75 (757 hrs.) | 94·25 | 66·1 | 80·18 |

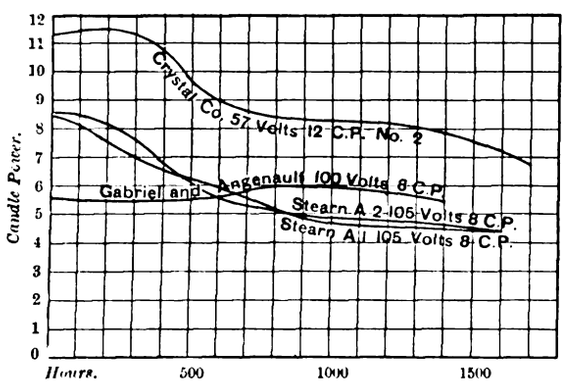
* Lamp burned 793 hours. † Lamp filament broken after 757 hours.



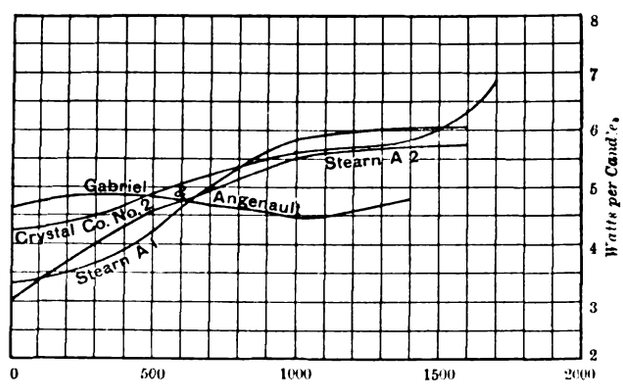

Specimen Curves of Candle-Power and Life for Group C, 16-c.p. lamps.




Specimen Efficiency Curves for Group C, 16-c.p. Lamps.




Specimen Curves of Candle-Power and Life of Group C. ; 8 and 12 c.-p. Lamps.




Specimen Efficiency Curves of Group C. ; 8 and 12 c.-p. Lamps.

GROUP C.—*Summarised Behaviour of Nominal 8 and 12 c.p. Lamps in 1,000 Hours.*

| Firm. | Initial c.p. | Per-centage drop in 1,000 hours. | Percentage efficiency | | Mean value of 4 and 5. |
|---|---|---|---|---|---|
| | | | of constancy in c.p. | comparative electricity | |
| Stearn (A. 1). 105 v. 8-c.p. | 8·52 | 46·0 | 54·0 | 63·2 | 58 6 |
| Stearn (A. 2). 105 v. 8 c.p. | 8·43 | 43·4 | 56·6 | 68·1 | 62·3 |
| Stearn (No. 1). 105 v. 8-c.p. | 8·5 | 18·8 | 81·2 | 72 5 | 76·8 |
| Stearn (No. 2). 105 v. 8-c.p. | 8 4 | 40·7 | 59·3 | 63·8 | 61·5 |
| Lamps as now made by the Crystal Electric Lamp Co. (No. 1) 57 v. 12-c.p. | 11·6 | 30·17 | 69·83 | 65·8 | 67·8 |
| Lamps as now made by the Crystal Electric Lamp Co. (No. 2) 57 v. 12-c.p. | 11·27 | 26·7 | 73·3 | 67·0 | 70·01 |

The lamp below started considerably below the stated 8 c.p., and is therefore regarded as of no comparative value.

| | | | | | |
|---|---|---|---|---|---|
| Gabriel and Angenault. 100 volts. 8-c.p..... ... | 5·52 | *6·4 | 106·4 | 75·3 | 90 8 |

* = +

*Summarised Behaviour of Lamps marked 16 c.p. and 8 c.p. in 1,000 Hours.*

It will be seen below that only one lamp (Lotts-Abbott, 100 volts 8 c.p. No. II.) out of the eight tested, gave the right candle-power at the start.

| Firm. | Initial c.p. | Per-centage drop in 1,0 0 hours. | Percentage efficiency | | Mean value of 4 and 5. |
|---|---|---|---|---|---|
| | | | of constancy in c.p. | comparative electricity | |
| Lux. 100 v. 16-c.p. (III.) ..... | 14·3 | 7 0 | 93·0 | 87·5 | 90·25 |
| Svea. 105 volts. 16-c.p..... | 14·3 | 25·87 | 74·13 | 84·1 | 79·11 |
| Lotz-Abbott. 100 v. 16-c.p. (I.) | 9·1 | 10·4 | 89·6 | 53·7 | 71·1 |
| Lotz-Abbott. 100 v. 16-c.p. (II.) | 13·3 | 5·26 | 94·74 | 78 8 | 86·72 |
| Lotz-Abbott. 100 v. 8-c.p. (I.) | 7·0 | *5·71 | 105·71 | 81·6 | 93·6 |
| Lotz-Abbott. 100 v. 8-c.p. (II.) | 7·9 | 0 | 100 | 75 9 | 87·95 |
| Greenhill. 100 v. 8-c.p. (II.)... | 7·3 | 12·3 | 87·7 | 64·9 | 76·3 |

* = +

The lamp below started considerably belew the stated 8 c.p., and is therefore regarded as of no comparative value.

| | | | | | |
|---|---|---|---|---|---|
| Greenhill. 100 volts. 8-c.p. (I.) ..... | 6·4 | 16·4 | 83·6 | 59·0 | 71·3 |

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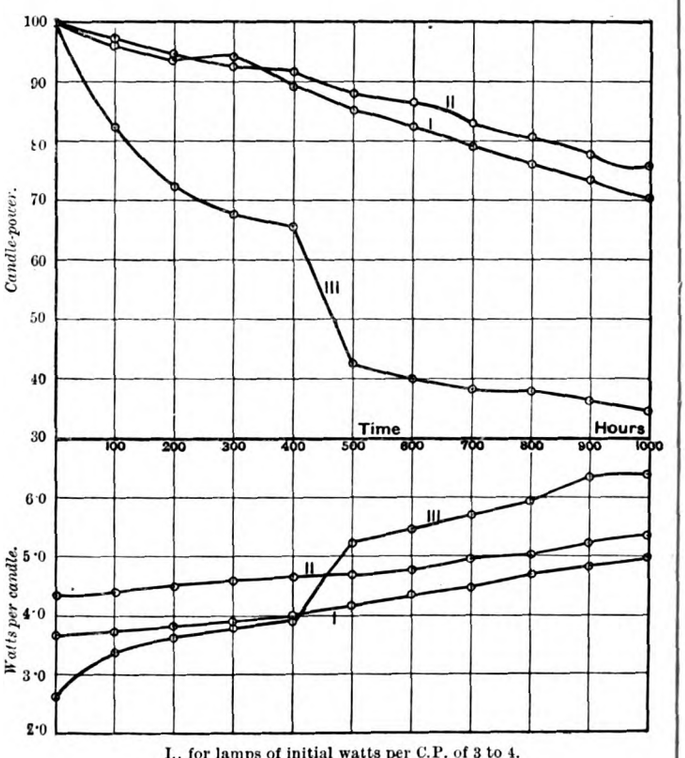
*Installation Tests.*

In the case of experiments 2 and 4, the lamps were rigidly mounted in suitable holders upon a stout shelf, fixed to a massive wall, so that no undue vibration should tend to shorten their life. The first group tried comprised two 8-c.p. lamps and two 16-c.pt lamps, as received from each of the firms mentioned againss experiment 2 in the above list, while a second batch of lamp. comprised one 16-c.p. and one 8-c.p., as supplied by each firm named against experiment 4. Two circuits were formed, one for 100 volt, and one for 105 volt lamps, on identically the same system as that described for the continuous-lighting tests. The illuminative power and current of each lamp at its normal voltage were taken before the trials commenced. Daily electrical measurements were made of each pair of lamps during the trial, and at the conclusion of the trial the existing lamps were again photometrically and electrically examined. If a lamp broke within the allotted 1,000 hours run, it was immediately replaced by another of the same make and kind of known efficiency. The so-called economical or high efficiency lamps evidently suffered more than those of about $3\frac{3}{4}$ watts per candle. In some cases the life was less than that of the same sort of lamps in the continuous-lighting tests, while in other cases no difference was observable. Of seven economical lamps supplied by one firm, five of the filaments broke within 1,056½ hours. The longest run was 1,056½ hours, and the shortest $23\frac{3}{4}$ hours. Omitting these




I., for lamps of initial watts per C.P. of 3 to 4.
II., ,, ,, ,, of over 4.
III., ,, ,, ,, of 2 to 3.

Curves Connecting Time with C.P. (percentage), and Watts per Candle respectively.

numbers and others below 100, the average life of *eight* 16-c.p. 105-volt lamps was 463·47 hours, and of three 8-c p. 100-volt lamps 556 hours.

*Breaking Voltage.*

Having obtained a fairly good knowledge of the efficiency and durability of various glow lamps under conditions of constant illumination and intermittent lighting, I next attempted to determine a quick and ready way of satisfactorily judging the quality of lamps. To obtain this end the voltage of several of the lamps already referred to was gradually run up for each lamp singly at a uniform rate until the filaments broke. At the moment of rupture the voltage, current and time of running up were noted in each case. Before increasing the normal voltage the current of every lamp was carefully measured, and the resistance (hot) afterwards calculated. In later trials the resistance (cold) was also found. The four mean factors at breaking point are diagrammatically represented in Diagram I. A suitable gearing controlled the motion of a falling electrode of copper as it gradually dropped through a column of very weak dilute sulphuric acid, which, on a 350-volt circuit, allowed the pressure of the lamp to be slowly raised to the breaking point. One assistant noted the volts and manipulated a chronograph, while another recorded the current at moment of collapse. Several lamps of like voltage and candle-power were obtained from various firms, and had their filaments broken in this manner. The average breaking voltage of the filaments was found to be 230.

*Three-fourths of Breaking Voltage.*

Another series of tests was carried out in the same way as experiment 5, except that the lamps were tested electrically and photometrically after, as well as before, being subjected to a high voltage. The object was to find what would be the effect on the electrical efficiency, candle-power, and the resistance of the same kind of lamps when slowly raised from normal potential to three-fourths of their mean breaking voltage. It is interesting to notice that the candle-power is found to be rather *more* after the filaments have been raised to a high temperature and retested at the initial pressure.

From the trials of numerous lamps that have been supplied to the Post Office, Table A has been calculated, showing their behaviour before and after being raised to three-quarters of their breaking voltage. They have been arranged in order of their initial efficiencies, and the percentage difference of candle-power and watts per candle-power, before and after raising the voltage. With the exception of the watts per candle-power in the case of the group of lamps of the initial efficiency 4 to 4·5, these differences are positive.

TABLE A.—*Table showing Behaviour of* 16 *c.p. Lamps* (100 *volts and* 105 *volts*) *before and after raising their voltage to* 170-2 *volts.*

| Initial efficiency watts per c.p. | No. of tests. | Before raising voltage. | | After raising voltage. | | Mean differences %. | |
|---|---|---|---|---|---|---|---|
| | | Mean c.p. | Mean watts per c.p. | Mean c.p. | Mean watts per c.p. | C.p. | Watts per c.p. |
| 3·0 — 3·5 | 29 | 15·8 | 3·34 | 16·1 | 3·45 | + 1·9 | + 3·3 |
| 3·5 — 4·0 | 93 | 14·5 | 3·76 | 15·5 | 3·81 | + 6·9 | + 1·3 |
| 4·0 — 4·5 | 66 | 13·3 | 4·19 | 14·86 | 3·85 | +11·7 | − 8·1 |
| 4·5 — 5·0 | 17 | 12·7 | 4·69 | 13·1 | 4·91 | + 3·1 | + 4·7 |

The foregoing results may be summed up thus :—

1. The continuous lighting experiments show that the candle-power falls about 30 per cent. in 1,000 hours, and the watts per candle rise about 28 per cent. in the same time, as illustrated in the curves below, which connect time with candle-power (percentage), and watts per candle.

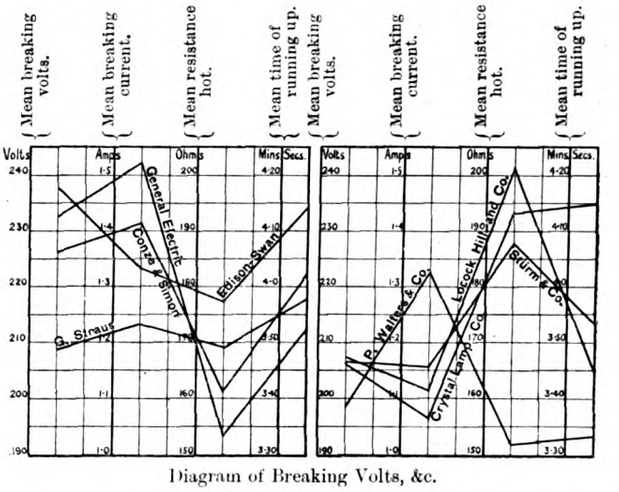



Diagram of Breaking Volts, &c.

2. In installation work lamps of about $3\frac{3}{4}$ watts per candle, burning from seven to nine hours a day, behave as regards life and efficiency about the same as when giving continuous illumination; but high efficiency lamps evidently deteriorate more quickly.

3. That good 100 or 105 volt 16 c.p. lamps, taking $3\frac{3}{4}$ watts per candle, should stand a gradual increase of pressure of direct current up to 225 or 230 volts (now made 210) in 3½ minutes before the filament breaks; that when slowly and regularly raised in 2½ minutes to, say, 170 volts, that is, approximately three-fourths of the mean breaking voltage previously alluded to, and afterwards retested at ordinary voltage, the candle-power should not be less than 14·4 nor higher than 17·6, while the watts per candle should not exceed four.

Evidently, in ordinary lighting, the candle-power of each lamp gradually drops, and the watts per candle rise; but when the pressure is raised in a short time to three-fourths of the breaking voltage the candle-power increases, and so also does the current, but the first more rapidly than the second, hence the watts per candle should not exceed four for lamps of $3\frac{3}{4}$ watts per candle after the increased pressure has been applied to the filaments.



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This is rather a curious fact, and seems to indicate that when the filament is raised to a temperature considerably above that of normal, it, if of good quality, undergoes a beneficial change, as if the sudden cooling, after being at an abnormal temperature, causes some molecular alteration, which not only lessens its diameter and resistance, but affects its emissivity. Under these conditions the temperature of the filament is increased, and thus produces a greater amount of light.

A copy of the present Post Office specification for glow lamps is given below. It is not yet regarded by me as being in its final form, but, so far, the conditions laid down have been satisfactorily met by certain lamp makers, and this has resulted in a considerable improvement in the lamps supplied. We frequently find that weakness is apparent at the lamp mounts through the wires being too thin, and the joints between the metal and filament being defective. Test No. 2, in conjunction with 1 and 3, has proved to be a valuable means of finding out the good, bad, and indifferent qualities of lamps; it is found to give a good forecast of what a lamp would do when used in the ordinary way, and may be regarded as equivalent to so many hundred hours' run. I have also obtained results recently obtained with some 2-watt "Montgomery" lamps. The drop in candle-power with these lamps, as with all other economical lamps that I have tested, is very large during the first two to three hundred hours' run, after which time they seem to reach a steady state and behave like ordinary 3 to 4-watt lamps; but at this stage the illuminating power is no longer serviceable for Post and Telegraph work, hence the lamps would have to be frequently renewed.

These experiments have been tedious and exhaustive. They have been carried out under the indefatigable supervision of Mr. Isaac Probert.

### Post Office Specification for Glow Lamps.

*Size of Lamp and Terminal.*—The glow lamps are to be to the size of a sample which is to be submitted for approval with the tender. In the case of lamps with screw holders, the screw-terminal is to be strictly in accordance with the standard which will be supplied to the contractor, and to be of such a size that it can be screwed home in the Post Office standard gauge and accurately fitted.

*Marking.*—Each lamp is to have distinctly marked on the glass the voltage, the candle-power for which it is designed, and the maker's name, with the normal watts per candle-power.

*Examination and Rejection of Broken or Defective Lamps.*—Each lamp will, on receipt, be tested for continuity of circuit. All lamps having broken filaments, loose terminals, or which are otherwise of defective manufacture, will be rejected, and an equivalent number of good sound lamps must be supplied free of charge by the contractors.

*Lamps to be selected for Test.*—From the bulk of each delivery a number of lamps will be selected at random and tested electrically and photometrically. This number will vary according to the quantity delivered, viz., 3 per cent. of a delivery of 1000 lamps or under, 2 per cent. of a delivery of 1,000 lamps, and up to 3,000, and 1 per cent. of a delivery of over 3,000 lamps, will be tested. The Postmaster-General reserves the right to reject the whole delivery if more than 25 per cent. of the total number so selected fail to pass either or all the tests hereafter specified. If further tests are undertaken at the contractor's request, it will be at his risk and cost.

*Tests.*—The following tests will be applied to all the selected lamps:—

1. A photometric test to determine the actual candle power of the new lamp at its standard pressure, and an efficiency test to determine the watts per candle. The limits of candle power, and the maximum watts per candle power allowable for each kind of lamp tendered are set out in the attached table.

2. After being so tested, the pressure at the lamp terminal will be gradually raised until it reaches in 2½ minutes the pressure stated in column 5 of the table. This pressure reached, the current will be at once turned off.

3. The lamps will then be retested as described in Test No. 1. The limits allowable for each kind of lamp as regards candle power, and the maximum watts per candle power, are set forth in the attached table.

| Terminals. | Stndrd C.P. | Standard volts. | Test No. 1. C.P. Max. | Test No. 1. C.P. Min. | Test No. 1. Mx. wts per c.p. | Test No. 2. Pressure raised to in 2½ mins. Volts. | Test No. 3. C.P. Max. | Test No. 3. C.P. Min. | Test No. 3. Mx wts per c.p. | Test No. 4. Pressure raised to in 3 mins. Volts. |
|---|---|---|---|---|---|---|---|---|---|---|
| E.S. or B.C. | 8 | 100 or 105 | 8·5 | 7·5 | 3·9 | 170·2 | 8·8 | 7·2 | 4·1 | 210 |
| | 8 | 110 or 115 | 8·5 | 7·5 | 3·9 | 174·6 | 8·8 | 7·2 | 4·1 | 215 |
| | 16 | 100 or 105 | 17 | 15 | 3·75 | 170·2 | 17·6 | 14·4 | 4·0 | 210 |
| | 16 | 110 or 115 | 17 | 15 | 3·75 | 174·6 | 17·6 | 14·4 | 4·0 | 215 |
| | 25 | 100 or 105 | 26·5 | 23·5 | 3·5 | 170·2 | 27·5 | 22·5 | 3·75 | 210 |
| | 25 | 110 or 115 | 26·5 | 23·5 | 3·5 | 174·6 | 27·5 | 22·5 | 3·75 | 215 |
| | 32 | 100 or 105 | 34 | 30 | 3·4 | 170·2 | 35 | 29 | 3·65 | 210 |
| | 50 | 100 | 53 | 47 | 3·3 | ... | ... | ... | ... | ... |
| Lug ... | 100 | 105 | 106 | 94 | 2·9 | ... | ... | ... | ... | ... |

4. In lieu of Tests 2 and 3 a proportion of the lamps not exceeding one-third of the whole number selected for test, will be raised gradually in three minutes to the pressure stated in column 7 of the table. The lamp under test must not fail in any way while the pressure is being increased from its normal voltage to that named in column 7 of the table.

5. The candle power of all lamps tendered for must be in terms of the English standard candle.

Note.—The Post Office measurements will be made with an improved Trotter photometer, and the standard of light will be either the Vernon-Harcourt or the Hefner-Amyl-Acetate, the former being taken for the purposes of this specification as one English candle, and the latter as 0·88 of an English candle.

## ELECTRICAL PLANT OF THE DUQUESNE STEEL WORKS AND BLAST FURNACES.*

The Carnegie Steel Company (Limited) have recently put into operation at Cochran, Pa., about 12 miles from Pittsburg, an extensive new blast furnace plant, on property adjacent to their well-known Duquesne Steel Mills. Several excellent features are noticeable in connection with the electrical plant, the function of which is to supply light and power to the steel mills, six furnaces, and the various buildings and yards appertaining thereto, an area of over 100 acres.

*The Electric Power House.*—This plant is situated in a separate brick building, 200ft. by 50ft., having a steel shell. The building is divided into three parts; the central, 120ft., contains the electrical machinery and switchboards, which will be described in detail below. The 40ft. at the northern end contains the office of the superintendent of the electrical department, and a storeroom for wire, spare parts, &c. The 40ft. at the southern end comprises the machine or repair shop, which is equipped with lathes, drill presses, milling and slotting machines, &c., all operated from a shaft driven by means of a 10 H.P. multipolar shunt-wound motor. A 10-ton electric travelling crane runs the entire length of the building. The great advantages of such a crane and repair shop are obvious.

*Generators.*—In the power house are two 500 H.P., 250-volt, direct-current, 10-pole generators, each direct connected to a Buckeye tandem compound condensing engine, 18in. and 32½in. by 33in., operating at 130 revolutions per minute, and exhausting into a standard Blake condenser. These generators were built by the Westinghouse Electric and Manufacturing Company, and represent their latest development in dynamo design and construction. The field poles are built up of laminated steel, and they are cast into the yoke, which is divided vertically. The armature core, which is pressed and keyed upon the engine shaft, consists of laminated steel discs slotted around the periphery. When the discs are superimposed upon each other, they form grooves into which the conductors are placed. These conductors are composed of rectangular copper bars, shaped upon moulds and thoroughly insulated before being placed upon the core. The brush-holder mechanism is supported by brackets projecting from a cast-iron ring secured to and supported by the field yoke. Each machine has 10 brush arms, each carrying five carbon brushes. These generators are operated in parallel, and supply power to a large number of direct-current 220-volt motors used for various purposes throughout the plant. Six direct constant-current 60-light arc dynamos supply current to arc lamps in the various buildings and yards. These machines are direct connected by flexible insulated couplings to six 50 H.P. shunt motors, which are also operated by power from the generators described above. The exciting current for the arc machines is also taken from the same generators. The arc machines are symmetrically located on each side of an aisle, which is directly opposite the arc switchboard, this arrangement being very convenient for the attendant. Each of these units (arc machine and motor) is mounted upon a separate foundation. On a similar foundation is a 45-kilowatt, 7,200-alternation, single-phase generator, which is also direct connected to a motor and excited by current from the large generator. This machine is used for supplying current to about 900 incandescent lamps distributed in the various buildings.

*Switchboards.*—A white marble switchboard, supported by an iron framework, stands between the two large direct-current generators. This is the power board, and upon it are mounted the necessary switches, circuit-breakers, ammeters, voltmeters, and rheostats, for controlling the two generators; it consists of two generator panels, one main panel and six feeder panels. All the connections are made on the back of the board. A large single-pole switch, mounted on an iron pedestal near each of the direct-current generators, is for the equalising circuit, which is carried

* Abstract from the *Electrical Engineer* of New York.

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directly from one generator to the other under the floor. The arc switchboard consists of six marble panels, the three on the right containing the circuit-breakers and switches for controlling the six direct-current motors, while upon the other three are mounted the ammeters, circuit-breakers, plugs and plug receptacles for controlling the arc machine and arc circuits. By means of the plugs any one of the machines may be connected to any of the feeder circuits. All wires from the arc machines and their driving motors are carried through hollow posts to a pine switchboard situated under the marble one in a light, dry cellar, the floors of which are concreted. No so-called "temporary work" can be found in the plant, the entire installation having a substantial and permanent appearance.

No wires are visible on the ceiling or walls of the building, except at the northern end, where they are brought from the cellar in two groups—positive and negative—pass up the wall and through a circular gable window to a line of steel poles, 50ft. in height, upon which they are carried through the yards and to the buildings. The arc machines, alternating-current generators, marble switchboard and all the motors installed in the power house were also manufactured by the Westinghouse Electric and Manufacturing Company.

*Electric Cranes.*—There will be over 40 Morgan electric cranes in the plant; all of these are driven by 220-volt direct-current motors manufactured by the Westinghouse Electric and Manufacturing Company. Each of the six casting houses is equipped with two 10-ton three-movement electric travelling cranes. A 10 H.P. multipolar motor, enclosed type, is used for the hoist—10 H.P. for bridge travel and 3½ H.P. for carriage. The hoist and carriage motors are equipped with automatic electric brakes—the bridge motor with powerful foot brakes—an arrangement which permits of a very accurate movement in each direction. These cranes carry the pig iron to the metal breaker. Each blowing engine house is provided with a 25-ton three-movement crane of 61ft. span; a 20 H.P. motor being used for hoist, 5 H.P. for carriage, and 30 H.P. railway type motor for bridge travel. Automatic electric brakes and foot brakes are supplied, as on the cranes in the casting houses. A 50-ton electric crane of a special type, built by the Morgan Engineering Company, is erected over the metal mixer. It is a four-movement crane; two hoists, one carriage, and one bridge movement. The motors are; 100 H P. for main hoist, 20 H.P. for auxiliary, 10 H.P. for carriage, and 30 H.P. railway type for bridge. By means of this crane the molten metal is poured from the ladles into the metal mixer. In this way metal from several different furnaces is mixed together before being run into the converters. There is a 10-ton electric crane of 50ft. span installed in the pump house. The motors thereon are 10 H P. for hoist, 10 H.P. for bridge and 3½ H.P. for carriage.

*Other Uses of Electric Motors.*—The metal breaker is direct connected to a 60 H.P. multipolar shunt-wound motor. The breaker, which is provided with a flywheel 4ft. in diameter, is fed from a long table, driven, through suitable gears, by a 30 H.P. railway type Westinghouse motor. Cranes are used to lift the metal to the table. This apparatus can handle over 100 tons of pig iron per hour. Each casting house is provided with a 5-ton conveyer; this is a carriage running the whole length of the casting house, and thence to the stock yards. Its function is to carry all the scrap iron to the foot of the furnace hoist, from where it will be taken to the top of the furnace again. A Westinghouse railway type motor moves this conveyer, and although working night and day in an extremely warm and dusty atmosphere, it has proved entirely successful. The operator on the conveyer is protected from the heat by an iron cage.

Over the ore stock yard are three electric travelling bridges of 200ft. span. These were constructed by the Brown Hoisting and Conveying Company, of Cleveland, Ohio, and are the largest ever built for the purpose. The carriages are driven by steel ropes, all the machinery, such as drums, clutches, &c., being mounted on the bridge. Two 100 H.P. Elwell-Parker shunt motors are direct connected to the drums, and enable the operator to move the bridge, carriage and hoist at the same time. The purpose of these bridges is to unload all the ores needed for the furnaces. A 20 H.P. shunt motor drives the crushing machines in the ore-sampling department, and a 2 H.P. motor is used in the laboratory. In fact, electric motors are in use in almost every part of the plant for a large variety of purposes.

**An Electric Street Cleaner.**—The New York papers describe an electric street-cleaning car recently introduced in the streets of that city, The car is fitted with a trolley and also accumulators, so that it can be used on any tram lines. The idea is to sweep the street from kerb to kerb inwardly toward the tracks, then when the self-loading car passes over the tracks at any desired speed it takes up the refuse and conveys it to any desired location.

## ON THE MULTIPLICITY OF BRUSHES IN LARGE GENERATORS.*

BY WILLIAM BAXTER, JUN.

When the multipolar generators first came into use there was quite a difference of opinion as to the proper number of brushes. German builders adopted the plan of making the number equal to the number of poles, but the English electricians maintained that this complication was undesirable and inexcusable, inasmuch as it could be avoided by the simple process of cross-connecting the commutator. American engineers, as a rule, were in favour of single brushes in the early days, but they soon changed to the multiple system; and at the present time it is doubtful if a manufacturer can be found who does not follow the latter construction.

The reason for this change from simplicity to complication is to be found in the fact that carbon brushes came into use at about the time when the multipolar machines were being introduced; and as these brushes are of a much lower carrying capacity than copper, the number in parallel, or in other words their cross-section, must be increased. This, as is evident, can be done in two ways, one of which is to widen the face of the commutator so as to place a greater number in a row; and the other is by placing brush holders at all the equipotential points and connecting the alternate ones in parallel. If the latter plan is adopted the face of the commutator can remain of the normal width, and this fact is, in all probability, the chief cause for its adoption, it being believed, no doubt, that the cost of construction would thereby be reduced and a more symmetrical design obtained. It is by no means certain that the multiplicity of brushes reduces the cost of construction or that it renders the design more symmetrical; but even if it did its adoption could not be deemed advisable for these reasons alone. There are two things to be considered in all such cases; the first and most important one is the effect upon the operation of the machine and the second the cost of construction.

A very little reflection will show that the two-brush machine will prove the most satisfactory to the user, and will be subject to less deterioration, owing to the fact that it will be better taken care of. If there are but two brushes, they can be located at any point on the periphery of the commutator, where they will be most accessible; and this fact, of itself, will ensure their receiving better attention. If multiple brushes are used this may not be the case, in fact it is almost sure not to be. The brushes on the sides, and on top of the commutator, will receive proper care, but those underneath will not, for even the most faithful attendant cannot be expected to watch as closely these inaccessible parts, and it is very probable that the owner himself would neglect them if he had to take care of the machine. Many men maintain that such objections amount to very little, that the attendants are paid for their services, and if they do not perform their duties faithfully they can be discharged and better men obtained; but the fact is, as every one who has had experience in such matters knows, that it is difficult if not impossible to find men who will give just as much attention to inaccessible parts as they will to those that can be reached without inconvenience or danger. Another objection to the use of multiple brushes is the difficulty involved in adjusting them to the non-sparking points. This is by no means an unimportant matter, for upon it depends the life of the commutator to a very great extent. Unskilled men very often find it difficult to set a single pair of brushes so that they will not spark; such being the case, what can be expected when multiple brushes are used? If all the men who take charge of electrical machines were competent, the difficulty of adjusting multiple brushes would not be very much of an objection, but the number of incompetent men is very great and is constantly on the increase. There was a time when those who know nothing about electrical machinery would not attempt to take care of it for fear of being killed by a shock; but any number have now found out that there is no such danger with incandescent lighting generators, and the result is that there are engine attendants everywhere who claim to be expert in the care of generators simply because they have had charge of one for a few months. The fact that the proper adjustment of multiple brushes is beyond the capacity of the majority of the men who are in charge of machines of that type can be verified by an actual inspection of isolated plants. Two-pole generators that run sparkless can be found everywhere; but a sparkless running multiple brush machine is the exception, and this is true even in plants of several hundred kilowatts capacity.

If these points are well taken then it is evident that machines with a single pair of brushes are the most desirable from the standpoint of the user. They will be kept in better adjustment, not only because it requires less skill to do so, but also because the parts are more accessible and therefore can be given the proper attention without inconvenience.

The sparking of multiple brushes is not always the fault of the attendant. In many cases it is due to the fact that the various

* From the *Electrical World* of New York.

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parts of the machine are not in accordance with each other, and therefore the non-sparking points either shift backward and forward as the armature rotates, or else are never in line with the brushes. If the brushes are placed at equal angles around the commutator they may and they may not rest on the non-sparking points. If the commutator segments and the armature sections are equally spaced, and the magnetic circuits are of equal strength, and the fields symmetrical, the equipotential points and the position of the brushes will agree; but under any other condition they will not. It is difficult to obtain exact agreement of all these points, therefore it is difficult to obtain a non-sparking condition with multiple brushes. The result is accomplished by the best manufacturers, but only by the exercise of the greatest skill in the design, and the greatest accuracy of workmanship in the construction.

With two brushes all these difficulties are considerably reduced, and the same amount of skill and accuracy of workmanship will produce better results, or more properly speaking, such a machine of equally good design and construction can be adjusted to run with less sparking. The reason for this is that if there are as many brushes as there are poles, each one must rest on a neutral point to avoid sparking. If the fields are not symmetrical and of equal strength, the neutral points will not be equally spaced around the commutator, and therefore it will be impossible to have all the brushes on the line. If only two brushes are used this difficulty will not be encountered; if the armature is wound with the equipotential sections in series, the irregularities in the induction of the several magnetic circuits will, to a very great extent, counteract each other, and as a result the difference between the arc separating the brushes and that between the neutral points on the commutator, with which they come in contact, will be so small as to produce little or no sparking tendency. If the armature is connected in parallel, the inequalities of induction in the several magnetic circuits may shift the position of the neutral points on the commutator; but as only two of these are in contact with the brushes, two can be adjusted so as to nearly agree with each other sufficiently well to obviate practically all sparking.

If the series connection of the armature could be used in every case perhaps the majority of engineers would be in favour of the two-brush system, as then the cross connection of the commutator would not be necessary. It is very generally believed that a cross-connected commutator is not as reliable as one not so made, and also that it is expensive to manufacture. These notions, however, are not correct; there are simple ways of cross connecting that are perfectly reliable and not at all expensive: in fact, as far as cost goes, the saving of the brush holders, and ring for supporting them, would more than pay for the additional expense placed on the commutator, by the cross connecting thereof. In the early days of multipolar generators there was a valid reason for not using two brushes, which was that as carbon brushes were used the surface of the commutator would have to be widened. Since that time, however, woven wire brushes have come into use, and have been found to be equal, if not superior, to the carbon. The carrying capacity of these is so high, and the resistance of contact so low, that, with them, extra width of commutator would not be necessary.

The writer has many times tried to find out why every one adheres to the multiple brushes, but has thus far failed. In almost every case the reason given is that the matter has been thoroughly investigated, and the latter arrangement found to be the best. This is a very indefinite although easy way of disposing of the case, but it proves nothing. A great many men may have come to the above conclusion after a thorough investigation of the matter; but others, and perhaps a greater number, after a similar investigation, have come to the opposite conclusion. To the writer it looks very much as if this were another verification of the old saying that men's minds run in grooves. There are very few leaders, and almost every one follows in the footsteps of those who are successful. As the large concerns have adopted the multipolar construction, the smaller ones fall into line and do the same thing, because they are afraid to strike out on an independent track. Perhaps some day a concern of more than ordinary courage will depart from the beaten path and place on the market two-brush machines. If such a thing should come to pass, we would be able to find out in a practical way which system is the best. In the opinion of the writer the two brushes would come out victorious.

## BOOKS RECEIVED.

"Taschenbuch für Monteure Elektrischer Beleuchtungsanlagen." By S. Von Gaisberg. Twelfth edition, revised and enlarged. (Munich and Leipsig: R. Oldenbourg.)

"Proceedings of the Northern Society of Electrical Engineers." January to May, 1896. Vol. III., No. 1. (Manchester: Eastwood and Co. Price 5s.)

"Transactions of the North-East Coast Institution of Engineers and Shipbuilders." Vol. XII., Parts 7, 8, 9 and 10. (London: Andrew Reid and Co.)

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September 18, 1896.*

**Street Railway Questions.**—At the Convention of the New York State Street Railway Association, held in Binghamton, N.Y., on the 8th inst., some valuable and interesting Papers were read on street railway subjects. Mr. W. J. Clark, in a Paper entitled "Some Hints on Railway Practice," referred particularly to the subject of standardising rolling stock. He argued that in street railway operation there was not the necessity for the full and constant study of standardising rolling stock that is being carried on on steam railroads. He stated, however, that it would be unquestionably an advantage, both to the manufacturer and the user of electric railway apparatus, if some definite positive rule for the rating of all electrical apparatus were fixed. It would make little difference what this basis of rating was, provided it was universal, well-understood and thoroughly insisted upon by street railway men. Mr. James B. Cahoon dwelt upon the importance and necessity of carrying out a system of daily inspection and care of street car equipments. Such a system of inspection had two principal objects, namely, first, to prevent breakdowns when the car is out on the road and the consequent annoyance to passengers, as well as the blocking of traffic and the throwing of the cars off their schedule time; and, second, the reduction to a minimum of the repairs necessary to maintain the equipment in good order and the prolongation of their life. He then discussed what he regarded as the best methods of accomplishing these objects, and by so doing obtain the best results with the least expense. In his address before the Convention, President Rogers referred to the universal adoption by large plants of direct-connected generators, over 80 per cent. of the machines produced during the year being of that class. He questioned, however, the wisdom of adopting direct-connected units in smaller cities and towns where the demand for power is not great and real estate is comparatively cheap.

**An Electric Yacht.**—On September 10th an electric yacht was launched at Nyack, N.Y., which in many respects is a remarkable vessel. In her construction expense was not stinted in the least, her owner, Mr. John J. Astor, being one of the most wealthy citizens of America. The yacht was christened "Utopian," and she is said to be the largest craft of the kind in the world. She is 72ft. long over all, 12ft. beam, and has a draught of 3ft. 6in. She is equipped with two screws, which are operated by 25 H.P. electric motors, deriving their current from 480 cells of storage battery. The batteries will be capable of maintaining current for a continuous run of 12 hours, at a speed of 16 miles an hour. The yacht is fitted with electric lights, electric bells, &c., and electricity is utilised in every manner possible to promote comfort and convenience.

**Assignment of a Prominent Engine Company.**—The Armington and Sims Engine Company, of Providence, R.I., a few days ago assigned all of its property to a committee of creditors. The insolvency of the estate of the late Henry C. Cranston, of Providence, is said to have been the immediate cause of the assignment. This Company was one of the first in the United States to undertake the building of steam engines that would meet the exacting requirements of electric lighting, and was very successful in its efforts. The concern was held in high regard in the electrical trade, and it is the subject of deep regret that the Company has thus become involved in its financial affairs.

**Water Power at Montreal.**—On September 12th the corner stone of the main dam of the power house of the Lachine Rapids Hydraulic and Land Company, at Lachine, Canada, a few miles from Montreal, was laid amid formal ceremonies, a large and representative party being present by invitation. The completed plant will have a total capacity of 14,000 H.P., and current will be generated on the three-phase system, at a pressure of 5,200 volts. It will be carried to Montreal, where it will be reduced to a working pressure of 110 volts, and distributed throughout the city in underground conduits, 500,000ft. of which have already been contracted for.

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# CORRESPONDENCE.

## LONG-DISTANCE TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You ask me to express my opinion regarding Mr. W. H. Preece's proposal in the direction of long-distance telephony or telegraphy. I have explained my own views so fully already that I am reluctant to do it again, and the nature of my opinion may be readily anticipated by anyone who has considered my theory.

Briefly put, I understand from the later portion of Mr. Preece's paper* that he thinks it right and proper to bring the two members of a pair of conducting leads as close together as possible. So I understood before. This will reduce the inductance of the circuit to the least possible, and at the same time increase its permittance. Now, it is a long way to America, and one may never get there; but it is as well to go in the right direction. Those who are acquainted with my theory will recognise that the direction taken is the opposite one to that which I have so often advocated, and have demonstrated both theoretically and by reference to practical examples—that is, we should go in the direction of increasing the inductance and reducing the permittance, so far as those two elements are concerned.

But the matter cannot be treated in a letter. I beg to refer all who may be interested in the subject to various papers in the second volume of my "Electrical Papers," and also to the portions of the fourth chapter of the first volume of "Electromagnetic Theory" which are devoted to this matter, where I have taken pains to express the general results of my theory in plain English. For any corrections that may be needful, and with which I can agree, I shall be thankful, for the sake of future editions. For I hope that electromagnetic theory, like self-induction, has come to stay.—Yours, &c.,

September 27, 1896. OLIVER HEAVISIDE.

## FREEZING OF BATTERY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The *Daily Chronicle* of this date quotes some interesting particulars (from the *Elektroteknisk Tidsskrift*) of the working of the electric-light plant on board the arctic ship "Fram." It is stated that the accumulators froze right through, but "the acid-blended ice proved an excellent electrolyte, and the frost did not interfere with the working of the accumulators."

It would be extremely interesting to know what exactly is the action of different degrees of frost on the electrolyte of secondary batteries (and other batteries, for that matter); and what alterations take place in the condition and working of a given cell, when frozen partially or solid. I cannot understand that a cell can act at all when it is frozen solid, for there can be no transmigration of the ions; and even when partially frozen, as was probably the case on board the "Fram" (the partial freezing being due to the different freezing points of acid and water), I should have thought the action would be impaired. Perhaps some of your readers (in North America, *e.g.*) can give authoritative information on these points. Such would be extremely valuable; though if there are any who have visions of refrigerating accumulator rooms as a means against buckling, I am afraid their hopes will be dashed.—Yours, &c.,

Croydon, September 28th. W. PERREN MAYCOCK.

## THE POSITION OF SCIENCE IN OXFORD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With your permission I should like to bring forward one or two points in relation to the position of Science in Oxford not dealt with in your leader on the subject.

A clear distinction should, I think, be made between Technical Education and the study of Applied Science. Centralisation would be fatal to the former, which is needed all over the country; but the latter can be studied to the best advantage where the most perfect appliances can be gathered together, and this is practicable only in a limited number of localities. The technical experience acquired in actual work is too frequently confined to the processes used in some one place; and although a university is powerless to impart this kind of knowledge, still it might give facilities for studying the methods of other countries and other minds, to an extent difficult of realisation under existing circumstances. At Oxford especially there is comparatively little provision made for work of this kind. The course ends just when it is beginning to become useful. The new Research Degree, it is true, affords a recognition of post-graduate study, and its scope might be easily extended to cover a number of departments of Applied Science, if the necessary appliances were forthcoming. For example, an organised study of the processes of electric smelting would undoubtedly lead to discoveries as valuable from a scientific as from a practical standpoint, but we have no current strong enough. Among our chemists are men capable of directing research, but their time is taken up with the ordinary routine of teaching. The laboratories are mainly adapted and mainly used for teaching for the schools, and to the majority of the men success means an appointment to a good teaching post. This state of things cannot last—the country is overrun with teachers. A university which trains men for the medical profession ought, to be consistent, to give instruction also, in a course of post-graduate study, in other branches of Applied Science. But if it does so at all, the thing must be done thoroughly. Few men after leaving Oxford would care to go to a second-rate technical college, and few technical colleges capable of teaching graduates would not also arrange to teach Pure Science. The new discoveries would naturally come from those most closely in touch with recent inventions, and in the end the universities that neglect Applied Science must be left behind. It is not possible to separate Pure and Applied Science. Faraday's experiments bore fruit in the dynamo, and Davy's discovery of the arc light gave birth to a new industry; but in return the problems of electric lighting supplied the physicist with data and a motive for the study of hysteresis and magnetic permeability. In the hands of the engineer the induction coil becomes the transformer, and affords new problems to the mathematician. There is scarcely a single department of Physics or Chemistry in which for the last 50 years the lines of research have not been marked out, and the means of prosecuting them provided, as the incidental result of some practical application of Science. Yet there are many in the university who seem to regard the study of these practical applications as *infra dig.*

It would be a waste of money to establish all over the country technical colleges in which only a minimum of Pure Science is taught, unless these are regarded in the light of elementary schools of practical science, and some great central institutions are provided where men who have got beyond the examination period may work out some definite problem, with all the advantages afforded by daily contact with specialists in the subjects connected with it.

I agree with the opinion expressed by Prof. J. J. Thomson in his opening address in Section A of the British Association as to the value to the student of research work, and I would go farther and say that the educative value of a research is not in the least diminished by the prospect of a practical outcome, if only the true scientific method is adhered to, as it should be in any institution for the study of Aplied Science in connection with the university.

The main difficulty is to provide the necessary appliances. New inventions follow one another so rapidly that the best appointed laboratory soon gets behind the times, unless large sums of money are spent yearly upon it; and the cost of keeping pace with modern progress in Applied Science would be prohibitive. I venture to make a suggestion specially applicable to electrical engineering, by which this difficulty might be overcome.

If suitable buildings were provided in Oxford, Cambridge, and some of the provincial colleges, a system might be intro-

* Liverpool Meeting, British Association, *The Electrician*, September 25, 1896, p. 689.

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duced whereby manufacturers should lend new forms of apparatus and machines to go the round, stopping in each place a term or more, and being then passed on and replaced by fresh exhibits. Something of this kind has been done in connection with Papers read before the Institution of Civil Engineers, and the loan collection of scientific instruments was a step in the same direction. What is wanted is for the students to see the machines in action, and if possible handle the apparatus, as well as have its construction explained. In some cases the objects, such as parts of dynamos or engines, would be merely exhibits, and the owners would have the benefit of a splendid advertisement. In others, something must be paid for wear and tear, or the equivalent loss of value credited to the owners as a donation. A cyclist can have the latest thing in bicycles by paying about £5 a year. Why should not a university have some of its teaching appliances on similar terms?

Obviously such a scheme could only be carried out in connection with a few large centres of instruction, and this is a strong reason in favour of Applied Science being undertaken at Oxford and Cambridge.—Yours, &c.,

Oxford, September 22, 1896. GEORGE J. BURCH.

## NEW MEN AND OLD PLANT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent, my late assistant, Mr. A. T. Cooper, has done well to admit his rivalry and present position. His disclaimer of pique and spite in view of his letter must be taken with a bushel of salt. I have hesitated to reply to him; and were it not that his newly-found championship of my predecessor (which does him credit, but was not needed) is eclipsed by his failing regard for truth, I would have refrained from answering. That his championship of these works is newly-found is evidenced by his letter to me of May 20th last (and which I now hold), wherein he expresses his opinion that the station and mains are in a half-hearted condition due to the amateurish way in which things were started here. He also declares himself to be ashamed of the place, and anxious to see things put straight.

Mr. Cooper is apparently sore about my "instance" of the "ramming and jambing" to which the cables were subjected. I did not rely upon that instance only, but gave the average number of cables in a single pipe over the whole town; *i.e.*, rather more than six. The figure is Mr. Hesketh's, not mine; as also is the recommendation to adopt paper cables.

With regard to the failure of the cables, I will quote your other correspondent under the same head, Mr. Jas. Pearson. After speaking of the fact that the Ferranti set is not yet running, he says, "You can easily guess the effect on the working. Extinction after extinction, the service brought into disrepute." Yes, Sir, "extinction after extinction" has been and is the order of the day, but caused entirely by cables! There has only been one breakdown of alternating machinery this year, and that was due to a "short" on the mains.

With regard to the subject matter of Mr. Pearson's letter, I was interested in his historical statements, but his personal remarks do not in the least affect me. I would say, however, that in formulating my report I was not influenced by, nor did I recognise, any clique or party.

I think I have said sufficient to prove my case to the satisfaction of any impartial mind; and the fact that my Committee spent no less than ten hours in the consideration of my report, and at the end of that time adopted it unanimously (as also did the General Purposes Committee and the Town Council) is, I think, sufficient evidence that those most nearly concerned, and those aware of the circumstances, were convinced that the statements made therein were true.

I must now withdraw from the controversy.—Yours, &c.,

ROBT. C. QUIN,
Borough Electrical Engineer.

Corporation Electricity Works, Blackpool,
September 25, 1896.

# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d.; abroad 9s.**

**The New Edition for 1897 is in active preparation, and circulars and full information will shortly be forwarded. The Subscription price remains 5s., postage 9d.; abroad, 6s. 6d., post free.**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A Fleming, M.A., D.Sc., F.R.S. *The New Edition is now ready.* Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated; price 12s. 6d. *Now ready.*

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. is also ready; price 7s 6d. (abroad 8s.). Prospectus on application.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d, (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application.

"THE STEAM ENGINE INDICATOR AND INDICATOR DIAGRAMS."—Edited and enlarged by W. Worby Beaumont. Price 3s. 6d., post free.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"ELECTRO-CHEMISTRY."—By Dr. G. Gore. Third Edition now ready. Price 2s., post free.

"MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY."—By E. Tremlett Carter, C.E., M.I.E.E. *Ready in a few days.* Price 12s. 6d., post free; abroad, 13s. 6d.

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TENDERS INVITED.—The Directors of the Lancashire and Yorkshire Railway invite tenders for the supply of stores during the 12 months ending October 31, 1897. Amongst the articles required are copper tubing, brake blocks, india-rubber, glass, iron castings (hydraulic and water pipes), ironmongery, steel and files, sundry tools, way materials, &c. Further particulars and forms of tender may be obtained on application at the Stores Department, Osborne-street, Manchester. Tenders addressed to the Directors must be lodged with the Secretary, Mr. C. W. Bayley, Hunt's Bank, Manchester, by 10 a.m. on Monday, the 12th inst. Some further information appears in our advertisement columns.

——— Tenders are invited for the delivery of 22,000 metres (13 miles 1,180 yards) of rails with the necessary fishplates and screws for the electric tram line about to be constructed between Christiania and Holmenkollen. Tenders to be sent in sealed envelopes, marked "Aubud," by 15th inst., to the Tramway Company's Offices, 47, Kirkevien, Christiania, where the conditions can be procured. The rails must be delivered in Christiania by Jan. 1st next.

——— Tenders are required for the supply of galvanised telephone wire (No. 8 B.W.G.) and various other stores by the Tralee and Dingle Light Railway Company. Tenders to the Secretary, Tralee, Ireland, by 6th inst.

——— The Leyton Urban District Council invites tenders for the installation of the electric light in the Public Library. Tenders must be delivered at the meeting of the Council at 7 p.m. on October 6th, at the Town Hall, Leyton.

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TENDERS INVITED.—The Directors of the Dundee Royal Lunatic Asylum invite tenders for boiler, fittings, steam pump and piping, wiring, fittings, accumulator batteries, steam and oil engines and dynamos, for the electric lighting of the Institution. Tenders required by noon Friday, Oct. 9th.

——— The Spanish Minister of Marine invites tenders for the laying of a submarine telegraph cable between the islands of Luzon, Panay, Negros, and Cebu (Philippine Islands). Provisional deposit, £2,000; definite deposit, £4,000. All particulars may be obtained from the Ministerio de Ultramar, Madrid, and tenders must be in by December 13th.

——— The Société Nationale des Chemins de Fer Vicinaux invites tenders for the electrical equipment of about 14 miles of suburban railway at Charleroi and elsewhere, on the overhead trolley system. Particulars from the Company, Rue de la Science, 26, Brussels. Tenders to be in by October 28th.

——— The French Post and Telegraph authorities invite tenders for the supply of 70 tons of galvanised iron wire, 2½mm. diameter; 50 tons ditto, 5mm. diameter; and 100 tons ditto, 7mm. diameter. Tenders to the Sous-Secretariat d'Etat des Postes et des Telegraphes, Rue de Grenelle 103, Paris, by Oct. 16.

——— The Municipal authorities of Bucharest, Roumania, require tenders for the supply and erection of two steam engines at the hydro-electric supply station at Grozaveste. Tenders to be directed to La Mairie, Bucharest, by Nov. 16.

——— The Municipal authorities of Werl in Westphalia invite tenders for the construction and working of electricity supply works for the supply of current for lighting and power purposes, including the supply of the necessary energy for the operation of an electric tramway between Werl and Wickede. Tenders to be sent to Der Magistrat, Rathhaus, Werl, Westphalia, by Nov. 3.

TENDERS ACCEPTED.—The question of the introduction of an improved system of mechanical traction on the Hull tramways has been before the Council for a considerable time. Though it is probable that electric traction will be eventually adopted no definite decision has been arrived at. Tenders were recently invited for working the tramways on lease for 12 months, and in response to this invitation the following offers have, it is stated, been received:—

| | | |
|---|---|---|
| W. Nettleton *(accepted)* ..... | £100 | per mile (single line) |
| W. S. Graff Baker..... ..... | 105 | " " |
| New General Traction Co. ..... | 105 | " " |

TENDERS RECEIVED.—The Markets and Fairs Committee of the Birmingham Corporation recommend the Council to accept the tender of Messrs. Mavor and Coulson, of Glasgow, for the supply of electric lighting plant for the meat market and slaughter houses. The amount of the tender is about £8,000.

APPOINTMENT.—Mr. Gilbert Bell, assistant engineer at the Manchester Electricity Supply Works, has been appointed resident engineer at Hammersmith. The commencing salary is £200 per annum, to be increased to £250, when the station is in working order.

APPOINTMENTS VACANT.—In our advertisement columns particulars will be found of various appointments vacant at the Northampton Institute, Clerkenwell, E.C. These include engineering workshop assistant, at £120 per annum; drawing office and mechanical laboratory assistant, at £120 per annum; carpenter and teacher of carpentry, at £2 per week; trained mechanic, 35s. per week; engine driver, 32s. per week; building construction lecturer, £60 per session; pattern maker and smith (in each case one evening per week), £15 per session. Applications, stating age and qualifications, to the Principal, R. Mullineux Walmsley, D.Sc., by 10th inst.

——— The Electric Lighting Committee of the County Borough of Huddersfield invites applications for the position of electrician-in-charge at the electric supply station, where there are two vacancies. Salary £2 per week. Applications, by Saturday, the 10th inst., to the Town Clerk (Mr. F. C. Lloyd), Town Hall, Huddersfield. Additional particulars appear in our advertisement columns.

——— A young man is required for an electric lighting installation on a country estate. Salary 30s. per week. Applications to "W.," care of J. W. Vickers, 5, Nicholas-lane, E.C.

BUSINESSES FOR DISPOSAL.—Particulars are given in our advertisement columns of an old established electrical contracting business in London for sale, and a similar business in Glasgow.

NEW ADDRESS.—Messrs. H. M. Salmony and Co., electrical engineers, and suppliers of electrical plant, apparatus, and accessories, have removed to more extensive premises at 118 and 120, Charing Cross-road, London, W.C.

PERSONAL.—Mr. A. C. Eborall, A.I.E.E., has terminated his engagement with Messrs. Brown, Boveri and Co., of Baden, in order to take up an appointment at Finsbury Technical College as demonstrator in the electrical department.

BANKRUPTCY.—Notice is given that Mr. Free Chilton, electric cycle and general engineer, 18, Adelaide-street, and Wellington-street, Luton, intends to apply for his discharge in bankruptcy at the Court House, Luton, on 22nd inst.

LIQUIDATION.—It has been decided to voluntarily wind up Thwaite, Tozer and Co. (Limited), engineers and metallurgists, and Mr. G. F. West has been appointed liquidator.

PATERSON AND COOPER (in Liquidation).—It is pointed out in a circular issued by Mr. Edward C. Moore, trustee, that this business has a large connection and considerable stock and most effective plant and machinery, and pending a sale to, or amalgamation with, some business of a similar character, Mr. Moore wishes it to be known that, by retaining the services of the staff under the direction of the late partners in the concern, he is able to carry out with the greatest proficiency any orders which may be placed with the business.

The public examination of Edward James Paterson and Charles Friend Cooper, trading as Paterson and Cooper, will take place on the 16th inst. at the Bankruptcy Court, Carey-street, London, W.C., at 11 p.m. All proofs of debt must be in the hands of the trustee (Mr. E. C. Moore, 3, Crosby-square, E.C.) in time to be lodged with the Official Receiver before the date of the examination.

"JANDUS" ARC LAMPS.—These well-known arc lamps have now been supplied to the Alhambra, and to Daly's and the Royal Court Theatres, London. The Directors of the Blackpool Winter Gardens after trial have decided to instal nearly 60 lamps. A large London printing factory has specified for 58 "Jandus" lamps, and the authorities of Cotsford Asylum and the extensive Caldercruix Paper Mills are also installing "Jandus" lamps. Messrs. Drake and Gorham, the sole agents for this lamp, have just issued a set of recent testimonials from users, which occupy ten large 4to pages, and embrace almost every description of possible users of arc lamps, including the Royal Arsenal at Woolwich, a number of large engineering firms, electric supply stations, &c.

"SVEA" INCANDESCENT LAMPS.—A new price list is now ready of these lamps, and can be obtained from Messrs. J. C. Lyell and Co., 55, Victoria-street, London, S.W.

ELECTRIC PUMPING PLANT.—The Arniston Coal Company, of Gorebridge, N.B., have placed a contract with Messrs. Ernest Scott and Mountain for the supply of an extensive electric pumping plant for their colliery. The same firm have in hand an electric pumping plant for the mines of the Clay-lane Iron Company, Saltburn-by-the-Sea, Yorks., this plant being required for the unwatering of the Company's South Skelton mines.

DYNAMO MAGNET STEEL CASTINGS.—Messrs. Edgar Allen and Co., of the Imperial Steel Works, Tinsley, Sheffield, have issued circulars giving particulars of recent testings of their patent dynamo magnet steel castings. The tests were carried out in the early part of the present year by Prof. J. A. Ewing, of Cambridge, who points out that the results generally confirm those obtained in 1894 from similar samples, and in view of recent improvements in the appliances and methods of testing the new tests are probably more accurate. The results give important evidence not only of the high permeability of this dynamo cast-steel, but of its uniformity. Taking the whole of the five samples tested the range of variation is remarkably small. A clearly-printed curve and tabulated figures dealing with the results of these tests are given in the circular, as well as illustrations of some exceptionally fine magnet steel castings, which can now be obtained in any weight up to about eight tons each.

SMALL MOTORS.—Messrs. E. H. Cadiot and Co., of Paris, forward an interesting *brochure* dealing with a large variety of small electric and other motors. This firm has for many years past been identified with this class of machinery, and the publication under review contains a mass of information in French, dealing with motors for driving domestic machines, fans, sewing machines, turn-tables, and, in fact, every purpose for which this handy type of electric motor is suitable. The illustrations, of which the book contains a large number, are very helpful to the text, and enable those seeking assistance in the selection of small motors to see at a glance what has been done to meet the demand for small units of power. Several types of small gas and petroleum motors are also dealt with, and the electric motors are for use with both continuous and alternating current.

THE "ENGINEERING MAGAZINE."—The contents of the October issue of this magazine are of the usual varied character. The articles include: "Our National Policy and the Industrial Outlook," by Cuthbert Mills; "Three Phases of American Railroad Development," (1) Fast Trains as Related to Business Policy, by H. G. Prout; "The Economy of the Modern Engine Room," by Charles Henry Davis; II. "The Problem of Engine Selection," by John S. Griggs, Jr.; "An Arraignment of American City Architecture," by E. C. Gardner; "Gas *versus* Electricity for Power Transmission," (1) The Overlooked Economies from the Use of Gas, by N. W. Perry; "Pavement Construction and City Growth," by Stevenson Towle; "Six Examples of Successful Shop Management," by Henry Roland; "The Phosphate Rock

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Deposits of Tennessee," by Lucius P. Brown; "The Water Supply of a Tropical City," by Raimundo Cabrera; and "The Possible and Impossible in Electric Development," by Wm. Baxter, Jr. The issue also contains the usual exhaustive review of the World's Press. This number, as well as all the back numbers, may be obtained at the offices of the European Edition, 1, 2 and 3, Salisbury-court, Fleet-street, London, E.C. A complete index to the main articles in the magazine from its commencement in April, 1891, to the present issue, is now ready, and will be forwarded post free on request.

CATALOGUE.—We have received a copy of the new catalogue of steam, electrical, and general engineering plant manufactured by Messrs. C. A. Parsons and Co., of Newcastle-on-Tyne. This is a well-bound, well-illustrated, and useful compilation, the information contained in which will be of great service alike to consulting engineers and contractors. This firm is chiefly known in connection with the steam turbine it manufactures, and which is extensively used in electric supply stations and private plants. Of the high efficiency, compactness, and general suitability of this turbine, as a motor for driving dynamos, we have frequently made mention in our columns; and the reports on the turbine made by Prof. Ewing and Prof. Forbes, which are given in abstract in the catalogue before us, we have also placed before our readers in previous issues. We need, therefore, only remind them that in the tests referred to in those reports an excellent steam economy and high efficiency were shown. Among the other plant manufactured by Messrs. C. A. Parsons and Co. are the following: Admiralty types of steam dynamos, and electric light plant for general purposes, alternate-current transformers, electric locomotives and traction plant, motors for elevators, fans, pumping, &c., and a variety of projectors for ships, coast defence, and harbour lighting.

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ACCIDENT.—On Friday evening last Mr. John H. Whittaker, electrical engineer, of Dudley, met with a serious accident while superintending some work in connection with the laying down of an electric lighting plant at the premises of a local firm. The sleeve of his coat was caught between the driving belt and a dynamo pulley, drawing in his arm. It was some time before the machinery could be stopped, and Mr. Whittaker narrowly escaped a painful death. He suffered a bad dislocation of the arm, and injuries to his face.

ALLEGED EMBEZZLEMENT.—At Bournemouth on Monday Edward Charles Offer was committed for trial on the charge of having embezzled £6. 1s. 8d., belonging to the Bournemouth Electric Supply Company, of which he was for several years secretary. For the defence it was urged, first, that there was no proof that the prisoner ever received the monies, and, second, that he was the victim of a robbery which happened at the offices last year, during his temporary absence, when it was alleged a large sum was stolen.

BLACKBURN.—The Gas Committee recommends the Town Council to apply to the Local Government Board for sanction to borrow £10,000 for electric traction purposes.

CHAPEL LIGHTING.—The Wesleyan Chapel at Moor Park, Preston, is being lighted throughout by electricity. About 120 lights are being installed by Mr. Barton, of Blackburn.

DOVER.—The Town Council has adopted the unanimous petition of the residents, and has decided to enter into an agreement with the Dover Electricity Company to light Biggin- and Cannon-streets by means of arc lamps at £30 per lamp per annum.

DUBLIN.—An important scheme for the amalgamation of the undertakings of the Dublin United Tramways Company and the Dublin Southern Company was recently submitted for adoption by the shareholders of the latter Company, and there is every reason to believe it will be carried through. The new Company would have a capital of £1,200,000 in 60,000 £10 Six per Cent. Preference and 60,000 £10 Ordinary shares. The Southern Company recently equipped the line from Kingstown to Hoddington-road (where it joins the Dublin United Tramway Company's system) on the overhead electric traction system, and endeavoured to obtain powers to extend their lines into the city. The Directors of the United Company subsequently decided to introduce electric traction throughout their lines, and as soon as this work has been executed the City of Dublin will have one of the most efficient tramway systems in the kingdom. The new Company propose to issue debenture stock in exchange for existing debentures of the two present companies, and will give one £10 Six per Cent. Preference Share for each share of the United Company. Ordinary shares will be issued to the syndicate who are providing the money for the purchase of the Southern District Company's lines, together with Three and a-Half per Cent. Debentures to the extent of one-third of the purchase money. Electric traction will be introduced throughout the whole of the lines, and the management will be in the hands of the present Directors of the United Company.

DUNDALK (IRELAND).—A combined electric lighting and traction scheme has just been submitted to the Town Commissioners by the Irish Tourist Development Syndicate. It is proposed that the Commissioners should obtain the necessary Orders in Council, which would be transferred to the Syndicate, all preliminary expenses being borne by the latter body. The Syndicate would bind itself to establish electricity supply works and to supply current to 18 arc and 15 incandescent lamps for public lighting at £650 per annum. The proposed tramway system would run through the principal streets of the town and on to Blackrock, a popular tourist resort. The Commissioners, it will be remembered, went to the trouble of obtaining an Electric Lighting Licence in 1885, but no serious attempt was made to comply with its provisions.

DUNDEE.—The borough electrical engineer has presented a report to the Gas Committee on the question of the extension of electricity supply. Mr. Tittensor's scheme provides for the erection of about 60 arc lamps in the central streets of the city, including Reform-street, Nethergate (as far as South Tay-street), South Tay-street, Overgate, Murraygate, Cowgate and Commercial, Dock and Union-streets. The question of extending the present electric lighting area is also under consideration.

EDINBURGH.—The fixing of the municipal assessments for the current year was the principal item before the Town Council on Tuesday. Mr. Treasurer M'Crae, in the course of his remarks, said that as the Council had not as yet given a decision as to disposal of the surplus on the electric light account, the City Chamberlain had to take that surplus into consideration for the purpose of estimating. That surplus and the surplus estimated for the current year gave a seeming advantage of £7,000 odd. Although this £7,000 was seemingly a credit they were taking advantage of, on the other hand they were to receive a sum of £5,900 from the Electric Lighting Committee, which was the amount of the several sums paid from the rates on account of the electric light undertaking before it reached a revenue-producing stage. So that if they took this sum of £5,900 and the surplus of £1,596, they were able to pay their way, although the Council should not vote any further sum from the electric lighting account to the rates. The extra cost of the public electric lighting for the present year would, therefore, be counterbalanced by the sum to be refunded by the Electric Lighting Committee. It was also stated that the Council proposed to issue fresh stock to the amount of £650,000, of which £100,000 would be employed for electric lighting purposes.

EXHIBITION AND MARKET.—We have received an advance prospectus of an exhibition which is to be held in August, 1897, at the Royal Agricultural Hall, Islington, London, N. The title may be described as fairly comprehensive, as the trades to be catered for represent the hardware, machinery, ironmongery, inventions, electrical and allied trades. The Agricultural Hall is an extensive building; but if the trades enumerated take kindly to the proposed show, two or three Agricultural Halls will have to be chartered to provide accommodation. The exhibition will, however, be organised by those who appear competent to deal with this class of enterprise, as the same Board of Directors and guarantors and other officials propose to organise exhibitions in the same building for paper makers, printers and stationers, brewers, maltsters, distillers, and the grocery and provision and allied trades during 1897. A grocery, provision, oil and Italian warehouse and allied trades exhibition and market is, in fact, being held at the Agricultural Hall at the present time, and will be open all next week. Those who are likely to take part in the Electrical Show in 1897 will, therefore, be able to judge for themselves the competency of the organisers of the present exhibition for dealing with this class of undertaking.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from September 23rd to September 29th, with the ports of destination:—

*Argentina*—Buenos Ayres, £1,424 (including £188 telegraph material). *Australasia*—Launceston, £870; Otago, £17; Sydney, £495; Wellington, £4,429 (including £4,300 submarine cable). *Belgium*—Antwerp, £21; Brussels, £602. *Channel Islands*—Jersey and Guernsey, £18 (telegraph material). *China*—Shanghai, £37 (telephone stores). *Denmark*—Copenhagen, £58 (telegraph wire). *Egypt*—Alexandria £454 (including £140 telephone stores and £264 telegraph wire). *Holland*—Amsterdam, £111; Flushing, £9; Rotterdam, £55. *India*—Bombay, £493 (including £38 telephone stores); Calcutta, £247; Madras, £204; Rangoon, £10. *Italy*—Leghorn, £100. *Japan*—Yokohama, £460. *Malta*—£23 (telegraph material). *Perim*—£102 (telegraph apparatus). *Peru*—Mollendo, £14. *Portugal*—Lisbon, £11 (telegraph material). *Russia*—Marioupol, £2,147; St. Petersburg, £252. *Siam*—Bangkok, £300. *South Africa*—Cape Town, £4,858 (including £4,550 telegraph material); Delagoa Bay, £15; Durban, £155; East London, £1,305 (including £45 telegraph material); Port Elizabeth, £461. *Straits Settlements*—Singapore, £73 (including £19 telephone stores). *Sweden*—Gothenburg £192 (telegraph wire); Stockholm, £155 (telegraph material); *West Indies*—Antigua, £10; Jamaica, £47 (telegraph material); Trinidad, £8. Total, £20,222.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods to the value of £16 have been re-exported to Madeira.

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EXETER.—The City Council has offered to supply electric current for lighting the Exeter Post Office on the same terms as those recently offered to the Devon and Exeter Hospital. The city surveyor is preparing a report on the question of the supply of current for motive power purposes, the price to be charged, &c.

FLEETWOOD.—The District Council notifies that, subject to the consent of the Board of Trade, it proposes to transfer the Fleetwood Provisional Order to the Fleetwood and District Electric Light and Power Syndicate (Limited), of London. The Council reserves the right of purchase at the end of 21 or 32 years, and the Syndicate has agreed to pay £600 to the Council for expenses actually incurred.

FULHAM (LONDON).—A letter has been received by the Vestry from the County of London and Brush Provincial Company offering to extend the electric light mains across Putney Bridge into the Fulham district. The Company intends to apply for a Provisional Order, and the Vestry will have the option of purchasing the distributing mains, &c., at the end of a term of years, and of putting down independent generating plant. The letter has been referred to the Electric Light Committee for consideration and report.

HAMPSTEAD (LONDON).—At the last meeting of the Vestry the resignation of the assistant engineer (Mr. O. Hansom) was received and accepted. At present the electricity department has 450 applications for current on its books, and of these 417, representing an equivalent of 31,602 8 c.p. lamps, have been connected up, compared with 385 applications and 355 connections (representing 25,292 8 c.p. lamps) on June 25th last. A Sub-Committee has been appointed to consider and report upon the question of lighting High-road, Kilburn, by means of arc lamps.

HANLEY.—Owing to the increased demand for electric current the Town Council has placed an order with S. Z. de Ferranti (Limited) for a second engine for the electricity works, at £3,300; and an application is to be made to the Local Government Board for further borrowing powers to meet the expenditure involved. The undertaking is at present paying its way, and there is some talk of reducing the price of current in order to still further stimulate the demand.

HULL.—At the last meeting of the Electric Lighting Committee Mr. Robert Hammond was appointed consulting engineer at a remuneration of 50gs., for the purpose of preparing a report upon the electric light extension scheme recently proposed by the Sub-Committee.

KING'S NORTON.—The District Council has sanctioned the scheme of the Canadian Syndicate for the acquisition of the tramways within the jurisdiction of the Council. The right of approving from time to time of the motive power to be adopted has, however, been reserved by the Council.

LEICESTER.—The accounts of the electricity department for the half-year ended June 30th last show a deficiency of £723. 0s. 5d., after taking into consideration the sinking fund instalment (£584) and the profit (£151. 14s. 6d.) on the Council's electric light fitting business. The deficiency to December last amounted to £1,337. 17s. 8d., making a total of £2,060. 18s. 1d. to date. In moving the adoption of the accounts the Chairman of the Gas Committee (Alderman Lennard) said they had spent £2,176. 19s. during the past half-year, and they had still an unspent balance of £6,861. 14s. The revenue from the sale of current had risen from £671 to £1,467. 12s. 6d., and the total revenue amounted to £1,670, against £963. Owing to wages and other items the expenditure had gone up to £1,254. 14s. 8d. from £863, so that there was a gross profit of £415. 11s. 8d. on the half-year's working. The department had made very satisfactory progress, as their customers had more than doubled during the period under review; and Alderman Lennard felt certain that next year they would make a handsome profit. After some discussion the accounts were approved; and, on the recommendation of the Committee, it was agreed to reduce the price of current from 6d. to 5d. per unit as from January 1st next.

LIVERPOOL.—The Lighting Committee has decided to illuminate London-road and Lime-street, from Monument-place to the Adelphi Hotel, by 20 arc lamps.——The City Electrical Engineer is preparing a report upon the advisability of the electric lighting of the Municipal Artisans' Dwellings.

MAIDSTONE.—Mr. W. C. C. Hawtayne has submitted a scheme to the Town Council for the establishment of electricity supply works in this town. The Council obtained a Provisional Order in 1892, but no steps have yet been taken to put its provisions into force. Mr. T. King has now notified that he proposes to place electric lighting cables across certain streets unless the Council decide to at once comply with the provisions of its Order. The Municipal Electric Light and Power Corporation has also asked the Council for consent to its application for a Provisional Order. The latter application is to be opposed.

MIDDLESBOROUGH.—The Imperial Tramway Company has submitted a project for the extension and improvement of the local tramway service for the approval of the Town Council. The scheme provides for the introduction of electric traction on the entire system. The matter was considered by the Streets Committee on Friday last, and it was decided to ask the Company to submit plans and details of the proposed scheme for the guidance of the Committee.

MOSS SIDE (MANCHESTER).—The District Council has resolved to apply for a Provisional Order. Letters had been received from the South Manchester Electric Light Company, and the Altrincham Electric Supply, for consent to their proposed applications for orders, but both have been declined.

PARCEL POST TO JAPAN.—The postal authorities have arranged for a largely extended parcel post to Japan, *viâ* Canada. The extension came into effect on the 1st inst. All the principal towns of the Mikado's country are included in the list. Parcels weighing up to 3lb. will cost 1s. 10d.; over 3lb. and up to 7lb., 3s. 6d.; over 7lb. and up to 11lb., 5s. 2d. The parcel post mails for Japan will be despatched for the first time on Oct. 22nd, and should be posted to reach Liverpool by the night mail of the previous day. The customary declaration and despatch note has to be filled in.

PLYMOUTH.—Colonel Luard, R.E., will hold a Local Government Board inquiry on Tuesday into the application of the Town Council to borrow £46,000 for the purpose of establishing electricity supply works.

PRESTWICH.—The contract for the renewal of the telephonic, electric signalling, and fire alarm service at the County Asylum has been let to Mr. Thomas Barton, of Blackburn. The maintenance of the whole system for seven years has been entrusted to the firm.

RESTAURANT LIGHTING.—The new Trocadero Restaurant at Piccadilly-circus, London, was opened last evening. The building is the old Trocadero Music Hall, which stands on the site of the old Argyll Rooms. An extensive installation of the electric light has been carried out by Messrs. Strode and Co., the wiring being effected on the new conduit system. The Trocadero is one of the largest buildings in London fitted up on this system. The arc-lamp brackets and columns and other electric light fittings used in the installation have been designed by Messrs. Strode and Co., who have also furnished the extensive range of steam supply pipes, steam urns, &c., required in the everyday work of the restaurant.

SOUTHAMPTON.—The Town Council proposes to introduce the electric light into the Council Chamber and Municipal Offices, the Guildhall and Magistrates' Court. It is also proposed to employ an electrically-driven fan for ventilating the Council Chamber. The Council has taken over the staff as well as the undertaking of the Southampton Electric Light and Power Company.

WEST HAM.—The borough electrical engineer (Mr. J. J. Steinitz) has presented his report on the proposed electric lighting scheme. The Town Council is recommended to start by putting down plant capable of supplying current to about 25,000 8 c.p. lamps, and to illuminate the principal thoroughfares in the district by means of 88 arcs. The Council has formally approved the scheme, and application has been made to the Local Government Board for sanction to borrow £50,000 for the purpose of carrying it out.

## PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

### APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

September 2, 1896.

19,396. J. W. LAWRENCE. London. A new or improved combined electric lamp and walking stick.

19,399. W. S. RAWSON. London. Improvements connected with the electrical coating of tubes, rods, and the like, and apparatus therefor.

19,415. F. C. ESMOND. London. Improvements in or connected with electric railways.

September 3, 1896.

19,455. S. P. THOMPSON and M. W. MORLAND. London. Improvements in automatic switches and safeguards for electric-traction systems.

19,456. S. P. THOMPSON and M. W. MORLAND. London. An electric-traction system.*

19,469. E. J. MACREADY. Higher Tranmere. A means of surrounding electric or other lights with a vessel or lining of glass or other materials containing liquids.

19,501. B. M. DRAKE and J. M. GORHAM. London. Improvements in electric light conduits.

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19,505. H. MAXIM. London. Improved method and apparatus for electro-thermally treating materials.

19,507. H. C. MADSEN. London. Improvements in electrical arc lamps.*

19,523. S. A. NASH. London. Improvements in dynamo-electric machines and electric motors.

September 4, 1896.

19,553. E M. D. ANDRÉ. London. Improvements in printing telegraph instruments.

19,583. J. A. COLEMAN. London. Automatic-closing telegraphic key.

September 5, 1896.

19,638. J. C. PARSONS. Leicester. Improvements in electrical indicators.

19,639. A. LEGÉ. London. An improved mode of electrical gas lighting.

19,650. T. BLANKINSOP and J. W. BROWN. London. Improvements in insulators.

19,660. W. D. WATSON. Manchester. Improvements in or relating to apparatus for supplying a certain definite amount of electric current (for lighting or other purposes) on prepayment.

19,664. SOWERBY'S ELLISON GLASS WORKS, LIMITED. Barnsley. Improvements in glass globes or shades for electric, gas, or other lights.

19,693. W. C. BERSEY, E. F. MOY, AND E. F. MOY, LIMITED. London. An improved electric switch for certain useful purposes.

September 7, 1896.

19,729. C. H. GADSBY. Loughborough. Improvements in electric traction

19,757. W. R. LAKE. London. Improvements relating to the connections of constant-current dynamos to electric lamp circuits. (C. N. Black, United States.)*

19,767. R. BELFIELD. London. Improved method of and means for controlling electric motors. (The Westinghouse Electric and Manufacturing Company, United States.)

September 8, 1896.

19,783. H. NUNNS. Halifax. Improvements in electric arc lamps.

19,818. J. E. MEEK and H. W. JOHNS MANUFACTURING COMPANY. London. Improvements in electric heaters.

19,821. F. J. WARDEN-STEVENS. London. Improvements in and relating to reflectors for electric arc incandescent and other kinds of lamps.

19,822. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED). London. Improvements in automatic circuit breakers. (E. M. Hewlett, United States.)*

19,870. S. A. NASH. London. Improvements in dynamo electric machines and electric motors.

19,871. A. B. BLACKBURN and W. L. SPENCE. London. Improvements in or connected with electric automatic regulating or controlling apparatus.

19,877. D. G. FITZGERALD. London. Improvements in connecting the plates or elements of voltaic cells and batteries.

September 9, 1896.

19,894. F. L. WILDER. Reading. An improved method of manufacturing permanent magnets.

19,903. F. G. THOMAS. Liverpool. Improvements in reflectors for incandescent electric lamps.

19,911. J. THOMPSON. Cardiff. An apparatus for determining or ascertaining the velocity of air currents in coal mines and other situations and for other purposes by novel electrical and other means.

September 10, 1896.

20,035 D. MATHIEU. London. Improvements in electrical batteries.

20,051. J. A. SINCLAIR. London. Improvements in the manufacture of filaments for electric lamps.

20,062. J. A. SINCLAIR. London. Improvements in the manufacture of filaments for electric lamps.

20,077. T. F. BOLAND, C. J. HUBBELL, and H. C. HUBBELL. London. Improvements in and relating to primary batteries.*

20,079. E. B. WRIGHT. London. Means for enabling the current from an alternating dynamo to be utilised for charging secondary voltaic batteries and for other purposes.

20,086. C. OPPERMANN. London. A new or improved armature for dynamo electric machines.*

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

18,725. NISBETT. Electric cables.

18,726. DEARLOVE and NISBETT. Electric cables.

19,027. WISE (Barstow). Electric metering apparatus.

19,402. HEYS (Kapp). Return circuits for electric railways.

19,442. HIRSCH. Electric welding.

19,605. VAUGHAN-SHERRIN. Dynamos and electric motors.

20,237. THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY, LTD. AND PROCTOR. Electric safety fuses.

21,543. ABEL (La Société Anonyme pour la transmission de la force par l'Electricité). Transforming continuous into alternating currents.

24,472. FYNN AND EASTON, ANDERSON AND GOOLDEN (LIMITED). Dynamo electric machines.

# COMPANIES' MEETINGS AND REPORTS.

## Brush Electrical Engineering Company (Limited).

The seventh annual report of the Directors of this Company will be presented to the shareholders at the general meeting at Cannon-street Hotel, E.C., on Monday next, at noon. The profit and loss account shows a gross profit of £33,736. 6s. 11d. After deducting general charges, maintenance of buildings, plant, and patents, staff bonuses under the Company's profit-sharing scheme, bank and debenture interest, there is a net balance of profit for the year of £4,615. 9s. 8d. The Directors attribute this poor result partly to a general falling off in the volume of electricity supply station contracts, and partly to the prevalence of unduly low prices for electrical machinery; but they anticipate that the future demand for electric traction plant will fully compensate for the shrinkage of orders for electric lighting machinery. Meanwhile every effort has been made to minimise general and administrative charges, as will be seen by the substantial reduction of nearly £4,000 which has been effected during the year. The Directors anticipate still further reductions.

During the past year the Directors have accepted an offer from one of the large Continental manufacturing firms for the purchase of the Vienna factory, and the amount realised fully reimburses the Company for its capital outlay on the business.

In deference to the wish expressed by shareholders at recent meetings, and in view of the disposal during the year of the Company's Vienna factory, the Directors consider the present a convenient opportunity for sub-dividing the capital item of property, patents, and goodwill, which has hitherto appeared as a single item in the balance-sheets. With this object they have obtained a full report from Messrs. Fuller, Horsey, Sons, and Cassell, whose valuation of the Company's freehold works, together with the fixed plant, machinery, loose tools and utensils, at Loughborough, Leicestershire, amounts to £83,847, and of the leasehold factories at Lambeth and Southwark to £5,000, together £88,847. Deducting this sum from the amount of £295,244. 8s. 9d., representing the aggregate value of the undivided items of property, patents and goodwill, a balance of £206,397. 8s. 9d. is represented by patents and goodwill. The Directors state that, while many valuable patents owned by the Company are still included in the item of patents, the early patents in connection with electric lighting, for which large sums were originally paid by the Company, have now mostly expired. In order to deal effectively with the position thus arising, the Directors recommend the shareholders to write off £1 per share from the nominal value of the Ordinary shares of the Company. This will produce £90,000, which it is proposed to apply during the current year to reduction of the item of patents and goodwill, and to eliminating from the books such of the items included in the suspense account appearing in the balance sheet as may prove to be valueless. The Directors have placed to this suspense account all assets standing in the books of the Company which they consider to be in any way doubtful; and the step now recommended, upon receiving the sanction of the shareholders, will ensure that profits of future years shall not be hampered by the uncertainty attaching to the doubtful assets referred to. A resolution to carry out this recommendation will be submitted to an extraordinary general meeting, to be held at the close of the ordinary meeting on Monday next.

Subject to the above recommendation being adopted by the shareholders, the Directors propose to pay to the Preference shareholders the balance of dividend due to them from last year, amounting to £2,141. 3s. 8d., and to carry forward the balance of £1,653. 18s. 8d., which remains after clearing off the debit of £820. 7s. 4d. brought forward from last year.

In accordance with the shareholders' approval at the last annual general meeting of the decision to create an issue of £105,000 Four and a-Half per Cent. Redeemable Second Debenture Stock, £76,770 of such stock was allotted in the autumn of last year.

During the year the Company have subleased the Lambeth factory for the remainder of their term, and have transferred the final remnant of their London manufacturing operations to Loughborough, where the whole of the Company's manufacturing is now concentrated. An important contract has been secured from the British Electric Traction Company for the equipment of the North Staffordshire tramways system with electric traction, and the contracts with the County of London and Brush Provincial Company for the equipment of electricity supply stations in St. Luke's, Middlesex, and the Wandsworth district have been in progress during the year, and it is expected that a supply of current will be available in both areas during the coming winter. The contract with the Government of Malta for the establishment of an electricity supply station for the lighting of Valetta and of the Government establishments is now practically completed.

During the year the "Universal" steam engine, to which the attention of shareholders was drawn last year, has been developed, tested and placed upon the market. Orders are in course of execution for central electricity supply stations, factories, mining works, &c. The Company are introducing a type of alternating-current dynamo, new to this country, for which they hold important patent rights.

Mr. J. B. Braithwaite, jun., and Mr. B. H. van Tromp are the retiring Directors, and offer themselves for re-election, as do the auditors, Messrs. Cooper Brothers and Co.

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The following is the special resolution to be presented to the extraordinary general meeting:—

*"That the capital of the Company be reduced from £750,000 divided into 150,000 Preference shares of £2 each (of which 90,000 have been issued), and 150,000 Ordinary shares of £3 each (of which 90,000 have been issued), to £660,000 divided into 150,000 Preference shares of £2 each, and 180,000 Ordinary shares of £2 each, and that such reduction and alteration be effected by cancelling paid-up capital to the extent of £1 per share on each of the*

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*90,000 Ordinary shares which have been issued, and by reducing the nominal amount of the said 90,000 Ordinary shares from £3 to £2 each, and by subdividing the 60,000 Ordinary shares of £3 each, now remaining unissued, into 90,000 Ordinary shares of £2 each."*

## Willans and Robinson (Limited).

The fifth half-yearly report of the Directors of this Company to June 26th last, to be submitted at the meeting of shareholders, to be held at Cannon-street Hotel, London, E.C., at 3 p.m., on Wednesday next, states that, after writing off as depreciation from plant, patents, &c., £4,039. 14s. 7d., and paying a small amount of interest accrued upon the recently-issued debenture stock, the balance to the credit of profit and loss for the half-year (including £821. 5s. 3d. brought forward) is £12,876. 12s. 4d., out of which it is proposed that full dividends be paid on the Six per Cent. Preference shares, and 7 per cent. per annum, as before, upon the Ordinary shares, together amounting to £7,312. 10s. The amount payable to the Directors is £1,422. 17s., and £2,500 is to be added to the reserve fund, raising the amount to £10,146. 9s. 11d. as the result of two and a-half years' working. The balance, £1,641. 5s. 4d., it is proposed to carry forward. The debenture stock authorised to be created in May, at par (the rate of interest being 4½ per cent. per annum), was largely over-subscribed. The Directors were advised to fix the issue at £100,000, rather than at the smaller amount ; and the growth of the business in the present year leaves no doubt that the larger amount can be utilised with advantage. The expenses connected with the issue amounted to £1,151. 8s. 2d., which sum appears on the present occasion as a credit in the balance-sheet. As the debenture stock is repayable after a term of years, it would be proper to write off the expenses by a small half-yearly charge extending over the same term, but it will probably be felt that so small a sum ought to be dealt with immediately by writing it off at once out of the balance to be carried forward in the profit and loss account. To this it may be objected that the balance in question is surplus profit, and, therefore, has already contributed to the contingent salaries of the Directors and staff ; whereas, strictly, the cost of the debenture issue is in the nature of an expense, which should reduce the surplus profits, and, therefore, the contingent salaries. If, on the other hand, the amount is written off at once, and the contingent salaries are reduced in proportion, it will fall somewhat hardly upon the present holders of office, who will bear a charge which ought partly to fall upon their successors. It is not urgent that the question be settled upon the present occasion ; and, as the Directors' own interests are involved, they trust to receive some expression of opinion on the part of the shareholders, as a basis for action to be taken next half-year.

The works of the Company continue to be very fully employed ; in fact, orders are in hand for a long period in advance. Work will shortly be commenced in the new shops at Rugby.

## NEW COMPANIES, STATUTORY RETURNS, &c.

**HORSFALL ENGINEERING SYNDICATE (LIMITED).**—This Company was registered on Sept. 25th, with a capital of £50,000, in £5 shares, to carry on the business of makers or builders of furnaces for the destruction of town or other refuse, to construct, maintain, and work any machinery, or plant for the generation of electricity to be used for lighting or other purposes, to undertake the supply of electricity to public bodies or private consumers, and to carry on the business of mechanical engineers, boiler makers, metal workers, &c. The first subscribers, with one share each, are :—T. Dalton, A. P. James, and G. Watson, G. H. Denison, C. W. James, Arthur Greenwood, and R. Watson, civil engineers. The first Directors are Messrs. A. P. James, Arthur Greenwood, G. H. Denison, C. W. James, and G. Watson.

**NEW MUTUAL TELEPHONE SYNDICATE (LIMITED).**—This Company was registered on Sept. 24th, with a membership of 20, each of whom is liable for £100 in the event of winding up, to acquire, work and dispose of any concessions, to carry on the business of a telephone company, to establish, work, manage, control and regulate telephone exchanges, to transmit and facilitate the transmission of telephonic communications, and to carry on and undertake any business undertaking, transaction and operation commonly carried on or undertaken by bankers, capitalists, promoters, financiers, concessionaires, contractors for public and other works, and merchants. The subscribers are :—George C. Haworth, Samuel W. Royse, William G. Shaw, John F. Newall, John Thomson, and J. Pilkington Young, all described as merchants of Manchester; and William Thomson, chemist, Manchester. The first Directors are :—George C. Haworth, Nathaniel Bradley, T. T. T. Shann, Samuel W. Royse, William Thomson (managing), Andrew McNair and John F. Newall.

**NEW AND MAYNE (LIMITED).**—This Company was registered on Sept. 25th, with a capital of £150,000, in £1 shares, to acquire the business carried on by Messrs. Anthony C. New and Arthur J. Mayne, in co-partnership, under the style of "New and Mayne," at Palace Chambers, 10, Bridge-street, Westminster, S.W., Woking, and other places, and to carry on the business of general and electrical engineers and contractors, electricians, and manufacturers, sellers and dealers of and in electricity, motive power, electrical apparatus, and appliances of all kinds. The subscribers, with one share each, are :—J. L. Higgs, A. W. Well, F. H. Golborne, A. P. Sprange, W. E. Wildmore, T. O. Dear, E. Mann (electrical engineer), and J. A. Lloyd. The first Directors are Messrs. Anthony G. New and Martin D. Rucker.

**AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).**—The annual return of this Company, made up to June 24th, has been filed. The nominal capital is £300,000, in shares of £10 each. 23,600 shares have been subscribed for, and the full amount called and paid.

**BROWETT, LINDLEY, AND COMPANY (LIMITED).**—The annual return of this Company to May 11th has just been filed. The nominal capital is £20,000, divided into 1,600 Ordinary and 400 Preference shares of £10 each. 1,562 of the former and 200 of the latter have been taken up, and 800 have been issued as fully paid. The full amount has been called on the remainder, resulting in the payment of £9,620.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 3 per cent. (Sept. 24, 1896). Price of silver, 30 5/16d. per oz. (Oct. 1st). Consols (2¾ per cent.) 110—110¼ for money, 110⅜—110⅜ for account; 2½ per cent. 105—106 (Oct. 1st). Stock Exchange Settling Days: Consols, Nov. 5th ; Stocks and Shares Continuation Day, Oct. 13th ; Ticket Day, Oct. 14th ; Pay Day, Oct. 15th ; Mining Share Carry-over Day, Oct. 12th.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended September 27th were £925, against £823 in the corresponding week of 1895, an increase of £102. The total receipts for the half-year amount to £11,813, against £10,971 for the corresponding period of 1895, an increase of £842.

**COMMERCIAL GAS COMPANY.**—The Chairman, at the meeting of shareholders yesterday, congratulated the Company on the fact that in their district (East London) there was little or no electricity in competition with the gas undertaking. Notwithstanding this, however, the Directors were not able to report any increase over last year's receipts.

**EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company have declared an interim dividend for the quarter ended June 30th of 2s. 6d. per share (free of income tax), payable on 15th inst. The share register will be closed from the 7th to 14th inst., inclusive.

**EDISON ELECTRIC COMPANY OF CHICAGO.**—This Company is stated to have completed the sale, to a powerful London group of financiers, of $1,200,000 new Five per Cent. Bonds. The *Economist* of Chicago speaks of the transaction as a remarkable achievement, considering the present state of business in the States. It attributes the success of the negotiations to the thoroughness of the preliminary investigations by the purchasers, which, it says, "has been of the most rigid character, and has not alone extended to the legal status of the securities offered and to the earning capacity of the property." The bonds are 5 per cent. mortgage gold bonds, payable in 1926. The proceeds of the loan are to be expended on improvements on the Company's property in Chicago, on which over $7,500,000 has already been expended.

**EVERED AND COMPANY (LIMITED).**—The Directors of this Company have declared an interim dividend for the half-year ended June 30th at the rate of 7½ per cent. per annum on the shares numbered 1—6,744 and L1—9,752.

**HOVE ELECTRIC LIGHTING COMPANY (LIMITED).**—The Directors of this Company have declared an interim dividend for the half-year to June 30th at the rate of 4 per cent. per annum.

**ISLE OF MAN TRAMWAYS AND ELECTRIC POWER COMPANY (LIMITED).** The Directors of this Company recommend an interim dividend for the past six months at the rate of 7½ per cent. per annum.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended Sept. 27th amounted to £1,168. The amount for the corresponding week last year was £1,266. Decrease, £98.

**METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).**—The Directors of this Company have declared an interim dividend of 4s. per share for the half-year ended June 30th last. The transfer registers of this Company will be closed from 3rd to 10th inst., inclusive, preparatory to the payment of an interim dividend.

**REUTER'S TELEGRAM COMPANY (LIMITED).**—The Directors of this Company have declared an interim dividend at the rate of 5 per cent. per annum, free of income-tax, for the half-year to June 30th last, payable on the 7th inst.

**SIEMENS AND HALSKE.**—A rumour is reported from the Berlin Stock Exchange that the well-known firm of Siemens and Halske is shortly to be converted into a limited company. We have been unable to obtain any confirmation of this rumour.

**STOCK EXCHANGE NOTICE.**—The Stock Exchange Committee has appointed Wednesday, the 7th inst., a special settling day for 12,500 Ordinary shares (Nos. 50,001 to 62,500) of the Metropolitan Electric Supply Company (Limited), and has ordered the same to be quoted in the Official List. Application has also been made to the Committee to appoint a special settling day in, and to grant a quotation to, £90,000 Four and a-Quarter per Cent. First Mortgage Debenture stock of the Aluminium Company (Limited), in lieu of the Six per Cent. Debentures now quoted, and 10,000 Four and a-Half per Cent. Preference shares of the Charing Cross and Strand Electricity Supply Corporation (Limited).

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the weeks ended September 4th, 11th and 18th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,589, £1,588 and £1,810 respectively.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price September 23. | | Price Wednesday, September 30. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Sept. 26. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 50 | 53 | 49 | 52 | 4 16 2 | Jan., Apr., July, Oct. | .. | .. |
| £1,993,560 | Stock | 24/0 | Do. Preferred | 95½ | 96½ | 95 | 96 | 5 4 2 | " " | 96¼ | 93 |
| £1,993,560 | Stock | 5/0 | Do. Deferred | 8¾ | 9¼ | 8¾ | 9¼ | .. | .. | .. | .. |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 | 104 | 100 | 104 | 3 17 6 | January and July .. | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ | 9½ | 8½ | 9½ | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 15 | 15½ | 14¾ | 15¼ | 4 11 10 | Mar., June, Oct., Dec. | 15⅝ | 15 |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 | 116 | 112 | 116 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | — | | 145 | 150 | 4 13 4 | Jan., Apr., July, Oct. | — | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12½ | 13½ | 12 | 13 | 6 3 1 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20½ | 21½ | 20½ | 21½ | 4 13 0 | " " | — | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ | 4½ | 3½ | 4½ | 4 8 11 | April and October .. | — | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 | 10½ | 10 | 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% | 110% | 107% | 110% | 4 2 7 | .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ | 9¾ | 9½ | 10 | 4 10 0 | Jan., Apr., July, Oct. | .. | .. |
| 400,000 | 10 | 5/6 | Eastern | 18 | 18½ | 17¾ | 18¼ | 3 11 3 | " " | 18¼ | 17⅞ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ | 19½ | 18½ | 19½ | 3 0 0 | " " | 18¾ | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 | 134 | 130 | 133 | 3 0 11 | May and November | .. | .. |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 | 107 | 104 | 107 | 4 13 11 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 18 | 18½ | 17¾ | 18¼ | 3 16 9 | Jan., Apr., July, Oct. | 18 5/16 | 17⅞ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 | 133 | 130 | 133 | 3 0 5 | February & August | 131½ | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 100 | 104 | 100 | 104 | 4 17 1 | January and July .. | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb., 1900 | 101 | 105 | 101 | 105 | 4 16 2 | " " | 101½ | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 | 109 | 106 | 109 | 3 13 9 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% | 114% | 111% | 114% | 3 10 11 | May and November | .. | .. |
| 180,227 | 10 | 3/9 | Globe Telegraph and Trust | 10¾ | 11¼ | 10¾ | 11¼ | 3 13 7 | Jan., Apr., July, Oct. | 11 5/16 | 11¼ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 17¾ | 18¼ | 17¾ | 18¼ | 3 5 9 | " " | 18½ | 17¾ |
| 150,000 | 10 | 5/0 | Great Northern | 24 | 25 | 23½ | 24½ | 4 1 8 | Jan., April, and July | 25 | 24½ |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 | 107 | 104 | 107 | 4 13 8 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 53 | 56 | 51 | 54 | 4 12 1 | May and November | .. | .. |
| 37,548 | 10 | .. | London Platino-Brazilian | .. | | .. | | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 | 112 | 109 | 112 | 5 7 5 | March & September | — | — |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 | 111 | 108 | 111 | 3 12 7 | — | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 7 | 8 | 7 | 8 | 5 0 0 | April and October | .. | .. |
| 3,331 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 138 | 143 | 138 | 143 | 4 3 11 | " " | .. | .. |
| 15,600 | 10 | 6/0 | West African Telegraph | 5 | 6 | 5 | 6 | 5 0 0 | January and July | .. | .. |
| £233,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 | 105 | 102 | 105 | 4 15 6 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | ½ | 1½ | ½ | 1½ | .. | January and July .. | ¾ | .. |
| £150,000 | 100 | 8% | * Do. 8 per Cent. Debentures, 1902 | 99 | 101 | 99 | 101 | 7 16 1 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1⅜ | 1⅝ | 1¼ | 1½ | .. | .. | 1 7/16 | 1⅜ |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11 13/16 | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ | 10½ | 9½ | 10½ | 5 14 3 | " " | 9⅜ | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 | 111 | 108 | 111 | 4 10 11 | June and December | .. | — |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8¾ | 9¼ | 8½ | 9 | 5 0 0 | May and November | 9 1/16 | 8¾ |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6½ | 7 | 5 1 0 | — | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2¼ | 2¾ | 2¼ | 2¾ | .. | — | .. | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 107 | 103 | 107 | 5 12 8 | February & August | 106 | 106 |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 | 107 | 103 | 107 | 5 12 8 | " " | — | — |
| $1,177,000 | $1,000 | 7% | *Western Union 7% 1st Mort. (Building) Bonds | 110 | 115 | 110 | 115 | 6 4 2 | May and November | — | — |
| £164,300 | £100 | 6% | * Do. 6 per Cent. Sterling Bonds (red.) | 100 | 105 | 100 | 105 | 5 14 6 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | | | |
| 44,000 | 5 | 4/0 | Chili Telephone (fully paid) | 3¼ | 3¾ | 3¼ | 3¾ | 5 6 8 | — | — | — |
| 221,850 | 10/0 | 1¼d. | Consolidated Telephone Const. & Manufacturing | 1/16 | 3/16 | 1/16 | 3/16 | .. | .. | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ¾ | ⅞ | ¾ | ⅞ | 5 14 3 | Yearly | .. | .. |
| 484,597 | 5 | 2/6 | National | 7½ | 7¾ | 7⅝ | 7⅞ | 3 17 2 | June and December | 7¾ | 7½ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 17 | 19 | 17 | 19 | 3 3 2 | " " | .. | — |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 | 19 | 17 | 19 | 3 8 7 | " " | .. | — |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 6⅞ | 7⅛ | 6⅞ | 7⅛ | 3 17 2 | — | .. | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 107 | 110 | 107 | 110 | 3 4 1 | January and July .. | 107½ | .. |
| 58,000 | 5 | 4/0 | United River Plate | 3½ | 4 | 3½ | 4 | 5 0 0 | July | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 101 | 103 | 101 | 103 | 4 15 3 | January and July .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| .. | 5 | .. | Birmingham Electric Supply (fully paid) | 9 | | 8¾ | | .. | .. | .. | .. |
| .. | 5 | .. | Do. (£4 paid) | 6 | | 6¼ | | .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 16 | 17 | 16 | 17 | 2 18 10 | February & August | .. | .. |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17½ | 18½ | 17½ | 18½ | 3 4 10 | January and July ... | 18½ | 18¼ |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 131 | 135 | 131 | 135 | 3 14 9 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | — | | .. | | .. | — | .. | — |
| £30,000 | £5 | 2/6 | Charing Cross & Strand Electricity Supply Corp. | 9½ | 10 | 9½ | 10 | 2 15 0 | — | 9¼ | 9 11/16 |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — | | — | | .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 | 9 | 8 | 9 | .. | .. | 8⅞ | .. |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 13¾ | 14¼ | 13¾ | 14¼ | 4 4 3 | — | .. | .. |
| 8,322 | £5 | — | House-to-House Electric | .. | | — | | .. | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — | | — | | .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | — | | .. | | .. | January and July .. | — | — |
| 111,000 | 5 | .. | London Electric Supply | 1 | 1¼ | 1 | 1¼ | .. | — | .. | .. |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 12½ | 13½ | 12½ | 13½ | 2 19 3 | — | 13¾ | 13 |
| £1[illegible] | Stock | 4½% | * Do. 4½% Debs. | 120 | 123 | 120 | 123 | 3 13 9 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 11½ | 12½ | 11¼ | 12¼ | .. | — | — | .. |
| .. | .. | .. | Rand Electric | 1½ | 1¾ | 1 7/16 | 1 9/16 | .. | — | .. | — |
| 14,980 | £5 | 2/6 | St. James and Pall Mall | 11½ | 12½ | 11½ | 12½ | 3 2 0 | — | 11¾ | — |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 10 | 11 | 10 | 11 | 3 6 8 | — | .. | .. |
| 59,900 | 5 | 3/0 | Westminster Electric Supply (fully paid) | 11 | 12 | 10 | 11 | 3 8 2 | — | .. | — |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | 1 | 1¼ | ¾ | 1 | .. | — | 1 3/16 | 1 1/16 |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1½ | 1¾ | 1⅛ | 1⅜ | .. | — | 1⅜ | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 110 | 113 | 110 | 113 | 3 19 8 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref | 2 | 2½ | 2 | 2½ | .. | January and July .. | .. | .. |
| 59,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1¾ | 2¼ | 1¾ | 2¼ | 6 13 4 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 | 106 | 103 | 106 | 4 5 9 | January and July .. | — | .. |
| £[illegible],000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | — | | .. | | .. | — | — | — |
| 110,000 | 2 | 1/0 | Electric Construction | 1½ | 1¾ | 1½ | 1¾ | 2 17 2 | — | 1 9/16 | — |
| 12,845 | 2 | 2/9½ | Do. 7 per Cent. Cumulative Pref. | 2½ | 3 | 2¼ | 3 | 4 13 4 | September | 2¼ | — |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ | ⅞ | ⅝ | ⅞ | .. | — | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. | | .. | | .. | .. | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 22 | 23 | 22 | 23 | 4 6 11 | February & August | 22¾ | 22½ |
| £[illegible]0,000 | 100 | 4% | * Do. 4 per Cent. Debentures xd | 107 | 110 | 105 | 108 | 3 14 1 | March & September | .. | .. |
| 20,000 | £5 | | Manchester Edison-Swan "A" (£1 10s. paid) | ¾ | ⅞ | ¾ | ⅞ | .. | .. | .. | .. |
| 37,350 | 12 | 1[illegible]/0 | Telegraph Construction and Maintenance | 40 | 43 | 40 | 43 | 4 3 10 | March and July... | .. | .. |
| £[illegible]50,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 104 | 107 | 104 | 107 | 4 14 4 | January and July | .. | .. |
| £[illegible]00,000 | 10 | 6/0 | W. T. Henley's Telegraph Works Ordinary | 18 | 19 | 18 | 19 | 4 10 1 | March & September | .. | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 18½ | 19½ | 18½ | 19½ | 3 11 10 | " " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 110 | 115 | 110 | 115 | 3 18 3 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | | | |
| £130,000 | Stock | 1⅜% | City and South London Railway Con. Ordy. | 49 | 51 | 48 | 50 | 2 17 6 | January and July .. | 49 | 48½ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14¾ | 15½ | 14¾ | 15½ | 3 5 7 | " " | — | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 | 138 | 136 | 138 | 2 18 0 | May and November | .. | .. |
| 37,500 | £10 | 2¾% | Liverpool Overhead Railway | 13⅜ | 13⅝ | 13 7/16 | 13 9/16 | 2 4 6 | — | .. | .. |
| 10,000 | " | 5% | Do. 5% Preference | 16⅞ | 17⅜ | 16⅞ | 17⅜ | 2 17 9 | — | .. | .. |
| 125,000 | Stock | 4% | Do. 4% Debenture | 112½ | 114½ | 112½ | 114½ | 3 9 10 | January and July | .. | .. |

* In calculating the yield on this security allowance has been made for accrued interest, but not for redemption.

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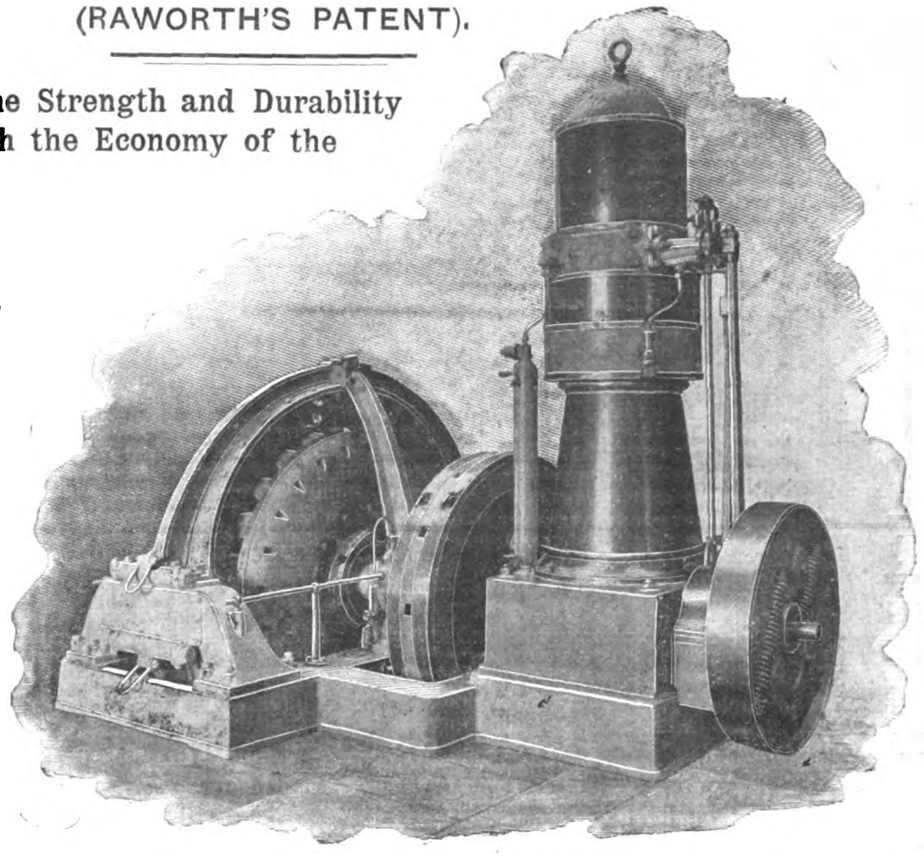
# THE UNIVERSAL ENGINE

(RAWORTH'S PATENT).



This Engine combines the Strength and Durability of the Corliss Engine with the Economy of the High Speed Engine.

***Small Space,***
***Small Cost,***
***High Efficiency,***
***Perfect***
***Governing.***

*For Prices and Particulars apply to*

THE

**BRUSH ELECTRICAL ENGINEERING CO.**

LIMITED,

49, Queen Victoria Street,

**LONDON, E.C.**

# WESTERN ELECTRIC COMPANY.

MANUFACTURERS OF

# TELEPHONES.

WHOLESALE ORDERS ONLY.

**79, COLEMAN STREET, LONDON, E.C.**

CHICAGO, NEW YORK and ANTWERP.

# CHEMICALS

ALL KINDS for ELECTRICAL WORK, and also for INDIA RUBBER & GUTTA-PERCHA MANUFACTURERS, SOLID SULPHURIC ACID and BICHROMATE SALT for EXPORT

**G. BOOR & CO., 1 & 2, Artillery Lane, Bishopsgate, LONDON, E.C.**

CONTRACTORS TO THE POST OFFICE, WAR OFFICE, ADMIRALTY, INDIA AND NEW ZEALAND OFFICES, AND LEADING TELEGRAPH COMPANIES.

CHICAGO WORLD'S FAIR—DIPLOMA AND MEDAL FOR INSULATORS. HIGHEST, AND ONLY, AWARD FOR TROLLEYS.
120,000 OF OUR INSULATORS NOW IN USE ON THE BOSTON AND BROOKLYN TRAMWAYS ONLY.

**ALBERT and J. M. ANDERSON,**

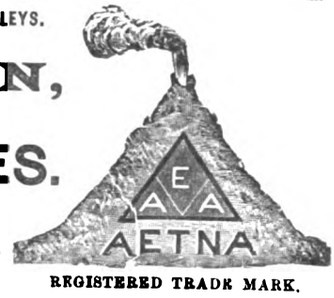
39, VICTORIA STREET, WESTMINSTER, LONDON, S.W.

# ELECTRIC TRAMWAY SUPPLIES.

"AETNA" Insulators and Hangers.

"ANDERSON" STANDARD LINE MATERIAL.

TROLLEYS, LIGHTNING ARRESTERS, SPECIAL TOOLS, &c. EVERY REQUISITE FOR OVERHEAD LINE CONSTRUCTION.




REGISTERED TRADE MARK.

# J. H. RIGG,

**ENGINEER & ELECTRICIAN,**

Inventors' Modeller & Scientific Apparatus Manufacturer.

**43, SKINNER LANE (Works: Cross Stamford St. and Telephone St.), LEEDS.**

Telegraphic and Cable Address: "MOTOR, LEEDS."

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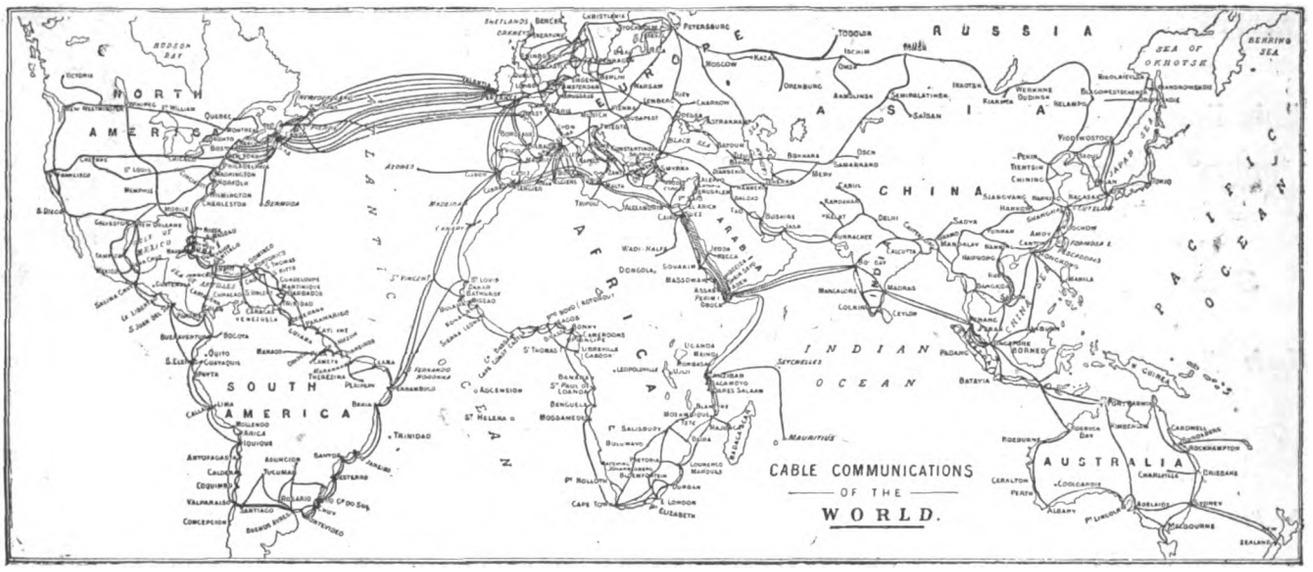
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

# EASTERN TELEGRAPH COMPANY

IN CONNECTION WITH THE (LIMITED),

**EASTERN EXTENSION (AUSTRALASIA AND CHINA), BRAZILIAN SUBMARINE, EASTERN AND SOUTH AFRICAN, EUROPE AND AZORES, WEST AFRICAN AND AFRICAN DIRECT TELEGRAPH COMPANIES.**

**By DIRECT TRIPLICATE CABLES, to Spain, Portugal, Gibraltar, Malta, Egypt, Aden, and India.**

**By DIRECT DUPLICATE CABLE ROUTES to Madeira, St. Vincent, Brazil, Argentine Republic, Uruguay, also to Peru, Chili, and other parts of South America; and to Suakin, Perim, Penang, Malacca, Singapore, Labuan, Java, Australia, New Zealand, Tasmania, New Caledonia, Bangkok, Cambodia, Saigon, Tonquin, Hainan, China.**

**By ALTERNATIVE CABLES to Zanzibar, Mombasa, Mozambique (duplicate), Lourenço Marques (Delagoa Bay), Durban and Capetown; Bathurst, Sierra Leone, Accra, Lagos, Bonny, Bolama, Bissao, Cameroons, St. Thome, Principe, Loanda, Benguella, Mossamedes, Conakry, Grand Bassam, and Gaboon.**

**By SINGLE CABLE to the Azores, Tangier, Tripoli, Cyprus, Seychelles, Mauritius, and Manila.**

Telegrams should be sent from the Company's Stations—

**LONDON—11, OLD BROAD STREET, E.C.; 8, LEADENHALL STREET; 3, GREAT TOWER STREET; 42, PARLIAMENT STREET, S.W.; 206a, WINCHESTER HOUSE, E.C.; 37, HOLBORN VIADUCT, E.C.; FOREIGN AUCTION HALL, COVENT GARDEN MARKET, W.C., and 449, STRAND, W.C.**

**MANCHESTER—20, Brown Street.** **LIVERPOOL—K13, Exchange Buildings.**

**GLASGOW—141, BUCHANAN STREET.**

### COMPANY'S LEVANT SYSTEM:

**Odessa, Constantinople, Dardanelles, Tenedos, Salonica, Smyrna, Chio, Syra, Candia, Rettimo, Canea, Sitia, Rhodes, Trieste, Corfu, Zante, Patras, Corinth, Athens, Cephalonia, Santa Maura, Tinos, Andros, Zea, and all the Greek Islands.**

**The Company's Cables are worked by Muirhead's DUPLEX principle upon all its Main Sections.**

In sending Telegrams from Postal Stations care should be taken to mark them— "VIA EASTERN," these words being signalled gratuitously by the Postal Authorities.

Books of Forms and Tariffs forwarded post free on application at the Company's Chief Offices as above, or at

**37, RUE CAUMARTIN, PARIS; and HOTEL DES POSTES ET TELEGRAPHES, MARSEILLES.**

Winchester House, 50, Old Broad Street, E.C. By Order, GEORGE DRAPER, *Secretary*.

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TELEPHONE No. 15,077. TELEGRAMS: "INDICES LONDON."

**WHEATLEY KIRK, PRICE & GOULTY**

*(ESTABLISHED 1850),*

**Electrical Auctioneers, Valuers, AND ARBITRATORS.**

**Average Annual Valuations exceed £1,500,000 Sterling.**

**49, QUEEN VICTORIA STREET, LONDON, E.C.**

## SALES BY AUCTION, &c.

WEST KENSINGTON.—TO BUILDERS, CONTRACTORS AND OTHERS.

MESSRS. HORNE, SON and EVERSFIELD have received instructions from Messrs. J. Lyons and Co., Limited, to SELL BY AUCTION, on THURSDAY, October 15th, at One precisely, at Cadby Hall (rear of Kensington Stores), Hammersmith-road, the Second Portion of the BUILDING PLANT removed from the Trocadero Restaurant, Haymarket, comprising a quantity of Electric Light Plant, Motors, Dynamo, Scaffold Poles, Boards, Putlogs, Trestles, Deals, Quartering, and other Timber; Garden and Bentwood Chairs, a superior Pair-Horse Private Omnibus, by Edwards and Son, of Torquay, and numerous other effects.

May be viewed day previous. Catalogues had on the premises, and of Horne, Son and Eversfield, 17, Great George-street, S.W., and 85, Gresham-street, E.C.

TO ELECTRICAL MECHANICAL ENGINEERS AND CYCLE MANUFACTURERS.

FOR SALE, as a Going Concern, the whole of the PLANT, MACHINERY, FIXTURES, PATTERNS, DRAWINGS, and STOCK-IN-TRADE of the Wigston Electrical and Engineering Co., Limited, in liquidation, 29, Regency-street, Westminster, S.W., together with the unexpired LEASE of the premises.

For particulars apply to the Liquidator, Mr. A. B. WYKES, Chartered Accountant, Leicester.

## TENDERS INVITED.

ELECTRIC LIGHTING OF THE DUNDEE ROYAL LUNATIC ASYLUM.

TIME for receiving TENDERS has been EXTENDED from 9th October to 16th OCTOBER.

WALTER H. TITTENSOR, Electrical Engineer.

Dudhope Crescent-road, Dundee.

CORPORATION OF GLASGOW.

ELECTRIC LIGHTING OF BAZAAR.

The Corporation of Glasgow are prepared to receive TENDERS for the Electric Lighting of the Bazaar.

Specifications and Forms of Tender may be obtained on application to Mr. William Arnot, Electrical Engineer, 75, Waterloo-street, Glasgow, and Sealed Tenders, marked "Tender for Electric Lighting of Bazaar," must be lodged with the Subscriber by Ten o'clock a.m. on WEDNESDAY, 14th inst.

The Corporation do not bind themselves to accept the lowest or any Tender.

J. D. MARWICK, Town Clerk.

City Chambers, Glasgow, 2nd October, 1896.

GREAT WESTERN RAILWAY.

The DIRECTORS of this Company are prepared to receive TENDERS for the SUPPLY of the undermentioned STORES from the 1st of December next to the 30th of November, 1897:—

1. Bricks and Tiles.
2. Lime, Plaster of Paris and Cement.
3. Stone, Slate, Drain Pipes, Crucibles, &c.
4. Fire Bricks and Fire Clay.
5. Glass—Plate and Sheet.
6. Lamp Glasses, Globes, Tubes, &c.
7 & 8. Drysalteries, Emery, Soap, &c.
9. Acids, Alkalies, &c.
10. Oils, Turpentine, &c.
11. Colours, Paints, &c.
12. Varnishes.
13. Brooms and Brushes.
14. Baskets, Sponge, &c.
15. Rope and Cordage.
16. Leather.
17. India Rubber Goods.
18. Telegraph Instruments.
19. Telegraph Apparatus.
20. Copper Wire, G.P. Wire, &c.
21. Telegraph Ironwork and Tools.
22. Telegraph Drysalteries.
23. Carbons for Electric Light.
24. Zinc, Tin, Antimony, Copper Pipes, Brass, &c.
25. Tin Plates.
26. Tin Ware and Lamp Work.
27. Wire—Iron and Steel.
28. Fish Plates and Bolts, Iron Rivets, Bolts and Nuts, &c.
29. Nails, Screws, &c.
30. Chain.
31. Cast-Iron Pipes and Rain Water Goods.
32. Locks.
33. Steel Tools (Files, Saws, Shovels, &c.)
34, 35 & 36. Ironmongery, General.
37. Ironmongery, Brasswork & Pressure Gauges.
38. Ironmongery, Galvanised Goods.
39. Sanitary Fittings, &c.
40. Tubes—Iron and Steel.
41. Waste and Lamp Cottons.
42. Canvas, Floorcloth, &c.
43. Carpets, Cloths, Calico, &c.
44. Carriage Trimmings and Horse Hair.
45. Handles, Spraggs, &c.
46. Fencing.
47. Telegraph Poles and Yellow Pine.
48 & 49. Horse Harness Fittings.
50. Leather, Brushes, &c., for Horse Department.
51. Mineral Oils.
52. Sundries.

Samples and Patterns may be seen at Swindon, from the 12th to the 23rd of October, on application at the Office of the Stores Superintendent, Swindon.

Specifications, with Forms of Tender (upon which alone Tenders can be received), may be obtained at the Office of the Stores Superintendent at Swindon.

Tenders, addressed to the undersigned, and marked outside "Tender for Stores," will be received on or before MONDAY, the 26th instant.

The Directors do not bind themselves to accept the lowest or any Tender.

G. K. MILLS Secretary.

Paddington Station, London, 1st October, 1896.

**STANLEY** 2 Gold Medals.

Manufacturer of

**DRAWING and SURVEYING INSTRUMENTS**

Of Every Description, of the Highest Quality and Finish, at the most Moderate Prices

— *PRICE LIST POST FREE.* —

Address: **GREAT TURNSTILE, HOLBORN, LONDON, W.C.**

Telegrams, "Turnstile London." Telephone, 65189

## TENDERS INVITED.

TENDERS for RED FIR TELEGRAPH POLES and for CREOSOTING.

GENERAL POST OFFICE.

By Command of the Postmaster-General.

TENDERS will be received until 10 a.m. on MONDAY, the 26th October, 1896, (A) for the SUPPLY of RED FIR TELEGRAPH POLES, to be delivered in London, Kings Lynn or Sutton Bridge, and at Northumberland Dock (River Tyne), West Hartlepool, Hull, or Grimsby; and (B) for CREOSOTING the poles with 10lb. or 12lb. of creosote to the cubic foot, as may be directed.

The Poles to be felled between 2nd November, 1896, and 1st March, 1897, and to be delivered during the following summer at the port at which the creosoting is to be performed.

Butt-sections, from not less than three Poles, to show the quality of timber offered, must precede, or accompany, the Tender of any person who has not already supplied the Postmaster-General with poles.

The Postmaster-General does not bind himself to accept the lowest, or any, Tender.

Forms of Tender, containing all particulars, may be obtained on application to the undersigned.

CHAS E. STUART, Controller of Stores.

General Post Office, London, E.C.,
6th October, 1896.

COUNTY BOROUGH OF BRADFORD.

The Borough Electrical Engineer is prepared to receive TENDERS for the following METERS, viz.:—

117 ARON METERS.
86 FRAGER METERS.
24 EDISON METERS.
21 OULTON and EDMONDSON METERS

A List giving details and capacity of the above Meters can be had on application to the Electricity Office, Town Hall, Bradford.

Tenders to be endorsed "Tender for Meters," and to be addressed to the Borough Electrical Engineer, Town Hall, Bradford.

All Meters are guaranteed to be in good condition and working order.

ALFRED H. GIBBINGS,
Borough Electrical Engineer.

Town Hall, Bradford,
5th October, 1896.

**W. T. HENLEY'S TELEGRAPH WORKS COMPANY, LTD.**

EXCEPTIONAL OPPORTUNITY FOR INVESTORS.

TENDERS are INVITED for the whole or any portion of 105 FULLY-PAID ORDINARY SHARES of £10 each in the above Company.

These Shares are offered by Executors and others under very special circumstances.

The Dividend for the last year was at the rate of £8 per cent., and a much larger one might easily have been declared as sufficient moneys are stated by the Chairman to have been kept in hand to pay a dividend of 8 per cent. this year without touching the reserve fund and without earning a penny this year.

Full particulars, with report of proceedings at last year's Ordinary Meeting of the Shareholders, and Forms of Application, can be obtained from

Messrs. ROOKER & BAZELEY, Solicitors,
Bideford, Devon.

SUBMARINE CABLES TRUST.

NOTICE is Hereby Given that on and after the 15th October the sum of £2. 7s. 6d., balance of the COUPON due 15th October, 1896, will be PAID by Messrs. GLYN, MILLS and CO., of 67, Lombard-street, between the hours of 10 a.m. and 2 p.m. The Coupons should be left with the Bankers for examination FOUR clear days before payment.

By Order of the Trustees,
A. BRODRICK, Secretary.

Winchester House, 50, Old Broad-street, London, October 8th, 1896.

**DOULTON & CO.,**

MANUFACTURERS OF

**INSULATORS**

**BATTERY JARS,**

**POROUS CELLS,**

AND ALL KINDS OF

**Pottery for Electrical Purposes.**

**LAMBETH, LONDON, S.E.**



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## SITUATIONS VACANT AND WANTED.

WANTED a skilled MECHANIC (age about 25 to 35) to act as Instructor to boys in general handicraft. In addition to a knowledge of turning and fitting, he must have had experience in simple smithwork, and be able to manage a gas engine. A practical electrician preferred (45 hours, £2. 5s. per week). High character indispensable.—Apply, stating experience, giving references and enclosing copies of three testimonials, to THE MASTER, Haileybury College, Hertford.

ELECTRICAL ENGINEER. — WANTED an Engineer thoroughly up to date in alternating and continuous current dynamos and motors. Must have had a first-class mechanical engineering experience, and be capable of undertaking the design of dynamos and motors for the electrical transmission of power, and other purposes.—Applications, which will be treated in strict confidence, to be addressed to Mr. SLATER LEWIS, General Manager, P. R. Jackson and Co., Limited, Salford Rolling Mills, Manchester.

AGENCIES WANTED.—St. Edmund's Electric Works, Salisbury. Sole Agents for West of England for Dr. Lessing's Dry Batteries (just awarded R.C.P.S. First-Class Bronze Mdeal).

FIRST-CLASS AGENTS WANTED in all countries, including Great Britain, for the sale of the well-known Perry Electricity Supply Meter (Prof. John Perry's patent).—Apply to the sole manufacturers, Messrs. JOHNSON and PHILLIPS, Victoria Works, Old Charlton, Kent.

DRAUGHTSMAN (mechanical) WANTED, with experience in dynamo and motor design and detail. Age about 28 and upwards.—Age, references and salary to BRUSH ELECTRICAL ENGINEERING Co., Loughborough.

IMPROVER WANTED, from Technical College. Must give six months in lieu of premium.—Apply personally to GILBERT AND Co., 35, High-street, Kensington.

WANTED at once, a thoroughly capable and experienced MAN to take charge of testing room.—Reply by letter only, stating age, experience and salary required, to NALDER AND HILTON, Trafalgar Works, Bow Common-lane, London, E.

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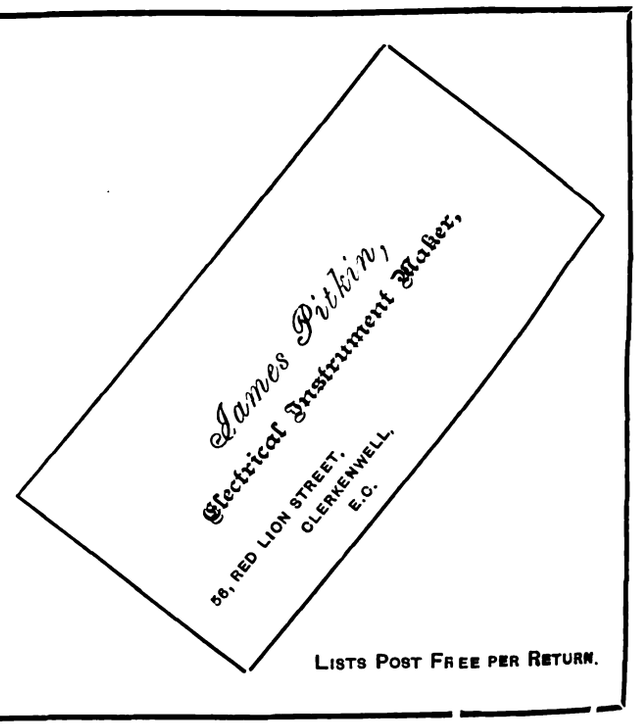


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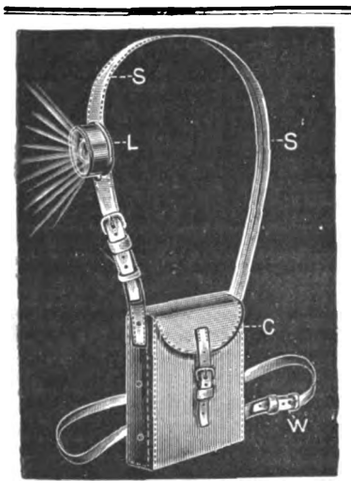


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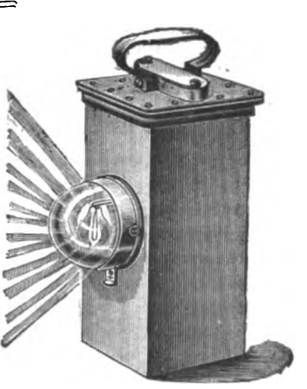

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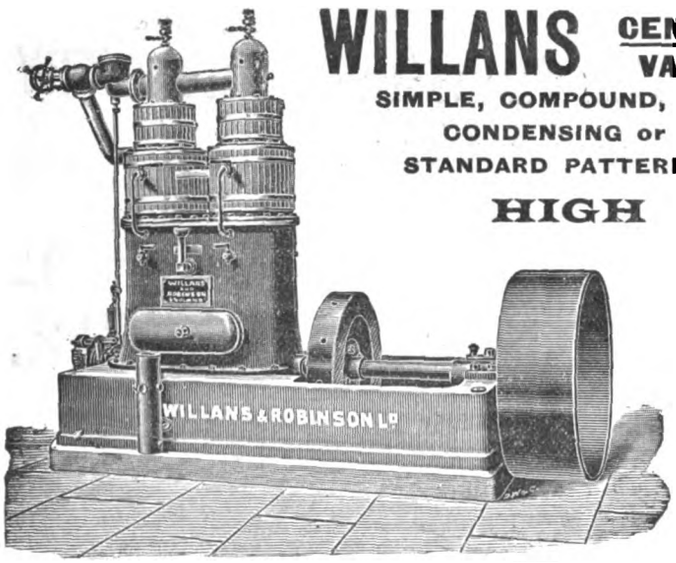


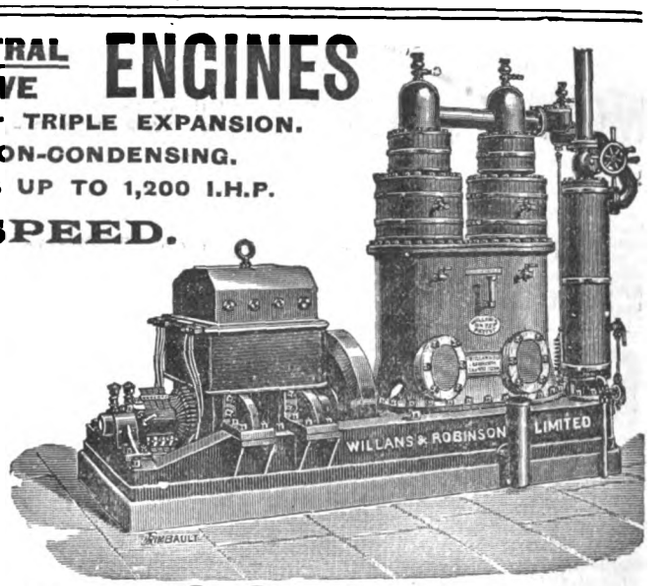


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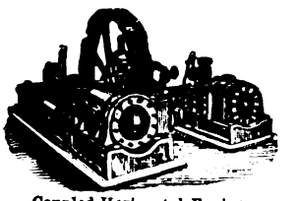

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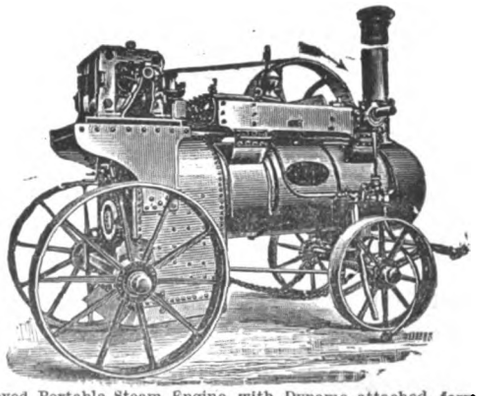

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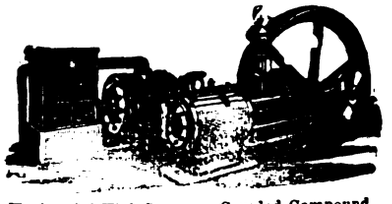

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 960. [Vol. No. 24. XXXVII.] FRIDAY, OCTOBER 9, 1896. PRICE SIXPENCE.


## NOTES.

ON Tuesday last was held the first meeting of the Submarine Telegraph Memorial Committee. Lord SELBORNE, Under Secretary of State for the Colonies, presided, and made an admirable opening speech. He refrained from repeating "any of the commonplaces as regards the effects of submarine telegraphy which are to be read in almost every newspaper article," but dwelt upon the curious conflict between the decentralising measures of statesmen and the centralising tendencies of telegraphy, "the more man struggles, the stronger is the influence of electric telegraphy in overcoming his desires;" and centralisation, Lord SELBORNE pointed out, meant also those human aggregations which "thinkers throughout the civilised world concur in deploring."

AFTER selecting an Executive Committee the meeting was invited to make general suggestions as to the shape the proposed Memorial should take. No proposals were forthcoming until the Secretary read a letter from Prof. SILVANUS THOMPSON, urging the claims of the Building Fund of the Institution of Electrical Engineers. A worthy addition to the not too numerous fine public buildings of the metropolis of the Empire would certainly be a fitting way of keeping green the memory of the founders of submarine telegraphy. Mr. W. T. ANSELL strenuously opposed this idea, but himself did not suggest anything. The scheme is now fairly launched. May it prosper!

THERE is in the electrical industry much the same regard for the Brush Company that the general public entertains for *The Times*; they are both great institutions which we should be sorry to see disappear, although our veneration for them is not always incompatible with a certain preference for more youthful and less ponderous concerns. When a manufacturing company with a paid-up capital of over £650,000 makes, after twelve months' hard work, a net profit of £4,615, and its Directors feel compelled to write £1 off every £3 Ordinary share, a mere outsider would not, at first sight, consider the condition of the undertaking as exactly healthy. However, as anyone can see for himself, who will take the trouble to conscientiously read through the lengthy report of the Brush meeting in our present issue, there are extenuating circumstances. It may be reasonably anticipated that ensuing years will not be quite so full of abnormalities as the past twelvemonth; for the entire absence of big jobs and the loss of the City contract are most distinctly abnormal events even in the chequered history of the Brush Company. At the same time the Directors, while they are about it, would have been well advised to have administered a more drastic purge to this over-capitalised company. It is something to straighten out the balance-sheet and to lighten the ship by £90,000, but it would probably answer to the helm better minus a good deal more dead capital. It cannot be too frequently insisted upon that the payment of huge sums for patent and similar rights always brings its retribution, and is, moreover, a distinctly unbusiness-like proceeding. No business man would dream of paying anything but a very moderate premium for a 14 years' insecure lease of a piece of land, even if that land were situated in the most favourable position possible. Our sympathies are with the members of the engineering staff, upon whose shoulders has fallen the thankless task of trying to earn a dividend upon an impossible capital, a task not rendered lighter by their gratuitous affrays with eminent consulting engineers.

WE reprint this week practically the whole of the Paper on "The Liverpool Overhead Railway," read by Mr. S. B. COTTRELL, the engineer and general manager, before the British Association. Only that part which describes the sewage arrangements at the new underground station, being of no electrical interest, has been omitted. Our own account of this line and the two Papers read, in 1894, before the Institution of Civil Engineers, by Messrs. GREATHEAD and FOX and Mr. THOMAS PARKER, have familiarised our readers with the construction of it. These descriptions, however, were written too soon after the starting of the line for much to be said about the working operations and costs. Mr. COTTRELL'S close acquaintance with the running of the Liverpool line since its commencement enables him to make his Paper a valuable supplement to those of the earlier date; he also gives an interesting and useful description of the constructive work now going forward in connection with the extension of the railway southward to Dingle.

THE low working costs of the Liverpool Overhead Railway have always given a special interest to that line. In our issue of August 7th we commented on the satisfactory state of affairs, as evidenced by the last Report of the Directors; and we analysed items of the accounts. The Appendix to Mr. COTTRELL'S Paper will enable our readers to make a further

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analysis of an instructive character. During the first half of this year the energy generated for running cars was 1,343,129 units, or at the rate of 4·29 units per train mile. A full train weighs 38 tons; but in the average load there has been only 60 per cent. of the seating accommodation occupied, representing in all about 35½ tons. The energy generated, therefore, exclusive of batteries for signals, &c., has been at the rate of 0·121 unit per ton-mile. In view of the frequent stoppages, and the high speed to which the trains are raised between stops, this is a remarkably good performance.

If the roller bearings about to be fitted to the rolling stock fulfils expectations, we may expect even better results when the newly-equipped trains are in regular service. For the ultimate reasons which have led to the adoption of this form of bearing we must refer our readers to Mr. Cottrell's Paper. We cannot, however, refrain from commenting upon the results which are expected to accrue. If we understood Mr. Cottrell aright, in his reply to the discussion, it is anticipated that a three-coach train with roller bearings will not put a greater maximum starting load on the motor than does a two-coach train under present conditions. It may be assumed, we surmise, that the start will be made in the same interval of time. In that case the acceleration load per coach will remain as large as before; and the only change will be a reduction in the bearing friction. Can it really be that this friction, without roller bearings, is so high that the substitution of this new form of bearing reduces the power required to start each single coach to 66 per cent. of its former magnitude? We cannot credit that ordinary bearing friction could be so high. No doubt, roller bearings will considerably reduce the statical and moving friction of the trains; and the effect upon economical working will be as marked when the train is in full motion as when it is starting. But, so long as trains must get up speed so rapidly as they do now, the main part of the starting load must arise from the inertia of their accelerated mass, and only a much smaller portion from rail and bearing friction.

Among the many initial difficulties of an electric lighting scheme, especially in suburbs or small towns, not the least is the difficulty of persuading householders and small shopkeepers to face the cost of house-wiring. No little ingenuity has been expended in getting round this obstacle; but it has been reserved for the Leyton Tradesmen's Association to triumphantly solve the problem. Given ten ten-light householders, combine the ten "joblets" into a single big one, and each individual may hope to get his wiring done at something like the cost per light that would obtain were he himself "installing" 100 lights. That, at any rate, is the idea and the hope of the Leyton Tradesmen's Association; and although ten little jobs, even if carried out simultaneously by one and the same contractor, will always prove more expensive than one large piece of work, there certainly ought to be a reduction worth striving for.

In our issue of July 3rd we referred to a report from the British Consul at Bilbao, in which he pointed out several openings for English engineering firms, more especially in connection with electric light, power and traction undertakings. It is now the turn of the British Consul at Cadiz to lament the fact that our electrical engineering firms have allowed the Germans to secure most of the concessions for electric lighting in Spain. In his report of the trade of Cadiz for the year 1895, just issued, a note from the British Vice-Consul at Seville states that a company was formed last year for supplying electric light to that town. About half the capital required was subscribed locally, and the remainder was promptly forthcoming from Germany. It is therefore needless to add that all the machinery has been imported from that country, and that the business is worked by Germans.

It would be satisfactory to learn that instructions had been given to our Consuls and Vice-Consuls abroad, when presenting their trade reports, to pay especial attention to the subject of electric light and power; and we strongly recommend our leading engineering firms to place this matter before members of Parliament representing the chief centres of our engineering industries, in order that no opportunity may be lost of obtaining early information regarding engineering schemes abroad. We would again refer to the suggestion made in these columns that a duly-qualified official should be appointed to digest these consular reports as they are sent in, with the object of placing their contents before our large contracting and financial houses at the earliest possible moment. At the same time these reports should be more frequently issued. It is said, though we know not with what degree of accuracy, that our big houses hear of everything worth hearing of long before our Consuls do, and that many promising-looking foreign concessions will not bear a close inspection. However that may be, since our Foreign Office officials abroad *do* busy themselves with trade matters, it is as well that they should do so effectually. To obtain belated information, and to publish it in a still more belated manner, may give employment to deserving clerks, but it can benefit no one else. Let us make these consular trade reports real, "live," "up-to-date" documents, or, in the sacred name of Economy, let them be abolished.

**Personal.**—Mr. Emil Kolben has resigned his position with the Oerlikon Maschinenfabrik.

**Prof. A. B. W. Kennedy.**—Prof. A. B. W. Kennedy's address will in future be 17, Victoria-street, S.W.

**The Utilisation of Niagara.**—The proprietors of the North Tonawanda nut and bolt works will use Niagara power to operate their plant as soon as it is transmitted to that village. They will take about 500 H.P.

**Carborundum.**—The Carborundum Company is now making about 3,500 pounds of carborundum a day, but one day recently they opened a furnace that turned out 5,000 pounds, which is the largest amount one furnace has yet produced.

**The Regulation of Private Plants.**—In Dresden a new regulation is to be enforced requiring plans and descriptions of private electric lighting plants about to be erected to be submitted to the Town Council. No independent installation may be made without the consent of the Council.

**Institution of Junior Engineers.**—On Friday, October 16th, at 8 p.m., there will be a meeting of this Institution at the Westminster Palace Hotel. This meeting will be the annual general meeting for election of officers, presentation of Council's report, &c.

**Patent Amendment.**—Notice is given that Carl Zipernowsky and Max Déri have applied for leave to amend the specification

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of the Letters Patent No. 3,379 of 1885, for "improvements in distributing electricity and apparatus therefor." The proposed amendments were set forth in the Illustrated Official Journal issued on September 30, 1896, and are purely verbal.

**Cable Interruptions and Repairs :—**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Puerto Plata—Martinique ..... | Dec. 19, 1895 ... | — |
| Monte Alegre—Santarem..... | May 5, 1896 ... | — |
| Bahia—Rio de Janeiro ..... | Sept. 4, 1896 ... | Oct. 3, 1896. |
| Penang—Medan ..... | Sept. 7, 1896 ... | Sept. 27, 1896. |
| Para—Maranham ..... | Oct. 8, 1896 ... | — |

**Brighton and Rottingdean Electric Railway.**—Notwithstanding the very heavy seas that accompanied recent gales, not the slightest damage has been done to the permanent way of the seagoing car. On Thursday afternoon last week several trial trips were made, over 100 visitors being conveyed on each trip. With the exception of a small amount of concrete work, everything is now complete.

**Electrical Disturbances in Submarine Cables. A Correction.**—We have received the following letter from Mr. Preece:

SIR: In my Paper on "Electrical Disturbances in Submarine Cables" there is an error in line 40, second column, p. 690, which though I detected while reading, I failed to correct in the proof. The sentence should read: "This perhaps is better seen if we consider the case of a concentric cable; for in this case the number of lines of electric force does not increase in the same ratio as the number of lines of magnetic force, while the outer conductor approaches the inner."

**Titles.**—At the last meeting of the City Commissioners of Sewers Mr. Hudson presented a report from the Streets Committee recommending that Mr. Voysey should be designated "electrical engineer" in addition to his title of electrical inspector. Mr. Morton strongly condemned the proposal. Mr. Lile thought that it was too early for a young man like Mr. Voysey, who had only been in the service of the Commission for two years, to apply for the title of engineer. Mr. Gordon said in Mr. Voysey the Commission possessed a gentleman of culture and intelligence, and a man who was socially and educationally far above the rank of an ordinary inspector, and worthy of the title of engineer. In the end the report of the Committee was adopted.

**Birmingham Municipal Technical School.**—We have received a programme of the course of instruction mapped out for the students at this technical school for the session 1896-7. The electrical engineering course, which is under the direct supervision of the Principal, Dr. W. E. Sumpner, includes lectures on theoretical and practical electricity, with special classes in telegraphy and telephony, railway telegraphy, instrument making, and the uses of alternating currents. A great deal of time is besides devoted to laboratory and workshop work. The programme is profusely illustrated with photographs of the various shops and laboratories; a view of the examination hall, in which the mean free path of the examinees is very large, particularly attracted us.

**The District Railway and Electric Traction.**—The following is an extract from the circular issued by the secretary of the Metropolitan District Railway Shareholders' Association to the shareholders in the Metropolitan District Railway:—

"In order to correct the many misstatements being made in connection with the projected deep-level express railway from Earl's Court to the Mansion House, under the existing lines of the Metropolitan District Railway, I am instructed to make known the following particulars of the scheme and the progress made to date:—(1) The scheme which has been unanimously approved by the Directors of the Metropolitan District Railway Company is for the construction of two deep-level tunnels for an up-and-down service of express electric trains between Earl's Court and the Mansion House, with an intermediate station at Charing Cross; (2) Sir Benjamin Baker, the engineer of the Company, foreseeing no unusual difficulties, acting upon the joint instructions of the Company and the Association, is now preparing a survey and report on the lines in projection; (3) the survey and report are expected to be completed and a Bill prepared for Parliament by November 15th next."

**Automatic Switches.**—We have received from Mr. Ballance. of Sheffield, a description of two ingenious automatic switches, The one is a time-switch which serves to automatically switch currents on and off—or over—at appointed hours. Although Mr. Ballance claims that it can be applied to any clock, it seems to us that the arrangement of the connections as described to the face of the clock would cause considerable sparking on the hand breaking contact. The second switch is intended to be applied to double filament lamps for mast-head and side-lights of ships. By an arrangement of differentially wound solenoids the second filament is automatically switched in as soon as the first one is burnt out, and at the same time a signal is rung to call attention to the fact. This second form of switch is also applied in a modified form to burglar alarms, so that when it acts, in addition to the alarm bell being rung, lamps in the building are switched on.

**Electrical Engineering Exhibition.**—An Electrical Exhibition, to mark the celebration of the 60th year of Her Majesty's reign, is now in course of preparation at Newcastle. The object will be to accentuate the progress which has been made in electrical engineering between the years 1837 and 1897. There being no permanent building adapted for showing heavy machinery, and machinery in motion, a site on Pandon Dene has been secured, on which special temporary buildings will be erected, and these will be so arranged as to meet the requirements of the exhibits referred to. It is intended to be strictly an Exhibition, and in no way an organisation for the sale of goods. Exhibitors, however, will be allowed to book or take orders for their various specialities. The importance of Newcastle as an electrical and general engineering centre will naturally create special interest in an Exhibition of the character described. The Act of Parliament which legalises the use of the motor car and the motor cycle will be in force, and it is intended to make a special feature of cars and cycles propelled by electric or other motor power.

**Scientific Education.**—The 26th session of the Durham College of Science, Newcastle-on-Tyne, was inaugurated on Monday last. The report of the Principal stated that in 1894-95 the number of students was 1,370, and last session it was 1,591, while upwards of 3,000 people attended popular lectures in the neighbourhood In the course of a lengthy speech the Home Secretary, Sir M. W. Ridley, said that he hoped the signs of the times pointed to the development of the system of secondary education, the clear distinction of it from elementary education and the establishment of it on sound principles. They had heard, he said, that day that the Chancellor of the Exchequer was sending certain persons to discover whether it would be wise to increase the Government grant to University colleges of science. He could assure the Chancellor of the Exchequer that if he should find it possible to increase the grant which the State now gave to the University colleges of science throughout England, he would be amply and satisfactorily supported by public opinion. It was never more necessary that the various professions and industries should receive the benefits of special scientific education.

**The Radiaphone.**—It is reported from an American source that Prof. Alexander Graham Bell is devoting his attention to the commercial development of his "radiaphone," which he devised nearly 20 years ago. In this instrument he utilises a beam or ray of reflected light for the transmission of sounds between distant points, in lieu of the ordinary wire. The transmitter is made up of a thin diaphragm of mica or of some other similar substance, silvered at its back so as to make of it a reflecting mirror. The diaphragm is connected with an ordinary speaking tube. Against this thin disc or diaphragm is projected a ray of light. The light is caught by a mirror, and directed through a concentrating lens whose focus is the transmitting diaphragm. The latter in turn reflects the ray through a second lens, which again makes the ray of light parallel, so that it may travel without dispersion. At the receiving station there is a parabolic reflector, at the end of which is fixed a selenium cell. The cell in turn is connected, telephonically, with the ear. When the ray of light is reflected from the transmitting diaphragm and the operator speaks into the tube joined with the latter, what he says may be clearly and distinctly heard at the other end of the line, that is, at the other end of the travelling ray of light.

**Electricity in Shipbuilding.**—The members of the Leeds Association of Engineers recently visited Newcastle, and were shown round the shipyards of Messrs. C. S. Swann and Hunter, at Wallsend. They first passed through the West Shipyard. On the way to the East Shipyard they inspected the various shops, also the electric-power and boiler-houses and gas

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and other furnaces. The firm have erected immense steel structures over the berths occupied by two of the vessels in process of construction. These structures when finished are to be roofed over with glass and their sides enclosed. By means of electrically-driven cranes, material can be carried right over the largest vessels and deposited at any part. Portable drills, wood-deck planing machines, punching machines, and fan blasts are also driven by electricity. The party also visited the Electrical Engineering Works of Messrs. Ernest Scott and Mountain, and saw the various appliances in course of construction. The President of the Association (Mr. James Bowers) opened the winter session by an address, in which he made special allusion to the saving effected by the electric transmission of power. In addition to the works above mentioned, he had seen the alteration made at Sir Wm. Gray's shipyard, West Hartlepool, where a complete electric driving plant had been put down, a separate motor being fixed to each machine. By this means the weekly coal consumption had been reduced from 72 to 38 tons.

**Electricity *v.* Gas.**—The greater portion of Mr. J. H. Penny's Presidential Address to the North of England Gas Managers' Association, last week, was devoted to demonstrating the inefficiency of electric light. Some extracts from the address, which is reported in full in the *Journal of Gas Lighting*, may be found interesting and amusing:—

". . . . It is an indisputable fact that gas is by far the cheaper of the two. This has been ably and conclusively demonstrated by actual and practical comparison. Hitherto there has been a great deal of mystery to the uninitiated about the price of electricity. The Board of Trade 'unit,' too, has been a something that 'no fellow could understand;' and the comparative prices of gas and electricity, as propounded from time to time by promoters of the latter, have been as uncertain as the weather, as changeable as the seasons, and about as unreliable as the light itself. The price will ever be the paramount consideration with the general public; and that is the standard by which each light will be judged. The promoters of the electric light certainly furnish to the public information in abundance; but we cannot accept their *ex parte* statements. They attribute many virtues to the light; and the persuasive arguments they use are sufficient to fascinate and win over the most hesitating to adopt the illuminant. Time, which is said to try all things, will show whether such flattering representations are real or visionary—'the proof of the pudding is in the eating thereof.' They tell us that it is a 'cool' light, signifying that it gives off very little heat; but by experiments referred to in the *Journal of Gas Lighting* for May 28, 1895, 'two incandescent electric lamps—one of 16-candle and the other of 25-candle power—decomposed gunpowder, and also caused water to boil in 15 minutes.' It is said that ceilings do not get blackened when the electric light is used. This is also a delusion. The heat from the electric light bulb as it ascends carries with it the particles of falling dust, which adheres to the ceiling, and after a while show a distinct discoloration, as may be observed where the light has been in use for some length of time. I myself have seen, in two well-known buildings in London, where electric light is exclusively used, beautifully embellished ceilings all blackened in this way. . . . . It is an oft-repeated truism that gas companies have more to fear from oil than electricity. At one time we heard much about cooking by electricity; but I am not aware that any appreciable advance has been made in this direction. A bountiful Providence has stored the earth with coal for our use. Man, on his part, by his untiring energy and perseverance has discovered enriching agencies, and has applied them for raising the illuminating power of the gas; and in these days of boundless chemical research and scientific investigation, we do not know what new developments there may be in store in the near future, calculated to revolutionise the manufacture of coal gas. We are familiar with the past; but the future is veiled from our view."

**Electrolysis of Sodium Chloride.**—The *Bulletin Technologique* recently published an article by M. Révillon on the electrolysis of sodium chloride for the manufacture of caustic soda and chlorine. During this electrolytic process hydrogen is produced which can easily be kept separate from the chlorine by interposing porous partitions in the cells between the electrodes. Yet there are several forms of electrolytic apparatus which are efficient enough as regards the electrolysis itself, but in which hydrogen and chlorine are given off in a mixed state. Until now this has been considered as a great inconvenience when chlorine was to be used in the manufacture of chloride of lime. It is known that a mixture of the two gases is so explosive, that it is even dangerous to expose it to a ray of sunlight. For this reason the chambers in which the chloride of lime is manufactured are usually of large dimensions, and they can contain a considerable volume of the gaseous mixture. M. Solvay, being sure that the presence of hydrogen is no impediment to the absorption of chlorine by the lime, and that the hydrogen exerts no reducing action, tried to devise a practical method of manufacturing the chloride in such a manner that, while employing the normal mixture of the two gases produced by the electrolysis, there should at the same time be no danger. Among other methods, he uses a continuously working apparatus of small volume, in which the chlorine and lime are systematically brought into contact. It consists of a rotating cylinder with a helical thread on its outer surface, the axis of the cylinder being slightly inclined. Another method of preventing any danger of the gaseous mixture exploding is to collect the unabsorbed gas (which is practically pure hydrogen) at the point of exit from the absorption chambers, and to introduce it again with the gaseous mixture which is entering, until the proportion of hydrogen in the mixture becomes so great that no spontaneous explosion need be feared. The hydrogen thus added acts as a neutral and inert gas, and makes the mixture inexplosive. For this latter method a continuously working apparatus for the absorption of the chlorine is no longer necessary, for one can use ordinary chambers. M. Solvay uses the mixture of chlorine and hydrogen to manufacture other hypochlorites by means of liquids, this being a direct and convenient method which obviates the necessity of employing large volumes of gas.

**Contemporary Electrical Science.**—In the *Nuovo Cimento* for August, Professor Cardani concludes his elaborate researches into the thermal phenomena of derived circuits. The development of heat was observed as before by enclosing the wire in a tube filled with liquid, and serving as a kind of thermometer. The author solved some important problems by this method with great ease and certainty. Metallic bands offer less resistance to oscillating discharges than cylindrical wires of the same cross section. When the thickness is small with respect to the breadth, the thickness is without influence. This confirms Dr. Lodge's results, according to which the surface of conductors is chiefly concerned in these discharges. The dielectric surrounding the conductors is, according to Cardani, without any effect. Ropes of wires in contact have nearly the same resistance as a single wire of equivalent cross section, but even when the wires are insulated the advantage is slight. The greatest advantage is gained by discharging through several wires in parallel at some distance apart.——Dr. Mario Sala writes on the coefficient of external conductivity of vertical wires, meaning the constant which determines the loss of heat (by radiation and convection) from a wire carrying a current when the current, the resistance and surface of the wire, and its excess of temperature over the surrounding medium are given. The method of investigation was rather original. A wire 30 metres long was suspended vertically in the tower of the Parma University. The temperature of the wire was determined by its extension on heating, a safe method when the metals are not magnetic. As a result, the author found that the coefficient varies with the diameter of the wire according to a law resembling that which obtains in the case of horizontal wires investigated by Cardoni. But the loss of heat is greater when the wires are vertical, and the wires themselves are therefore kept cooler. This loss is chiefly due to convection, and not radiation, as it is almost the same if the wires are blackened. But in the vertical wires it depends to a considerable extent upon the mechanical condition of the surface, being greater when it is rough. The coefficient is, moreover, independent of the temperature in vertical wires, and Newton's law of cooling is strictly true.——Dr. Fortunato Florio demolishes Bagard's assertion that Hall's phenomenon may be observed in liquids. He proves that the transverse differences of potential observed are due to concussion.——We also find abstracts of three pages by E. Villari on the bending of X-rays round the edges of opaque bodies. The disc of an electroscope placed in the shadow of a metallic plate exposed to X-rays is protected to an extent depending upon the distance and width of the plate. Prof. Villari adopts the explanation that the electroscope is discharged by charged particles of air. More detailed experiments showed that a maximum shadow effect was obtained at a certain distance from the shadowing plate. A distinct penumbra was also obtained photographically, well within any penumbra due to the tube itself. All this is very curious and profoundly interesting. We cannot help thinking that a more detailed investigation of this bending of the waves may reopen the question of their alleged excessive shortness.

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## ELECTROMAGNETIC THEORY.—XCI.*

BY OLIVER HEAVISIDE.

(*Continued from page 661.*)

If we superimpose two distributions of electrification, one given by $V = V_0$, constant on the whole of the left side of the origin and up to distance $x = \frac{1}{2}a$ on the positive side, the other given by $V = -V_0$ on the whole of the left side except from the origin to the distance $x = -\frac{1}{2}a$, the result is simply $V = V_0$ along distance $a$ at the origin itself, or the charge $SV_0a$. Keeping the last constant, say Q, and decreasing $a$ indefinitely, the result is a finite charge Q at the origin only. The waves of voltage and current which arise from it are therefore given on the positive side by the difference of the waves arising from the two uniform distributions of V before described, which neutralise one another save at the origin. In this way the solutions (121), (122) for a point-charge are derived from (109), (115).

But the following way is interesting. We know that $C = \epsilon^{-qx}C_0$, if $C_0$ is the current impressed at the origin. Take $C_0 = \frac{1}{2}pQ$; then $C_0$ is due to the charge Q impulsively introduced and dividing into two equal parts at the origin. Therefore

$$C = \tfrac{1}{2}Q\epsilon^{-qx}p1 = \tfrac{1}{2}Qvq\epsilon^{-qx}\frac{p}{qv} = -\tfrac{1}{2}Qv\frac{d}{dx}\left(\epsilon^{-qx}\frac{p}{qv}\right). \quad (125)$$

This is done by introducing $qv/qv$, and then noting that the first $q$ is equivalent to $-d/dx$.

Now the function in the brackets is already known. For

$$\frac{p}{qv} = \epsilon^{-pt}I_0(\sigma t), \quad \text{and} \quad \epsilon^{-qx}\frac{p}{qv} = \epsilon^{-\rho t}I_0\{\sigma(t - x^2/v^2)^{\frac{1}{2}}\}, \quad (126)$$

by (59) and its extension in § 367, before done, equation (91) leading to (101), or (105) to (109). So (125) produces (122).

The voltage formula to match may be derived thus,

$$V = \left(\frac{R + Lp}{K + Sp}\right)^{\frac{1}{2}}C = (R + Lp)\tfrac{1}{2}Qv\,\epsilon^{-qx}\frac{p}{qv}$$

$$= \frac{Q}{2Sv}(p + \rho + \sigma)\,\epsilon^{-qx}\frac{p}{qv} = \frac{Q}{2Sv}\epsilon^{-\rho t}(p + \sigma)I_0\{\sigma(t^2 - x^2/v^2)^{\frac{1}{2}}\}, \quad (127)$$

which is (121).

Knowing the voltage and current due to initial charge or momentum at a single point, we can at once write down the integrals expressing the voltage and current arising from any given initial states of voltage and current. But we do not want them at present.

**§ 372.** Now let us tackle the more difficult problem of the waves of voltage and current generated by a steady voltage impressed at the origin. It is the combination of resistance with leakage that makes this case complicated. But it must be done, to complete the investigation. If $e$ is the steadily-impressed voltage, started at the initial moment, we have

$$V = e\,\epsilon^{-qx}1 = e\,\epsilon^{-\rho t}(\cosh - \sinh)(x/v)(p^2 - \sigma^2)^{\frac{1}{2}} \cdot \epsilon^{\rho t}, \quad (128)$$

by making $\epsilon^{\rho t}$ the operand, and separating even and odd powers of $x$. Here the cosh operator contains only integral powers of $p$, and the potence of $p$ is therefore $\rho$. So

$$V = e\,\epsilon^{-\rho t}\left\{\cosh(x/v)(p^2 - \sigma^2)^{\frac{1}{2}} - \frac{\sinh(x/v)(p^2 - \sigma^2)^{\frac{1}{2}}}{(p^2 - \sigma^2)^{\frac{1}{2}}}(p^2 - \sigma^2)^{\frac{1}{2}}\right\}\epsilon^{\rho t}. \quad (129)$$

A part has been algebrised. In the rest, the shin operator divided by the radical involves even powers of $p$ only. Also

$$(p^2 - \sigma^2)^{\frac{1}{2}}\epsilon^{\rho t} = p\left\{1 - \tfrac{1}{2}\frac{\sigma^2}{p^2} - \frac{1.3}{2.4}\frac{\sigma^4}{p^4} - \frac{1.3.5}{2.4.6}\frac{\sigma^6}{p^6} - \ldots\right\}\epsilon^{\rho t}, \quad (130)$$

by the binomial theorem. Algebrising, we get

$$= p\left\{\epsilon^{\rho t} - \tfrac{1}{2}\frac{\sigma^2}{p^2}(\epsilon^{\rho t} - e_1) - \frac{1.1}{2.4}\frac{\sigma^4}{p^4}(\epsilon^{\rho t} - e_3) - \ldots\right\}$$

$$= \rho\epsilon^{\rho t}(1 - \sigma^2/\rho^2)^{\frac{1}{2}} + \rho\left\{\tfrac{1}{2}\frac{\sigma^2}{\rho^2} + \frac{1.1}{2.4}\frac{\sigma^4}{\rho^4}e_2 + \frac{1.1.3}{2.4.6}\frac{\sigma^6}{\rho^6}e_4 + \ldots\right\}, \quad (131)$$

where $e_n$ = sum of first $n + 1$ terms of $\epsilon^{\rho t}$. A point to be noticed in the above that in (130) we introduce $pp^{-1}$. The differentiation should be done afterwards, as in (131). Let

$$U_0 = \tfrac{1}{2}\frac{\sigma^2}{\rho^2} + \frac{1.1}{2.4}\frac{\sigma^4}{\rho^4}e_2 + \frac{1.1.3}{2.4.6}\frac{\sigma^6}{\rho^6}e_4 + \ldots; \quad (132)$$

then by (130), (131),

$$(p^2 - \sigma^2)^{\frac{1}{2}}\epsilon^{\rho t} = \epsilon^{\rho t}v(RK)^{\frac{1}{2}} + \rho U_0. \quad (133)$$

Now when the shin operator works on this, the potence of $p$ is $\rho$ again on the first term in (133) on the right side. So a second part is algebrised. Putting the two algebrised parts together we shall obtain $e\,\epsilon^{-rx}$, where $r = (RK)^{\frac{1}{2}}$. Therefore (129) becomes

$$V = e\,\epsilon^{-rx} - e\,\epsilon^{-\rho t}\frac{\rho x}{v}\left\{1 - \frac{\sigma^2 - p^2}{\lfloor 3}\frac{x^2}{v^2} + \ldots\right\}U_0; \quad (134)$$

or, in a more convenient form,

$$V = e\,\epsilon^{-rx} - e\rho\epsilon^{-\rho t}\left\{\frac{x}{v}U_0 - \frac{x^3}{v^3}\frac{U_1}{\lfloor 3} + \frac{x^5}{v^5}\frac{U_2}{\lfloor 5} - \ldots\right\}, \quad (135)$$

where the U's are time functions, of which the first is as in (132), whilst the rest are derived from it by

$$U_n = (\sigma^2 - p^2)^n U_0. \quad (136)$$

It is quite easy to derive $U_n$, because $p^2e_n = \rho^2e_{n-2}$. Thus, to illustrate, first $(\sigma^2 - p^2)^n 1 = \sigma^{2n}$, and then,

$$(\sigma^2 - p^2)e_2 = \sigma^2e_2 - \rho^2, \qquad (\sigma^2 - p^2)e_4 = \sigma^2e_4 - \rho^2e_2,$$
$$(\sigma^2 - p^2)^2e_2 = \sigma^4e_2 - 2\sigma^2\rho^2, \qquad (\sigma^2 - p^2)^2e_4 = \sigma^4e_4 - 2\sigma^2\rho^2e_2 + \rho^4,$$
$$(\sigma^2 - p^2)^3e_2 = \sigma^6e_2 - 3\sigma^4\rho^2, \qquad (\sigma^2 - p^2)^3e_4 = \sigma^6e_4 - 3\sigma^4\rho^2e_2 + 3\sigma^2\rho^4,$$

&c., &c. So we have

$$U_1 = \frac{\sigma^2}{\rho^2}\left\{\tfrac{1}{2}\sigma^2 + \frac{1.1}{2.4}\frac{\sigma^2}{\rho^2}(\sigma^2e_2 - \rho^2) + \frac{1.1.3}{2.4.6}\frac{\sigma^4}{\rho^4}(\sigma^2e_4 - \rho^2e_2) + \ldots\right\},$$

$$U_2 = \frac{\sigma^2}{\rho^2}\left\{\tfrac{1}{2}\sigma^4 + \frac{1.1}{2.4}\frac{\sigma^2}{\rho^2}(\sigma^4e_2 - 2\rho^2\sigma^2) + \frac{1.1.3}{2.4.6}\frac{\sigma^4}{\rho^4}(\sigma^4e_4 - 2\sigma^2\rho^2e_2 + \rho^4) + \ldots\right\},$$

and so on. I regret that the result should be so complicated. But the only alternatives are other equivalent infinite series, or else a definite integral which is of no use until it is evaluated, when the result must be the series (135), or an equivalent one. In it, the term $e\,\epsilon^{-rx}$ represents the steady state, all the rest ultimately vanishing.

As regards the wave of current, there are several ways of obtaining it. The one analogous to the above goes thus :—

$$C = \left(\frac{K + Sp}{R + Lp}\right)^{\frac{1}{2}}\epsilon^{-qx}e = \frac{e}{Lv}\epsilon^{-\rho t}\left(\frac{p - \sigma}{p + \sigma}\right)^{\frac{1}{2}}\epsilon^{-(p^2 - \sigma^2)^{\frac{1}{2}}x/v}\epsilon^{\rho t}$$

$$= \frac{e}{Lv}\epsilon^{-\rho t}(p - \sigma)(\cosh - \sinh)\frac{x}{v}(p^2 - \sigma^2)^{\frac{1}{2}} \cdot \frac{\epsilon^{\rho t}}{(p^2 - \sigma^2)^{\frac{1}{2}}}, \quad (137)$$

by first making $\epsilon^{\rho t}$ the operand, and then introducing $(p - \sigma)/(p - \sigma)$. We now have the potence of $p$ in the shin operator divided by the radical equivalent to $\rho$. This algebrises a part. For use with the cosh operator, we have

$$(p^2 - \sigma^2)^{-\frac{1}{2}}\epsilon^{\rho t} = \frac{1}{p}\left(1 + \tfrac{1}{2}\frac{\sigma^2}{p^2} + \frac{1.3}{2.4}\frac{\sigma^4}{p^4} + \ldots\right)\epsilon^{\rho t}$$

$$= \frac{1}{\rho}(\epsilon^{\rho t} - 1) + \tfrac{1}{2}\frac{\sigma^2}{\rho^3}(\epsilon^{\rho t} - e_2) + \ldots$$

$$= \epsilon^{\rho t}(\rho^2 - \sigma^2)^{-\frac{1}{2}} - \frac{1}{\rho}W_0, \quad (138)$$

where

$$W_0 = 1 + \tfrac{1}{2}\frac{\sigma^2}{\rho^2}e_2 + \frac{1.3}{2.4}\frac{\sigma^4}{\rho^4}e_4 + \frac{1.3.5}{2.4.6}\frac{\sigma^6}{\rho^6}e_6 + \ldots. \quad (139)$$

Using (138) in the previous equation, we see that the potence of $p$ in the cosh operator on the first part is again $\rho$, and as regards the rest we have a series of functions derived from $W_0$ according to

$$W_n = (\sigma^2 - p^2)^n W_0. \quad (140)$$

So, finally, putting together separately the parts independent of the time, we obtain

$$C = e\left(\frac{K}{R}\right)^{\frac{1}{2}}\epsilon^{-rx} - \frac{e\,\epsilon^{-\rho t}}{Lv}\frac{p - \sigma}{\rho}\left\{W_0 - \frac{x^2}{v^2}\frac{W_1}{\lfloor 2} + \frac{x^4}{v^4}\frac{W_2}{\lfloor 4} - \ldots\right\}. \quad (141)$$

As before, the W functions are easily developable.

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§ 373. I shall now explain another way of algebrising the operational solutions, which is, perhaps, the simplest possible in the ideas concerned, and also sometimes in the execution thereof. Say we require to find the wave of voltage generated by impressed voltage at the origin; that is, $V=\epsilon^{-qx}e$, where $e$ is a given function of the time. Practically $e$ is suitably selected to ease the work. As an example, in passing, take

$$e=e_0\epsilon^{-\rho t}I_0(\sigma t), \tag{142}$$

where $e_0$ is constant (zero before, steady after $t=0$). We can see at once that

$$V=e_0\epsilon^{-\rho t}I_0\{\sigma(t^2-x^2/v^2)^{\frac{1}{2}}\}, \tag{143}$$

because we have already found the effect of $\epsilon^{-qx}$ on the function in (142). See (126) above.

Now, in the distortionless case, when $\sigma=0$, if also $R=0$, $K=0$, we have $q=p/v$. Therefore, if $e=f(t)$, we have

$$V=\epsilon^{-px/v}f(t)=f(t-x/v), \tag{144}$$

by Taylor's theorem operationally considered. That is, the voltage impressed at the origin travels out at speed $v$ without any change whatever.

But if there is resistance, and also leakage to balance, so that $\sigma=0$ still, then $qv=\rho+p$, and

$$V=\epsilon^{-qx}e=\epsilon^{-\rho x/v}\epsilon^{-px/v}e=\epsilon^{-\rho x/v}f(t-x/v), \tag{145}$$

Thus the disturbances impressed at the origin now travel out at speed $v$ and attenuate according to $\epsilon^{-\rho t}$ in the interval, because $t=x/v$ is the time of transit from the origin to $x$. At the same time the wave of current is $C=V/Lv$, the current and transverse voltage being in the same phase and in constant ratio. This is the beginning of the theory of the distortionless circuit, which I recommend every electrician to study in full detail, as an introduction to electromagnetic waves in general, since it casts light in the most obscure places. It allows us to understand electromagnetic waves mathematically not merely as a collection of formulæ, sometimes disagreeably complicated, but in terms of physical ideas of translation, attenuation, distortion, absorption, reflection, and so on. I beg to refer again to the portions of Chapter IV., Vol. I., which are devoted to the subject of waves along wires. It is obvious that an electrician who aims at telephony through very long cables by methods which violate the conditions under which it is possible, is only wasting his labour.

There are only two ideas concerned in (145), viz., the progression of the wave, and the uniform attenuation which occurs by absorption in transit. If $\sigma$ is not zero, there must be a third process involved. This is the partial reflection that occurs to every part of a wave in transit, whereby its parts are redistributed, or the wave shape is deformed or distorted. It follows from the distortionless theory that when $\sigma$ is not zero, we still have propagation at speed $v$, and still have the attenuation factor $\epsilon^{-\rho t}$. It therefore suggested itself to me that in

$$\epsilon^{-qx}e=\epsilon^{-\rho t}\epsilon^{-(p^2-\sigma^2)^{\frac{1}{2}}x/v}\epsilon^{\rho t}e, \tag{146}$$

the operator containing $p$ should be expressed thus,

$$\epsilon^{-(p^2-\sigma^2)^{\frac{1}{2}}x/v}=\epsilon^{-px/v}F(p^{-1}), \tag{147}$$

where $F(p^{-1})$ is a series in rising powers of $p^{-1}$, having unity for its first term, because when $\sigma=0$, $F=1$. Say,

$$F=1+F_1(\sigma/p)+F_2(\sigma/p)^2+F_3(\sigma/p)^3+\ldots, \tag{148}$$

so that

$$V=\epsilon^{-qx}e=\epsilon^{-\rho t}\epsilon^{-px/v}\left(1+F_1\frac{\sigma}{p}+F_2\frac{\sigma^2}{p^2}+\ldots\right)\epsilon^{\rho t}e. \tag{149}$$

If this is possible, the algebrisation will be immediate. First carry out the operation F. This will effect the rearrangement of parts. Then carry out $\epsilon^{-px/v}$. This will do the translation. Finally, the factor $\epsilon^{-\rho t}$ will attenuate properly.

It does not appear from the operator in (146) that the expansion in inverse powers of $p$ is a natural one. But it goes well. The F's are simple functions of $x$, of which the first three are

$$F_1=\frac{\sigma x}{2v}, \qquad F_2=\frac{\sigma^2x^2}{8v^2}, \qquad F_3=\frac{\sigma x}{8v}+\frac{\sigma^3x^3}{48v^3}. \tag{150}$$

How to obtain these will be explained separately. Supposing them known at present, we can show the working of (149).

The simplest case is $e\epsilon^{\rho t}=e_0$, or $e=e_0\epsilon^{-\rho t}$. Then $(\sigma/p)^n1$ is the same as $(\sigma t)^n/\lfloor n$, so the F series is algebrised. Then the next operator turns $t$ to $t_1$, if $t_1$ means $t-x/v$. Therefore,

$$V=e_0\epsilon^{-\rho t}\left\{1+\sigma t_1F_1+\frac{\sigma^2t_1^2}{\lfloor 2}F_2+\frac{\sigma^3t_1^3}{\lfloor 3}F_3+\ldots\right\} \tag{151}$$

expresses the complete wave of voltage. Or,

$$V=e_0\epsilon^{-\rho t}\left\{1+\sigma t\left(1-\frac{x}{vt}\right)\frac{\sigma x}{2v}+\frac{\sigma^2t^2}{\lfloor 2}\left(1-\frac{x}{vt}\right)^2\frac{\sigma^2x^2}{8v^2}+\ldots\right\}. \tag{152}$$

Observe that V has the same value at the wave front as at the origin, at any moment. This is because we have chosen V at the origin so that it shall be so. The natural attenuation from origin to wave front is $\epsilon^{-\rho t}$, when $t=x/v$, and this is just the law assumed for the variation at the origin. In the distortionless case the curve of V is a straight line all the way up to the front, where V drops to zero suddenly. But it is not generally a straight line, even when V is the same at the extremes. It is easy to see that if $e$ subsides faster than $\epsilon^{-\rho t}$, the voltage at the wave front will be greater than at the origin; and conversely, less.

Next, let $e$ be constant, zero before, steady after $t=0$, then we have to integrate $\epsilon^{\rho t}$ once, twice, &c., according to (149). Thus,

$$V=e\epsilon^{-\rho t}\left\{\epsilon^{\rho t_1}+F_1\frac{\sigma}{\rho}(\epsilon^{\rho t_1}-1)+F_2\frac{\sigma^2}{\rho^2}(\epsilon^{\rho t_1}-1-\rho t_1)+\ldots\right\}, \tag{153}$$

where we have put $t_1$ for $t$, as before explained. Collect together the terms involving $\epsilon^{\rho t_1}$; that is, $\epsilon^{\rho t}\epsilon^{-\rho x/v}$. Then

$$V=e\epsilon^{-\rho x/v}\left\{1+\frac{F_1\sigma}{\rho}+\frac{F_2\sigma^2}{\rho^2}+\ldots\right\}-e\epsilon^{-\rho t}\left\{F_1\frac{\sigma}{\rho}+F_2\frac{\sigma^2}{\rho^2}e'_1+F_3\frac{\sigma^3}{\rho^3}e'_2+\ldots\right\}, \tag{154}$$

where $e'_n$ means the sum of the first $n+1$ terms of $\epsilon^{\rho t_1}$.

This is an alternative form of the solution (135) above. We conclude that

$$\epsilon^{-rx}=\epsilon^{-\rho x/v}\{1+F_1\sigma/\rho+F_2\sigma^2/\rho^2+\ldots\}, \tag{155}$$

so (155) may be simplified to this extent. When $\sigma=\rho$, then $r=1$; therefore,

$$\epsilon^{\sigma x/v}=1+F_1+F_2+F_3+\ldots=\Sigma F, \tag{156}$$

since $F_0=1$.

As a third case, let $e\epsilon^{\rho t}=e_0\epsilon^{\sigma t}$, where $e_0$ is constant. Then $e=e_0\epsilon^{-Kt/S}$, subsiding according to the natural leakage law. We have now to integrate $\epsilon^{\sigma t}$ in (149), instead of $\epsilon^{\rho t}$. That is, instead of (154) we have the following:—

$$V=e_0\epsilon^{-\rho t}\left\{\epsilon^{\sigma t_1}+F_1\frac{\sigma}{\rho}(\epsilon^{\sigma t_1}-1)+F_2\frac{\sigma^2}{\rho^2}(\epsilon^{\sigma t_1}-1-\sigma t_1)+\ldots\right\}; \tag{157}$$

or, collecting the terms involving $\epsilon^{\sigma t_1}$,

$$V=e_0\epsilon^{-Kt/S}\epsilon^{-\sigma x/v}\left\{1+F_1\frac{\sigma}{\rho}+\ldots\right\}-e_0\epsilon^{-\rho t}\left\{F_1\frac{\sigma}{\rho}+F_2\frac{\sigma^2}{\rho^2}e_1''+\ldots\right\}, \tag{158}$$

where $\epsilon''_n$ is now the sum of the first $n+1$ terms of $\epsilon^{\sigma t_1}$.

But use (155). Then in the first portion of (158) we have

$$\epsilon^{-Kt/S}\epsilon^{-\sigma x/v}\epsilon^{\rho x/v}\epsilon^{-rx}=\epsilon^{-rx}\epsilon^{-Kt_1/S},$$

and therefore

$$V=e_0\epsilon^{-rx}\epsilon^{-Kt_1/S}-e_0\epsilon^{-\rho t}\left\{F_1\frac{\sigma}{\rho}+F_2\frac{\sigma^2}{\rho^2}e_1''+F_3\frac{\sigma^3}{\rho^3}e_2''+\ldots\right\}. \tag{159}$$

This is an alternative form of the solution (115) of the same problem.

An important reduced case is $\sigma=\rho$, or no leakage. Then $e_0=e$, and is steady. We get

$$V=e-e\epsilon^{-\sigma t}\{F_1+F_2e_1''+F_3e_2''+\ldots\}. \tag{160}$$

If we desire the expansions to be entirely in rising powers of $1-x/vt$, like (152) in fact, then the operand $\epsilon^{\rho t}$ or $\epsilon^{\sigma t}$ should be expanded first, and integrated term by term. Thus, instead of (153) and (154) we shall get

$$V=e\epsilon^{-\rho t}\left[1+\rho t_1+\frac{\rho^2t_1^2}{\lfloor 2}+\frac{\rho^3t_1^3}{\lfloor 3}+\ldots+\frac{\sigma x}{2v}\left(\sigma t_1+\frac{\sigma\rho t_1^2}{\lfloor 2}+\frac{\sigma\rho^2t_1^3}{\lfloor 3}+\ldots\right)+\frac{\sigma^2x^2}{8v^2}\left(\frac{\sigma^2t_1^2}{\lfloor 2}+\frac{\sigma^2\rho t_1^3}{\lfloor 3}+\frac{\sigma^2\rho^2t_1^4}{\lfloor 4}+\ldots\right)+\ldots\right]. \tag{161}$$

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Now rearrange in powers of $t_1$, and we obtain

$$V = e\epsilon^{-\rho t}\left[1 + \left(1 - \frac{x}{vt}\right)\left(\rho t + \sigma t\frac{\sigma x}{2v}\right) + \frac{1}{\lfloor 2}\left(1 - \frac{x}{vt}\right)^2\left(\rho^2t^2 + \rho t\sigma t\frac{\sigma x}{2v} + \sigma^2t^2\frac{\sigma^2x^2}{8v^2}\right) + \ldots\right].$$

This is when $e$ is constant. And in the other case, instead of (157) or (159) we obtain

$$V = e_0\epsilon^{-\rho t}\left[1 + \left(1 - \frac{x}{vt}\right)\sigma t\left(1 + \frac{\sigma x}{2v}\right) + \frac{1}{\lfloor 2}\left(1 - \frac{x}{vt}\right)^2\sigma^2t^2\left(1 + \frac{\sigma x}{2v} + \frac{\sigma^2x^2}{8v^2}\right) + \ldots\right], \quad (162)$$

where $e_0$ is constant. It follows from the previous equation by changing $e$ to $e_0$, and putting $\rho = \sigma$ inside the square brackets.

Expansions of this sort, which are so easily obtained, and in a variety of cases, are useful in calculating the initial stages of the development of waves, whether due to impressed force or to an initial distribution of charge or current. It is not desirable, then, to exhibit the $\epsilon^{-\nu x}$ term separately.

*(To be continued.)*

## ON CRITICISM AND ON THE SEAT OF E.M.F. IN A CELL.

BY DR. OLIVER LODGE.

There seems to be an impression in the minds of some of our technical friends that the meetings of Section A should be conducted on the lines appropriate to meetings of the Royal or other great publishing Societies, and that the contributions read by the members should be in the form of solid Papers written out long beforehand, passed by referees, and solemnly read either by the author or by an official secretary. On the other hand, the contributions thought most appropriate by the leaders of Section A are brief and vivid oral expositions of the main results of an investigation, with only enough detail to make the methods intelligible; and the chief value of the meeting is held to lie in the rapid impromptu discussions which sometimes arise, even though the connection between them and the "Paper" from which they arose is anything but obvious at first sight.

This divergence of opinion as to the methods appropriate to a unique gathering of leaders of science from many parts of the world usually finds subsequent expression in the technical Press, which is liable to contrast unfavourably the manner of Section A with the manner of Societies and Institutions who meet regularly for the purpose of going into minute details, such as are necessary and interesting to those engaged in the practical application of science.

But the manner of Section A, whether mistaken or otherwise, is not due to casual laziness; it is definitely thought the method best adapted to a body engaged at the high-water mark of scientific progress, and in the presence of many of the recognised leaders of the world's physical science.

It might be expected, also, that the general public would be interested at seeing science in the making, and at hearing fresh ideas spring spontaneously from the lips of Kelvin and Stokes and FitzGerald; but, on the contrary, we find this exciting phenomenon referred to as a *"degeneration" of the discussion into "a triangular word-war." As if the critic had just entered the room, and concluded that the sparks being then and there struck out of genius, for the enthusing of scientific work throughout the greater part of the ensuing year, were but the signs of some sort of public-house squabble.

Another example of a different kind of airy criticism is to be found in Mr. Swinburne's second Cantor lecture, as reported in *The Electrician*, pp. 694-695, on the subject of the seat of the E.M.F. in a voltaic cell. "There is not any," says Mr. Swinburne; and proceeds to show how he has allowed the elementary notion of a cyclic or many-valued potential function to confuse his mind.

To illustrate his views of the galvanic circuit he proceeds to use something less "familiar," viz., a magnetic circuit; but when illustration is desired it is surely better to take our example from something still more familiar, and if Mr. Swinburne had employed a water or air circuit he could hardly have fallen into a mistake.

Consider, then, a simple closed pipe circuit completely full of water, with a pump at some place occupied in pumping the water round and round. To simplify matters the pipe circuit may all lie horizontal, so that gravitation shall not introduce apparent (but really non-existent) trouble, and the pump may be either an ordinary force pump, or it may be thought of as an endless screw embedded axially in the channel of the pipe and rotated from outside.

At the pump, energy enters the circuit from outside, and *there* is located the seat of the water-motive-force. The water moves round and round the circuit in obedience to the propulsion, and expends its energy in overcoming friction or other obstacles, especially at the throttles of the pipe; and it may be easily thought of as propelling other screw motors and doing other work on its way. The water will be flowing from places of greater pressure to places of less pressure continually (this will be accurately true if the pipe is full of shot or sand, or other adequate resistance, but it may be sufficiently true for illustrative purposes even in a free-bore pipe):—the water is being everywhere urged forward against friction by a force behind it, and it is likewise flowing round and round, exactly like Mr. Swinburne's electric or magnetic units; but would he therefore argue that the hydraulic pressure at any part of such a pipe has no definite value, or that a pressure gauge could not measure it? Would he further say that the locality of the water-motive-force region is not perfectly definite, and indeed that it was non-existent?

As a matter of fact, there is now no real controversy about the seat of E.M.F. in a voltaic cell: the controversy has been settled. The propelling E.M.F. exists wherever energy enters the electric circuit; chemical energy, as well as heat energy, can enter at a liquid-metal junction; heat energy alone can enter at a metal-metal junction. At these places chemical combination occurs with inadequate production of immediate heat; or else heat itself, the heat of surrounding objects, disappears and is converted into electrical energy on the spot. At other places chemical combination may be undone, or heat may reappear; and at these places there is an opposition or back E.M.F. Or the E.M.F. may be produced magnetically (either forward or backward) by the inclusion of dynamos or motors in the circuit, and these may be likened hydraulically to centrifugal motors and pumps.

So far for a closed circuit. But now cut the circuit, or introduce an obstructive partition across the pipe, and study the behaviour of pressure gauges on either side of the infinite resistance. If the pressure gauges communicate freely with the liquid they will show its correct pressure; and in that case an exploration would lead to a detection of the seat of the maintaining force; but if the gauges have variable elastic membranes across their mouths, or are otherwise kept out of immediate communication with the interior of the pipe, their indications may be misleading.

An open voltaic circuit studied with an electrometer may show what appears as a difference of potential between the copper and the zinc in contact. More accurately, the air in the neighbourhood of the copper and the air in the neighbourhood of the zinc are found to be at different potentials directly the zinc and the copper are put into contact. This is a true phenomenon, and is capable of ready explanation, but it has nothing to do with the seat of the E.M.F. in the voltaic circuit. It is an electrostatic side-issue, depending on the different boundary effects between copper and air and between zinc and air; just as the E.M.F. in the circuit itself depends on the different boundary effects between copper and acid and between zinc and acid.

The whole thing is luminously clear at the present day, whatever the text-books so far written may say about it; and it is a little late for a Cantor lecturer to deny the existence of so well-known a phenomenon on the strength of a subjective mental confusion brought about by the consideration of many-valued or cyclic functions.

[* Our readers will better appreciate the point of these playful observations by referring to the account of the proceedings of Section A, published in *The Electrician*, September 25th.—ED. E.]

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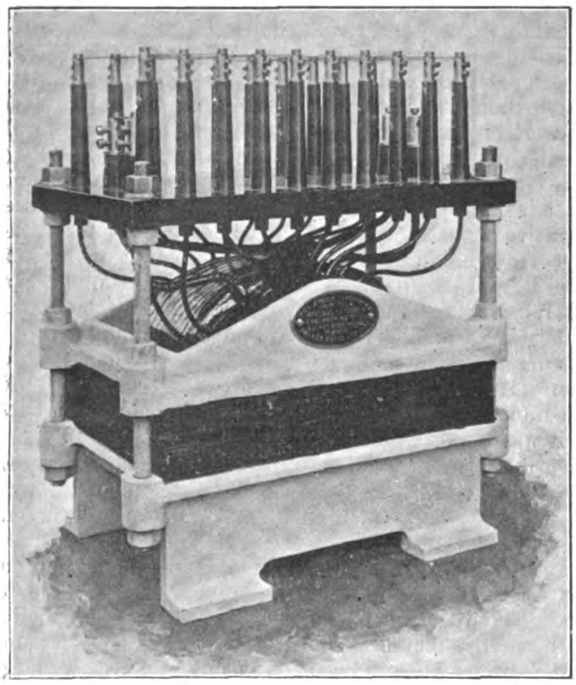
## A 10,000-VOLT TESTING TRANSFORMER.

There is considerable demand for a conveniently arranged transformer for cable testing and laboratory purposes, especially for one that will develop a moderately large amount of power at high pressure when run off ordinary 100-volt alternating supply mains. The need for such an apparatus has been met by a transformer recently designed by Mr. Mordey, and now being manufactured by the Brush Electrical Engineering Company. The accompanying illustration shows the general arrangement of this transformer. By grouping the secondary windings in various ways from 200 to 1,000, and by successive



The Brush 10,000-Volt Cable Testing Transformer.

steps of 1,000, up to 10,000 volts can be obtained on the secondary terminals. The rated output is 6 kilowatts. We understand that the transformer may be used for Röntgen ray experiments, but that its use for this purpose is attended with more personal risk than the use of ordinary spark coils, owing to its greater power.

## OLD CABLE STORIES RETOLD.

BY F. C. WEBB.

*The Persian Gulf Cable of 1864.*

Thirty-two years ago! Thirty-two years seem a tremendous period in the history of submarine telegraph engineering! That most important branch of civil engineering only dates back to 1850, say 46 years ago. And yet, what has been done during those 46 years? North Sea, Irish Channel, Mediterranean, Red Sea, Atlantic North and South have been traversed by submarine cables; and, not content with that—not content with crossing channels, seas and oceans, where land lines could not possibly compete—submarine cables have beaten the land lines by fringing South America, Africa and several other continents with their audacious, full, black lines on the maps. But to carry out all these splendid works a generation of engineers and electricians has gradually been born and educated. I feel that they would and will scorn anything written by their "great-grandfather" on cable work generally, only perhaps they have never, with all their experience, laid 1,300 nautical miles of heavy telegraph cable *from large sailing ships* in tow. Therefore, I feel this—that though many may scorn what I write, yet others may learn; for they can never tell when it may again become cheaper to lay cables from sailing ships in tow, rather than from steamers. Time will show. Cables of hundreds, nay thousands, of miles in length have been laid since then in deeper water, under greater difficulties and more stringent conditions of supervision, without any mishap of any kind. In fact, since then (1864) the laying of cables has become to the public such a matter of humdrum engineering that the process seems almost classed with the laying of the permanent way on a railway, the cuttings and embankments and tunnels of which have been already prepared; or, we will say, the making of a macadamised road in the suburbs of London. Who cares about a submarine cable being laid from Europe or Africa to America? A brief paragraph appears in a morning paper, and announces that a telegraph cable has been laid, say from Africa to South America; scarcely anybody takes the slightest notice of or feels a particle of interest in the subject. The shareholders, perhaps, watch the price of the shares; the Directors watch the reports of their engineers and contractors, and, if all goes well with the cable, engineers, certifying electricians, contractors, Directors, shareholders, the Press and the Stock Exchange, another cable is soon suggested by an engineer, projected by a Director, endorsed by a contractor; an additional line in due time appears in the maps across the northern or southern hemisphere (as the case may be), with a certain amount of profit to the contractor and a more or less certain profit to others. But during these various operations the energetic engineers and electricians of the contractors see at every expedition some improvement that can be made in the general machinery for paying out, &c., including the important part of buoyage and moorage of buoys, and the electricians foresee what can be improved in the "shore-to-ship" testing arrangements. Again, the eagle-eyed and conscientious engineers and electricians who act on the part of what may be termed the *buying* side—that is to say, the companies for whom the cable is to be laid—are constantly discussing, inventing and scheming every possible honest way that may enable them to prevent even the fraction of an ohm of insulating resistance per "knot" (Oh! how I hate that word!) passing where it ought or ought not to be; or the hundredth part of a degree centigrade of temperature being allowed one way or the other, whether "in the tanks," or "on board ship," or *at the bottom* of the deep blue sea after one month, as to the resistance of the copper or the gutta-percha, without any remonstrances to the contracting company.

With this preamble I will start right away to describe the laying of the Persian Gulf cable in 1864. For the political and engineering reasons for laying the cable from Kurrachee to Fao I must refer readers of *The Electrician* to the issue of July 9, 1886. It had been decided on by the British Government, on the advice of the Indian Government, to lay a heavy cable from Kurrachee, the western terminus of the Indian land telegraph lines, to a place called Fao, a miserable little village on the banks of the Shat-el-Aral (River of the Arabs), which river is the result of the confluence of the sacred and historic rivers, the Euphrates and the Tigris, fifty miles above Fao. The cable was to touch at Gwadur, on the Meckran Coast, then at Mussendom, on the Arabian Coast, from thence to Bushire, the seaport of Persia, and then finally on to Fao.

The Indian Government entrusted Major Patrick Stewart, R.E., with practically a *carte blanche* to carry out the whole work. He was previously a very distinguished officer in the Bengal Engineers, who had carried the land lines on poles from the rear to the front as the army advanced to the relief of Lucknow, and this at times under round shot fire from the mutineers. Colonel Stewart engaged Sir Charles Bright and Mr. Latimer Clark, then in partnership, as engineers for the Indian Government, and decided not to give the making and laying of the cable to any one single firm, but to have the cable made, and the Government to lay it at their own risk.

The gutta-percha-covered conductor was ordered from the Gutta-percha Company in Wharf-road, and Mr. W. T. Henley obtained the contract for covering it with serving, iron wires, and the "Bright and Clark" serving and compound. The conductor was 225lb. per nautical mile, with three coatings of

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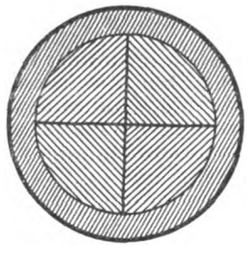
gutta-percha with Chatterton's compound, weighing 275lb. The conductor was made on a pattern suggested by Mr. L. Clark, which was supposed to fulfil the conditions of a strand with the smaller surface of a circular conductor. It was formed of five sections, four in the form of a quadrant in section, held together by the fifth, which had the section of a ring, as shown in figure below, in fact a tube. The lengths of about 4,000 yards were tested in tanks at the Gutta-percha Works for insulation at a temperature of 24°C., and gave about 230 millions of Siemens units per knot. A serving of soft yarn, untarred, followed, and 12 No. 7 galvanised iron wires formed the sheath, which was again protected by two layers of hemp, pitch, lime and silicon. The completed cable weighed 3·75 tons per nautical mile.

The Government chartered four sailing ships, as follows :— The "Marion Moore," 1,036 tons; the "Kirkham" (iron), 1,061 tons; the "Tweed" (formerly the "Punjaub," paddle-wheel frigate, but converted into a sailing ship), 1,744 tons; the "Assaye" (also formerly a paddle frigate, but converted to a sailing ship), 1,528 tons; and the "Cospatrick," 1,199 tons.

The Government also bought the screw steamer "Charente," of 441 tons, and rechristened her the "Amberwitch." This vessel was fitted with tanks, bow and stern sheaves, picking-up machine and paying-out gear; and the sailing ships were fitted each with three tanks, stern sheaves and paying-out gear. Newall's cones and rings were used. The cones were of wood, and the rings of gas pipe, with radial arms and pieces of pipe clasping the arms near the ring, and passing through holes in the deck and castings on the deck above. These castings had clamp-screws, so that when the rings were lowered the straight pieces could be clamped into that position to prevent the ring being thrust upwards by the cable when paying out, which it



was likely to do when the outer coating of the cable caused it to stick to the flake below. The paying-out drums were all overhanging, as was that of the picking-up machine on the "Amberwitch." This had internal spur gearing, and a knife fitted to the afterpart that could be allowed to fall down, by pulling out a large cotter, in order to allow the turns of cable to be taken off the drum. This was, I believe, the first example of an overhanging picking-up drum, or of internal spur gearing on the drum itself. By this arrangement no strain came on the spokes of the drum and no torsion on the shaft that carried the drum.

The cable was hauled on board the ships off Mr. W. T. Henley's works, two ships at a time being loaded in some cases. When all the cable was on board each ship she was towed into the Victoria Docks, and 3in. decking laid on sleepers over the coils. The decking was caulked. Each ship was fitted with a centrifugal pump, worked by a small engine, in order to pump up the tanks from time to time after it had become necessary to run the water off to change it. The ships left the Victoria Docks in the following order: The "Marion Moore," August 15, 1863, with 174·92 nautical miles of deep-sea cable, Mr. E. Donovan in charge of the cable; the "Kirkham," September 13, 1863, with 181·25 nautical miles of deep sea and 6·34 nautical miles of shore end, Mr. Walker in charge; the "Assaye," with 367·98 nautical miles of deep-sea, Mr. J. T. Woods in charge; the s.s. "Amberwitch," with 12·5 nautical miles of shore ends and tapers, Lieut. Arthur Stiffe, I.N., in command, on October 21, 1863; the "Tweed," with 347·53 nautical miles of deep sea, on October 24, 1863, Mr. Moseley in charge; the "Cospatrick," with 103·15 nautical miles of deep-sea and 23 nautical miles of shore end and 12 nautical miles of double shore end (that is, with two conductors for Bushire). I have not the date when this ship left. This ship had also five separate mile lengths of experimental cables of different types by different manufacturers and patentees, to be laid and tested in the Persian Gulf, and where eventually laid, tested and reported on by me in 1865. The total length of cable shipped was therefore 1,228·27 nautical miles, excluding the lengths of experimental cable. The ships arrived at Bombay in the following order: "Marion Moore," December 22, 1863; "Kirkham," January 13, 1864; "Tweed," February 6, 1864; "Assaye," February 12, 1864; "Amberwitch," March 2, 1864; "Cospatrick," April 16, 1864.

As soon as the "Marion Moore" and "Kirkham" had arrived the decking was removed from the coils, and the paying-out machinery which had been stowed below for the voyage round the Cape, was re-erected. On January 21st the Indian Government corvette "Coromandel," having on board Col. Stewart, his brother, Capt. Stewart, Sir C. Bright, Dr. Esselbach and Mr. A. Brasher, left Bombay for Gwadur; and the same evening the "Kirkham," in tow of the "Zenobia," paddle frigate, and the "Marion Moore," in tow of the "Semiramis," paddle frigate.

The ships arrived at Gwadur January 29th, and were met by the "Victoria" and "the Clyde," gunboats. The "Kirkham's" cable had to be laid first, as she had on board the shore end for Gwadur. It was found she could not approach nearer than three miles to the landing-place. To land the shore end from boats would have been difficult; the "Clyde" was therefore used, her heavy gun being shifted from the after-deck to forward, and the cable coiled where the gun had been. For a brake the "holding-back gear" of the "Marion Moore's" paying-out gear, consisting of a V-sheave and brake, with jockey-pulley, was used, and answered very well. Two miles of cable were coiled into the "Clyde," and half-a-mile into each of the "Zenobia's" paddle-box boats. The end being landed, and all the shore-testing arrangements made under the supervision of Mr. J. Laws, the electrician, and his assistant, Mr. F. Lambert, paying out commenced, the "Kirkham" being in tow of the "Zenobia," in command of Lieut. Carpendale, I.N. Of course, as the motive power was not in the cable ship, it was impossible to stop as quickly as in a steamer, where the engines can be reversed. To signal to the towing ship we used a *white* hand-flag for "go ahead," a *blue* one for "ease her," and a *red* one for "stop her," and at night the same colours with lanterns. It was also necessary to be able to converse, and this we did by (Morse) dot and dash; at night by a lantern with shutter, which was kept *closed* by an elastic band and opened by means of a handle. This was suggested by Mr. Walker, one of our staff. For the day an arrangement was constructed by which, when pressing a handle, a white dot about 6in. in diameter, appeared on a blackboard. The Morse alphabet was thus possible by day and night. We had telegraph operators on board the "Zenobia" as well as in the cable ship. The system answered very well, and was soon taken up by the officers of the men-of-war, who soon learnt to "read" and "send," and at one time in Gwadur East Bay, the "Assaye," "Zenobia" and "Amberwitch" were constantly flashing signals between them at night, thus saving a lot of work in sending away boats. I believe this is about the first time that the dot and dash Morse was used for signalling at sea. I should be glad to hear whether this can be contradicted.

We payed out at first at about 4·75 knots per hour. At 5 a.m. of February 5th we changed from fore to after hold. To do this safely we rehearsed. When there were only three or four flakes of cable left in the tank we stopped the towing ship and counted the turns of cable which ran out by the time the ship entirely lost her way. It was very tedious and very curious. Then going on again we stopped when a similar length of cable was left in the hold, which allowed the cable to slowly pay out until it was perfectly tame and could be handled for the change. This plan answered very well, and was adopted on every change of hold throughout the expedition. On the 6th, at 11 a.m., we had payed out all the cable but about half a mile from the "Kirkham," and the "Marion Moore" was anchored on our beam. The end of the cable that we had laid was then passed (by means of hawser and boats) to the stern sheave of the "Marion Moore," and then spliced on to the cable in the "Marion Moore's" fore tank. It

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took till the 7th to transship the men, telegraph instruments, and various ropes and apparatus. At 9:45 a.m. of the 8th we anchored off Ras Jask, and started paying out at 6:30 p.m., so as to make the land near Malcolm's inlet, on the Arabian coast, by daylight of the 9th. We anchored in this magnificent harbour at about noon of the 9th.

I suppose that some day, say two or three hundred years hence, civilisation will spread to the coast of Arabia. When it does, let us hope that the British Government will seize on this magnificent harbour, and its twin brother or sister, called Elphinstone inlet. The time must come. We invade Africa on every side, but Arabia seems to hold its own and remain impenetrable.

We landed the cable. We had laid altogether 361·83 nautical miles of cable; but it was not until February 13th that we finally landed the end, with a salute from the guns of the "Zenobia." Then we (Mr. Laws, self, and staff) returned on board the "Marion Moore" in tow of the "Zenobia" to Bombay.

On the passage we each had an *un*patented log of our own invention, some electrical and some mechanical; but we each watched our own children, and we were very jealous of any interference with our own particular child.

To be on board a large sailing ship in tow of a man-of-war is the most extraordinary situation I have ever been in. Nobody on board is responsible for anything. The captain of the ship you are in feels, after bringing his ship safely round the Cape of Good Hope, he has done his duty, and now, finding his ship in tow of a *Government* ship which is thoroughly responsible, and a safe party to pay for damages if anything wrong occurs, feels a lightness of heart that is absolutely indescribable. He improvises concerts and all manner of entertainments. You glide along. There is no screw or paddle thrashing or pounding away. I don't know which I hate or love the most, the irregular *pum-pum* of the paddle, or the monotonous but more regular *hum pum pum* of the screw. Your readers will understand that it is not a usual situation to be without sound of paddle or screw or any shouts of "hard-a-starboard" or "port," or "steady," or "stand by" here or there, or "let go" this or "hold on" that. Yachts are not in it. Even in a sailing yacht there must be *something* going on on deck: something must be let go, and the slack rope falls in a lump just over your head on the deck within a foot of your nose, just as you hope to get a wink of sleep. Or they "go about," and begin shifting ballast. But to be in tow of one of Her Majesty's Indian Government ships is the most tranquil manner of gliding through or over the Indian Ocean. Having given your readers some idea of the laying of cables from sailing ships in tow, it will be of very little interest to describe the laying of the cable from Elphinstone inlet (where there is another magnificent harbour) to Bushire, from the ships "Tweed" and "Assaye," as the operation was a repetition of the laying of the Gwadur Mussendom section. The two harbours mentioned are separated by a narrow isthmus, across which a land line was laid, and from the shore of the isthmus in Elphinstone inlet a short piece of cable was laid to a small island in the inlet itself, on which the station was to be built, but which had to consist of tents, &c., for the present. Two old 10-gun brigs were moored on either side of the island to protect the station in case of any attack from the Arabs. The "Tweed" payed out from the island towards Bushire until all her cable was out, when we anchored and awaited the arrival of the "Assaye" in tow of the "Semiramis." This splice was about 32 miles from Bushire. At Bushire the "Amberwitch" was employed to land the end of the ordinary deep-sea cables; the double shore end, with two tapers, intended for the shore end here, being in the "Cospatrick," which had not arrived. This was afterwards laid by me from the "Amberwitch," and the other cable cut out and picked up. We landed the end of the Bushire-Fao section from the "Assaye" and payed out towards the landing place near Fao. When about nine miles from the landing place the "Assaye" was anchored. And then Mr. Laws reported a want of continuity, 92·5 nautical miles from end in "Assaye." This we repaired in the "Amberwitch," and the fault proved a clean fracture through the whole five parts, just as if it had been a solid conductor. No doubt the two ends had been in contact until the conductor shrank when immersed for some hours in the colder water at the bottom of the sea.

The landing place for the Bushire-Fao section was not at Fao, but on the sea coast outside the Shat-el-Aral and about four miles across flat land to Fao itself, which is situated close to the river. This four miles was constructed of trenched cable laid by Sir Frederick Goldsmid, who kindly undertook to superintend the native labourers.

To join the "Assaye's" cable to the shore we put nine miles on board the "Amberwitch," which was then anchored by Lieut. Stiffe as near the landing place as she could approach, this being apparently four miles. Five miles of cable were therefore coiled into two paddle-box boats and two barges and other boats. The next day the string of seven boats started paying out towards shore; but when the two barges and one paddle-box boat had been emptied, the whole of the rest grounded on the mud, about three-quarters of a mile from the shore—if a waste of a little dryer mud could be called shore. However, there was nothing else for it than to try and drag the bight ashore, that is to say, to keep hauling out of the boat two legs of cable. The first man out sank nearly to his waist. I followed, and then followed the rest. We could not stand, we could only sit or crawl on all fours. The men sat down and hauled at the bight, and I crawled and superintended as to when they had to crawl back and get hold of some more, and so on until the end was landed. A thunderstorm came on, and we had to walk four miles barefooted over hard mud and stubble to the village of Fao. Mr. J. C. Laws and self were the last and utterly alone; nearly dark; we had no coats, waistcoats, or trowsers on, nothing but shirt and drawers, no socks even. We had left all our garments in the boats. It was nearly dark, and the lightning was flashing about over our heads; and I recollect Laws, electrician like, saying, "Look here, Webb, we are the highest points on the plain," which was quite true.

The "Coromandel" (head-quarter ship), with Lieut.-Col. Stewart, &c., was anchored in the Shat-el-Aral, and sent boats to take us all on board. The next day we got off and payed out from the "Amberwitch" to the "Assaye," and on April 7, 1864, made the final splice of the Bushire and Fao section. On April 8th we spoke through from Fao to Bushire.

Col. Stewart and Sir Charles Bright now went up to Bagdad, and placed me in charge of laying the Gwadur-Moiree section. We got to Gwadur (east bay) on April 28th, and on May 3rd at 5 p.m. began paying out from the "Assaye" in tow of the "Zenobia" towards Moiree (a point about 17 miles from Kurrachee). We knew that we had only enough cable to go a certain distance towards Moiree, and that then we should have to cut and buoy and make for a rough harbour called Ormarra on the Meckran coast, and wait until the arrival of the "Cospatrick" with the last balance of cable. We payed out accordingly as usual from the "Assaye" in tow of the "Zenobia," until we eventually buoyed with double buoys; that is, one buoy a quarter of a mile from the end and the other on the end. This is an old precaution of mine. I could write volumes on it; but at any rate in this case it proved, as it has done many and many a time before, a proper precaution.

In paying this length of cable—viz., 159·81 miles—we had one incident worth notice. I was going to say worth recording; but it is already "recorded" and printed in my report to Lieut.-Col. Stewart—from which I will quote from page 29—"A little after daylight we sighted Astola, and the 'Amberwitch' took up position No. 2, which we passed about 8 a.m. We passed the 'Amberwitch' in position No. 3 about noon; No. 4, position about 4; and sighted her about to take up position No. 5 at 6:30, but we kept considerably inside her."

This quotation may appear like Greek or Hebrew to many who have laid more and longer cables than I have; but the reason is this—I am a civil engineer, and do not do things haphazard. When we laid the Hague cables in 1853, we put down buoys every 10 miles to prevent the ship being swept out of her course by the tide, &c.

In the case in point the sea between Gwadur and Moiree deepens very rapidly along a line running nearly parallel to the Meckran coast. The problem was to lay a comparatively

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heavy cable along the top of a submarine cliff. It was, therefore, arranged that Lieut. Stiffe, in the "Amberwitch," should go ahead and sound out at certain positions to a certain depth, and then anchor or make signals so as to keep us off the edge of the cliff. At first, it was intended to have buoys laid; but this was eventuallly abandoned for the system pursued, which was most carefully and energetically carried out by Captain Stiffe. The "Amberwitch," in fact, acted like a guide to us, keeping us out of the deep water, in which it was never intended to lay the cable.

I quote again from my report:—"A little later we saw every indication of a squall from the W.N.W., which with very little warning burst on us about 7 p.m., accompanied by a little rain, some lightning, and a fearful quantity of fine sand, which enveloped us in such solid darkness that we could not see even a trace of the 'Zenobia's' lights, although she was close under our bows, the hawsers being so slack that Lieut. Carpendale thought we had cast them off. Both ships broached to, in spite of their helms, and the 'Assaye,' with her helm hard up, and the fore-topmast staysail set headed for some time due north, or nearly at right angles to her course. Before the awning could be furled the foremost part of it, which has no stanchions between the mizen and main rigging, to which it extends, had been caught from underneath by the wind, and bellying up into an arch reaching nearly as high as the mizen top, then, with a report like that of a heavy gun, carried away, snapping all the strong iron stanchions abaft the mizen mast short off like carrots, carrying them up into the air and dashing them down on deck on the leeside of the brake machinery, burying the latter in the wreck. 'Fortunately, and almost miraculously, although the quarter-deck was crowded with the 'watch below,' just called to attempt to furl awning, no one was hurt. During this time the ships were being blown along at the rate of 8½ knots, as indicated by the brake, which was revolving at the rate of 45 revolutions a minute. Fortunately, the ridge chains, awnings, and ropes were cleared with great smartness by our men from the brake before anything caught on the cable itself, although for a considerable time the ridge chain was actually resting on the revolving drum. During the whole of this time all communication with the 'Zenobia,' which we had hitherto kept up so successfully by means of the telegraphic lantern, was entirely cut off by the intense darkness, the last message sent before total eclipse being one from myself to Lieut. Carpendale, requesting him not to get blown into deep water. Fortunately, the squall had caught us on the port quarter, so that when we broached to we headed into the land. Had it caught us on the starboard quarter we should have headed seawards, and might have got off into deep water. For a short time during the commencement of the squall the 'Zenobia' was on our weather bow, but she shortly afterwards drifted to leeward, where she was when we first attempted to telegraph after the squall had moderated. It was fortunate that the squall did not occur a couple of hours later, as in such case we must have let go the end without buoying it, as it would have been impossible to head the ships to the wind or check their way in any manner sufficiently to attach the buoy chains, and we should have only been able to leave buoys near the end, which would have involved grappling for the cable afterwards. The wind died away nearly as rapidly as it came, and at about 10 p.m. there was scarcely any, and that little heading us. As soon as we had only one mile left in the hold a blue light was burnt from the 'Assaye,' which, had the wind been otherwise than ahead, was the signal for the 'Zenobia' to round to head to wind, but this evolution was now rendered unnecessary by the wind heading from N.N.E. When half a mile was left in the hold I eased and stopped the 'Zenobia,' and dropped our fore-topsail to check our way, and attached the first buoy at about a quarter of a mile from the end. Giving the ships a little way and checking again at the right moment, the buoy on the end was attached, and the end was successfully let go at 10.30 p.m."

We went into Oormara Bay, and on the 7th the "Cospatrick," the last of the five sailing ships with cable, arrived in tow of the "Semiramis." On the 9th I went out in the "Amberwitch" to find the buoys. One buoy, the one on the end, was gone; but by means of the other buoy, cutting, &c., we got the cable end on board the "Cospatrick," which ship had arrived out in tow of the "Zenobia." We then attempted to make a joint between the core of the cable laid and that of the cable in the "Cospatrick." I will here quote again from my report to Lieut.-Col. Stewart:—

"We here, however, experienced the same difficulty in making the gutta-percha joint as we had during the repairing operation between Fao and Bushire, and which I have fully detailed in my report to you on that expedition. After trying to make several joints, and cutting off all the spare cable of the submerged portion without success, we found it impossible."

I consequently passed the end of the submerged cable back to the "Amberwitch." We picked up mile after mile, cutting and trying to make a joint without success, the air left between the gutta-percha and the copper conductor being always squeezed out, and making the soft gutta-percha into a bubble. At last we tried a plan suggested by Mr. J. Laws, which answered perfectly.

I now quote again:—"It seemed feasible that if we could stop the air from oozing up from the submerged cable by throttling or choking the cores immediately on each side* of the joint, the formation of bubbles could not take place. The plan suggested by Mr. Laws consisted in having four pieces of hard wood, about 6in. long and about 1½in. thick, having each a semicircular groove in them, running longitudinally and rather smaller and shallower than that which would fit on to the gutta-percha covered wire. These were then clasped in pairs on the two portions of core to be joined about 2in. from the ends to be joined, and then lashed tightly together with all the force that a 'Spanish windlass' in the hands of a sailor can apply, so that the gutta-percha was squeezed up tightly in every direction to the copper wire, thus preventing the passage of any air."

This plan succeeded perfectly, and does great credit to Mr. J. Laws. We again spliced on to the cable in the "Cospatrick," and payed out towards Moiree near Kurrachee. The cable we knew could not now reach within ten miles of the landing place. We accordingly buoyed the end as usual. Afterwards we landed the end of the shore end cable from the "Amberwitch" by means of paddle-box boats, and payed out to the buoys, and made the final splice on the 15th, thus completing the cable through to Fao.

I have endeavoured to give a sketch of the laying of the Persian Gulf cable of 1864, but, of course, it is not a detailed account, as that could hardly be given within the limits allowed me.

## APPLIED ELECTRO-CHEMISTRY.†

BY JAMES SWINBURNE.

*Removing Tin from Scrap.*

As sheet tin has from 3 to 5 per cent. of pure tin, it is clear that if all the scrap could be collected and have its tin taken off, the process would be very valuable. Tin is a very expensive metal, worth, say, £80 a ton. If scrap tin is worth £1 a ton, £100 worth would contain £240 worth of tin, and the iron or steel would be worth considerably over £100. The presence of tin makes scrap tin useless as iron, but if it is completely removed the scrap can be worked up into good quality iron. My attention was specially attracted to tin by an inventor who came to me with a patent for stripping it. As the patent he owned seemed useless I worked out another process. This was not electric, and consisted in dipping the scrap in baskets into fused caustic. If old tins were used this also melted out the solder, and corroded labels and varnishes so as to get at and remove the tin under them. The resulting stannate of soda was to be sold in that state, as it is a marketable chemical. The scrap coming out of the fused caustic had a good deal of the caustic sticking to it. It would, on a large scale, therefore be washed in successive baths, getting weaker and weaker and ending in water; the liquid being gradually moved up into the fused vat to replace that removed as stannate. By this means the expense of evaporating down all the caustic that adhered to the tin could be kept down. This process works fairly well, but it is difficult to get the caustic to take up enough tin. The stannate thickens it very quickly, and the resulting mixture never contained enough stannate to be a commercial article. The tin could be easily removed from the caustic by electrolysis and came down well. This process seemed fairly promising, but at this stage it was found

* Each side was not necessary. † Cantor Lecture.—III.

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it had been tried before. A company had been formed to work it. Whether that company is now flourishing or not I do not know. As a matter of fact, the process is probably quite old, as it is fairly obvious, and the skinning of scrap tin has exercised a great fascination for inventors for years. As it was of no use going on with an old process another method was sought. Acid electrolytes attack the iron as well as the tin, and were therefore out of the question. Curiously enough, if sheet tin is used as anode in caustic soda solution, the tin does not go into solution; oxygen comes off. I had tried a number of experiments in 1882, with sheet tin as backing for peroxide plates in alkaline solutions, for secondary batteries. If sheet tin is boiled in caustic lye the tin is not attacked. If clean iron is dropped in, bubbles of hydrogen come off the iron, and tin goes into solution. Strangely enough, however, this process does not act, because very soon the clean iron gets coated with tin, and the action stops. It is very odd that tin should be eaten off one piece of iron and then deposited from the solution on to another piece. This gave the key to the electrolytic process. All that is needed is to heat the caustic bath. The anode no longer gives off oxygen, and the tin is stripped off perfectly and deposited nicely on the cathode. This process seemed perfectly successful; the next thing was to try it commercially. There are supposed to be thousands of tons of scrap tin wasted every year. It is said to be largely used for mending roads. When we tried to get it, none was forthcoming; and it seems as if the whole idea of there being an important industry in the recovery of tin from scrap is erroneous; the difficulty is to get the scrap. Makers of large tin goods sell their clippings to people who do smaller work, and, finally, the scrap is distributed in such a way that it cannot be collected profitably. The recovery of tin and lead from old cans might be carried on on a very small scale by corporations, but it is questionable if it would pay, owing to the quantities available. This is an illustration of the principle that the great difficulty of the inventor is to discover a long-felt want.

*Aluminium.*

It would be of little use, even if there were room for it, to write a long description of the manufacture of aluminium by the various electrical processes, as full accounts of the works at Niagara, and to some extent of the Swiss and French, as well as the English works, have frequently gone the round of the technical journals. It is very difficult to know what place aluminium will ultimately take in commerce. It is first to be marvellously strong, light and cheap metal, practically indestructible, and combining all the good points of all other metals; then it is run down as being soft, treacherous, easily corroded, and only useful in a few overrated alloys. The truth, of course, lies between these extremes. It is now becoming more generally realised that aluminium has really a very great affinity for oxygen, even at ordinary temperatures. The only reason why it does not combine with the oxygen of the air quickly enough to catch fire seems to be that the coating of oxide formed is very adherent and hard, and protects the metal. At the same time it is exceedingly thin, and so transparent that the metal shows a beautiful polish, though the surface is really covered with a crust of alumina. The presence of this thin crust is shown by the difficulty of getting solder to take on to it. The coating of alumina also makes it difficult to make electrical contact with aluminium unless enough force is used to abrade the metal and expose a new surface. I have utilised this property in connection with the telephone used as a galvanometer in a Wheatstone bridge or potentiometer. The telephone circuit is made and broken by scraping a wire over a piece of sheet aluminium. This is far more easily heard than the scraping of a wire over the teeth of a file, or anything of that sort. No doubt the copper wire only occasionally breaks through the coating of alumina, and makes a short contact which is soon absolutely broken by the coating of insulating alumina again. If mercury is placed on aluminium, and the aluminium scraped so as to expose a clean surface to the mercury, the mercury amalgamates it. The amalgam, however, cannot protect itself by an inherent coating of alumina, and the oxide forms in light growths of fluffy alumina. If a drop of fairly strong amalgam of alumina is left exposed to the air, the oxide will grow from the surface of the mercury into a thing like the "Pharaoh's Serpent," which children make by burning sulphocyanate of mercury, when their parents are foolish enough to let them. Caustic alkali, or any acid that dissolves the alumina, will corrode aluminium. Another old experiment which shows the coating of oxide is due to Farmer, who fused a piece of aluminium wire by means of an electric current, and found it kept its form as a perfectly flexible and mobile conductor, which could be deflected by a magnet, and so on. On pricking the wire with a needle the melted aluminium ran out from the inside. This experiment shows that even melted aluminium, which appears beautifully bright and remains clear like silver, is really protected by a surface film of alumina. The action of dilute acids, such as nitric and sulphuric, is very curious. Though aluminium does not deposit from the nitrate or sulphate in an electrolytic cell, hydrogen coming off instead, it is not at all quickly dissolved in dilute acid. I tried to make use of this property in an electrolytic meter for alternating currents. Two plates were to be employed in dilute acid, the aluminium going into solution at the anode during each half period, without being deposited at the cathode. No sample of aluminium that I could obtain was acted upon little enough by the acid when there was no current for such a meter to be accurate within commercial requirements.

Commercial aluminium loses greatly by being impure. Very slight traces of impurity spoil the metal. Commercial aluminium contains traces of silicon, sodium, carbon, and of other metals such as iron. A quarter per cent. or so of sodium is quite a common impurity, and may do great harm. It may not be diffused equally throughout the mass, but may be segregated. This not only makes the metal non-homogeneous, and provides veins or flaws of weak metal; but on passing from sodium to aluminium every grade of alloy from nearly pure aluminium to nearly pure sodium is traversed, and some of these alloys are certain to be brittle. Sodium must also have a great tendency to cause corrosion. Not only does sodium oxidise in air and decompose water, but the hydrate formed itself, dissolves alumina, and attacks aluminium, forming sodium aluminate. It is questionable if the contamination by sodium can be avoided in the electrolytic processes. There must be sodium present in the electrolyte, and the amount that goes into the metal must be rather a matter of current density and of the strength of the electrolyte in aluminium. Such impurities as carbon and silicon give trouble, not only because they alter the character of the metal, but because they are strongly electronegative to aluminium; and when they are exposed in small particles they form little local couples, and give off hydrogen, thus allowing the neighbouring surface to be oxidised. It would probably make a very great difference in the value of aluminium if it could be purified further. Ninety-nine per cent. aluminium is already a commercial product, but it would be worth much more if it were 99·9 or 99·99 per cent. of aluminium. There is a great opening for a cheap and efficacious method of refining this metal further. There are rumours of such a process recently brought out or set to work in Paris, but no particulars are to hand yet.

One of the great difficulties in the commercial use of aluminium and many of its alloys is that of soldering. The problem of soldering aluminium is like that of making motors for ordinary alternating currents; it is solved with a flourish of trumpets every week or two, but somehow commercial aluminium articles are found to be carefully designed not to need solder. One of the difficulties is to get a clean surface of metal exposed to the solder. The principle underlying the use of such fluxes as zinc chloride, rosin, or borax, is that they dissolve the oxide of the metal to be soldered, and of the solder leaving two clean surfaces to run together. Now, there are few chemicals which will dissolve alumina which will not also vigorously attack the surface of aluminium. There are, however, a few substances available, but some of them need such a high temperature to enable them to dissolve the alumina that the metal is softened. This prevents such fluxes being used for rolled or stamped aluminium work, as once it is softened a metal loses much of its value. A soldered vessel, for instance, cannot be re-rolled to harden the metal again. One method of getting the solder to stick is to scratch the aluminium under the surface of the solder. There are also several kinds of solder on the market which take on aluminium. This is not enough, however. To make soldering efficient it should not only adhere where carefully rubbed on, but should run easily and quickly into joints and crevices, as in sheet-tin, lead, or brass work. Once the solder has been got to adhere the joint may be quite useless. It is quite easy, for instance, to solder two pieces of aluminium together so that they will tear through the metal rather than through the solder. Similarly, a screw head may be soldered to sheet aluminium, and when torn off it will take a disc of aluminium with it rather than break the joints. Make these joints and examine them after a few months or even weeks, and it will be a very different matter. The solder appears to separate completely from the aluminium, or, at any rate, it comes off with the slightest force. I believe this does not happen with all samples. It may be due to sodium in the metal, or it may be due to an alloy between the solder and the metal being able to decompose water and thus being corroded. It is possible, for instance, a trace of sodium may help an alloy of aluminium and tin to decompose water. It is a curious thing that a failed soldered joint frequently has the same smell as iron has when acted on by dilute acid. This is generally said to be due to minute traces of hydrocarbon formed from the carbon in the iron, and there is very much less carbon in aluminium. The smell seems to be good evidence of the decomposition of water at the soldered joint. A soldered joint will also sometimes evolve gas very slowly if left in water for some time. There is another possible explanation which may be brought forward. The two explanations are not antagonistic, and the effects may work together. Aluminium alloys are generally very brittle, or even powdery, if they have a large proportion of aluminium and of the

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other metal. Thus aluminium with a little copper is a good alloy, and so is copper with a little aluminium; but an alloy of about equal parts is very brittle. Some of the alloys containing large proportions of aluminium and another metal tumble to powder spontaneously in a few weeks. If a metal or alloy is used as a solder, which forms with aluminium in any proportion a brittle or unstable alloy, the probability is the joint will go; for if you pass from the solder to the aluminium you must pass through strata of solder containing more and more aluminium until you are in pure aluminium; and therefore you must pass through a stratum of unstable alloy. This stratum must completely separate the solder from the aluminium; and if it is brittle, or if it spontaneously falls to powder in course of time, the joint must be bad. The obvious cure here is to use a solder that already contains more aluminium than the unstable alloys. Various solders of this sort are in the market.

As regards the uses of aluminium and its alloys, enough has been written in the various technical journals. As already suggested, the pure rolled or drawn metal may come into much more extended use when it is supplied free from impurities, such as sodium and silicon. There are other uses than mechanical to which aluminium may be largely applied in the near future. Its great affinity for oxygen, which is its worst characteristic in mechanical work, is its merit in chemical and metallurgical applications. A little aluminium greatly improves many cast metals. It may be that the metals contain dissolved oxide. Copper, for instance, is apt to contain dissolved oxide, which deteriorates it, and is stirred with a green pole before running off. [It was a Cambridge undergraduate who asked his coach if a blue pole would do as well.] It is quite possible that such traces of oxide are reduced at once by aluminium, and that the alumina is insoluble in the molten metal, and rises out at once. Aluminium can also be used to replace other metals, as it has a very strong affinity for oxygen, sulphur, and chlorine. Thus Vautin makes chromium by heating aluminium with a salt of that metal. Aluminium heated with sulphide of iron yields pure iron with no trace of carbon, a substance that is not familiar to many. As, in such cases, the products are not easily volatile, and as the action disengages a great deal of heat, enormous temperatures may be obtained in this way. In this way almost any metal may be obtained, as few have such avidity for oxygen, chlorine, or sulphur. The amalgam of aluminium, or amalgamated aluminium, can also be used as a reducing agent in organic chemistry. It decomposes water rapidly, and reduces many organic compounds. It was generally thought that water must be present for the reduction to take place. This is probably the remains of the nascent hydrogen notion of reduction. People saw bubbles of hydrogen come off zinc in dilute acid, and they found reduction of reducible salts took place, so they jumped to the conclusion that the reduction was the result of the nascent gas, not merely another effect of the same cause. Wislicenus and Kaufmann have finally shown that the amalgam works without water; absolute alcohol, previously freed from all traces of water by amalgamated aluminium, being used as the solvent. It is a question of price how far aluminium may come in in the organic colour industry.

There is a difficulty about electro-plating aluminium. It seems as if it might be possible by using a very high-current density, just as sodium can be deposited from caustic. It may also be possible to deposit an aluminium alloy from an aqueous solution, as alumina has great affinity for some metals, incandescing on alloying, just as sodium does when dropped into mercury. Various accounts of processes of plating aluminium from aqueous solutions have appeared, but I, for one, have never seen a decent sample of the results. It is, by another process, quite easy to coat iron or copper with either aluminium or aluminium bronze, and to produce a thick and impermeable coating which is quite permanent. This coating is rough, however, and has to be filed up and polished; and it is difficult to do this without occasionally getting through the coating down to the metal underneath. Such a coating may be very useful for large objects exposed to rough usage or to the weather, as merely sandpapered up or pickled it has a handsome appearance. The further cheapening of aluminium seems to depend on perfection of detail in manufacture which will be caused by keen competition. Cheaper methods, or, rather, cheapened methods, of producing pure alumina will gradually be introduced. There has been a good deal of talk recently aboutmaking aluminium from the sulphide; but it is difficult to say how far any sulphide process has been reduced to practice. It might give purer aluminium, and take less power. It might also save expense in anodes, as at present the anodes are burned just as much as if they were used for reducing alumina in a furnace. The use of sodium for replacing aluminium seems quite a thing of the past. There seems much more chance of aluminium being obtained by furnaces without electrical aid. The Cowles furnace really seems to work by temperature alone. The heats of combination do not necessarily settle whether an oxide will be reduced by carbon or not. It may be that the very high temperature is necessarily only to bring the carbon and alumina into contact. Either the alumina may melt, or the carbon may volatise. A solution of alumina in a haloid salt is not easily reduced by carbon, however.

*The Electrolysis of Fused Salt.*

The manufacture of sodium and chlorine, or sodium and bleach-powder, from fused salt direct seems so absurdly simple and easy, that it is a very tempting problem; and if there were not very much more serious difficulties than appear at first sight, such a process as the simple electrolysis of melted salt would very soon oust all others. If a simple method could be devised, sodium could be made at a few pounds per ton. It would be used in very large quantities for the reduction of aluminium, and for replacing iron in the making of cyanides for gold extraction. It would doubtless also be used in innumerable other processes where a cheap and powerful reducing agent could be employed. All this is, however, a small matter; caustic and carbonate would be made from the metal. Instead of a ton of caustic soda, a paper maker would buy 11½cwt. of sodium, which he would convert into hydrate by treating with water. At present we need hardly trouble ourselves about means of treating sodium with water by the ton. It could, of course, be done. The hydrogen might or might not be utilised, and in some cases it might be worth while to get electrical energy by using the sodium in cells. This is unlikely, however; and we are not yet sufficiently near the economical manufacture of sodium to discuss its uses at length. The difficulties in the way of the direct electrolysis of salt are enormous. In the first place it must be fused. If it is heated by a furnace it must be in a suitable vessel. Most kinds of stoneware and earthenware are attacked by fused salt, and are also likely to crack. Iron is the most promising material, but in time it will probably oxidise and scale away. The cost of thick cast-iron pots, something like those used in finishing caustic, might not be excessive. It might be possible to heat the salt by the current that electrolyses it. With a given fall of potential spent on the resistance of the electrolyte it is easier to keep a large vat hot than a small one, so this method can only be used economically on a large scale. The containing vessel may then be practically solidified salt. The anode does not give any serious trouble. Carbon is practically indestructible in fused chloride of sodium, as even hot chlorine has no action on it. If the salt contains any oxygen compounds, such as oxide of sodium, due to combustion of the sodium or sulphate of sodium, a carbon anode will, of course, be attacked and eaten away. The chlorine that comes off must be kept within some sort of hood; and this gives rise to a new difficulty. Red-hot chlorine, if one may use such an expression, is not at all convenient to handle on a large scale. Perfectly dry chlorine is said not to attack metals; and sodium will keep a bright surface in contact with dry chlorine. But though the chlorine from red-hot salt must be fairly dry it attacks metals at once. No metal can be used as anode in fused salt, for instance, and after it has come off the chlorine will attack, say, an iron hood. Then there is also difficulty in making good contact between the conducting lead and the anode, as the lead being metal cannot be in contact with the hot chlorine, and the carbon on the other hand must not be exposed to the air. On a large scale it is probable there will also be some difficulty in cooling large quantities of chlorine, as the chlorine must, of course, not be led into the bleach chambers already hot. The cathode itself of course offers no difficulty. Iron or, perhaps, copper can be used. Sodium, however, floats on fused salt. The surface round the cathode must therefore be covered in, and the sodium either collected and poured off, or distilled over. To distil sodium needs a fairly high temperature, which, other things being equal, is a drawback. A still greater drawback is that the sodium does not distil clean, but comes over mixed with salt vapour, and the sodium and salt are condensed together, making a mixture which is difficult to treat. The chief difficulty as regards the cathode is the hood. Such materials as porcelain are attacked by sodium or sodium vapour, so sodium must not come in contact with them. If iron or copper is employed, as soon as there is a layer of sodium on the top of the salt it makes contact between the cathode and the hood, and the further liberation of sodium is on the outside of the hood, where the metal burns. This not only means waste, but the oxide formed dissolves in the fused salt, and finally burns the carbon anodes. Porcelain hoods have been tried. Many kinds of stoneware or fireclay will stand fused salt well enough; but it does not follow that it will stand in an electrolytic vat. Apparently at the temperature of fused salt it conducts enough to be practically electrolysed. Poincaré gives the conductivity of hot porcelain as about a hundred-thousandth of that of fused salt. It may also be partly attacked by the rather mysterious subchloride of sodium, which is supposed to be produced. Such a compound may reduce silicates, just as sodium does. Borchers has proposed or used chamotte, which is, I believe, stoneware made of old fired stoneware, ground up and mixed with new slip, and again fired. I do not know what success this material secured. Another proposal is to use porcelain hoods both for the anode and the cathode, and to prevent any action by keeping



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them cool by water circulation. The hood is then coated at all vital points with a casing of cold solid salt, which is an insulator, and protects the porcelain from all attacks on the part of the salt, electrolysis, sodium, or sodium subchloride. Still, the close proximity of melted salt, red-hot sodium, chlorine, and cold water, with nothing but porcelain to separate them, must always be discouraging to a workman whose life is not insured. When all the difficulties so far mentioned have been successfully surmounted, there is still another drawback, and that is that probably there will be no sodium. If a small current density is used, no sodium will appear. It was most likely this phenomenon that led the earlier experimenters to suppose that fused electrolytes conducted without decomposition, like metals. What really happens it is very difficult to say. It is generally supposed that the sodium forms a subchloride, but a subchloride of a nomad element is a little difficult to believe in. Photographers are on very familiar terms with subhaloids of silver, so we must not be too sceptical about subchlorides of sodium. If the cathode is watched in a cell of fused salt, the liquid appears to be violently disturbed, and luminous red streaks come from the cathode. This looks rather as if sodium was being carried in clouds of small particles into the mass of the salt, and these combined with the salt with evolution of heat. If salt is taken from the neighbourhood of the cathode and cooled, and examined through the microscope, it is found to be full of black specks. On adding water there is effervescence. This looks as if the sodium was not in the form of subchloride, but in little metallic globules. The luminous clouds may be merely clouds of globules of hot sodium, the high temperature being due solely to the enormous current density in the immediate neighbourhood of the cathode. The presence of sodium or of particles that may be assumed to be sodium in the cooled salt does not show that they exist at the higher temperature. It is possible that subchloride of sodium exists at the temperature of melted salt, but splits up into normal chloride and sodium on cooling.

It is possible that sodium is not actually deposited against or on the electrode, but in the immediate neighbourhood only. If mercury is used as cathode in a strong solution of a lead salt, and a large current density is employed, it will be found that lead trees grow on the surface of the mercury. Mercury amalgamates clean lead at an enormous rate—so fast that if you agitate the cathode by touching the cell, trees several inches long will disappear into the mercury so quickly that the eye cannot follow the movement. If the surface of the mercury is watched, it will be seen that the lead is always beginning to form trees, but they are rapidly sucked in by the mercury. It appears as if the lead is not deposited into or really in contact with the mercury, but is thrown down in its immediate neighbourhood, and is then amalgamated by the mercury. If this is the case, it may account for the small yield of sodium from fused salt. It is possible the sodium is deposited in very small globules in the immediate neighbourhood of the cathode, and that a large proportion of it is swept away by the surging salt, and is eventually burnt on the surface of the electrolyte, or turned into salt again at the anode. The melting point of salt is reduced in practice by adding other chlorides, such as that of calcium, to the bath. Of course, only those chlorides can be used which do not deposit metals more readily than salt. It is quite possible that a little calcium is deposited with the sodium; but it is so difficult to make sodium commercially by this method that an inventor would feel quite encouraged if he obtained any sodium to speak of, even if it were largely contaminated with calcium. The difficulty, as regards the collection of sodium, has been overcome by Vautin in a very ingenious way. He uses a cathode of fused lead. According to Borchers, whose works are a veritable mine of information, this idea is old, as Rogers deposited sodium into lead and zinc in 1886-89, and published an account of his successful results. Vautin has gone further than this, however. The lead-sodium alloy is in connection with a second vat to which steam is admitted. This takes out the sodium, and if the steam supply is properly regulated pure fused caustic is produced, and has only to be run into drums and sold. This arrangement overcomes a great many of the difficulties inherent in the electrolysis of fused salt. There is no difficulty in collecting the chlorine, as the sodium does not also rise to the top of the vat. Lead sodium alloy is available for very many of the purposes for which plain sodium is employed. It would probably not pay to use it for getting aluminium, as the electrolysis and substitution would probably cost more than the simple electrolysis of a cryolite and alumina bath. It is available for the production of cyanides from potassium ferro-cyanide. As sodium has a lower combining weight as well as a lower price than potassium, sodium cyanide is, on the whole, preferable to potassium cyanide; and it is, I believe, just as good in gold extraction. It must be practically entirely ionised in the very weak solutions used in leaching gold ores; so the metal can hardly make any difference. As potassium cyanide is estimated by its cyanide, the metal being assumed, the use of sodium in the reaction with the prussiate of potash gives a cyanide which tests at over 100 per cent. This has astonished not a few analysts, but is pretty generally understood now.

## NOTCHING PRESS FOR ARMATURE CORE DISCS.

The following is an abstract of an article sent to us by Messrs. E. W. Bliss and Co., of Brooklyn, U.S.A.:—

"The extensive introduction of electric motors for power purposes in mills and factories has created a large and increasing

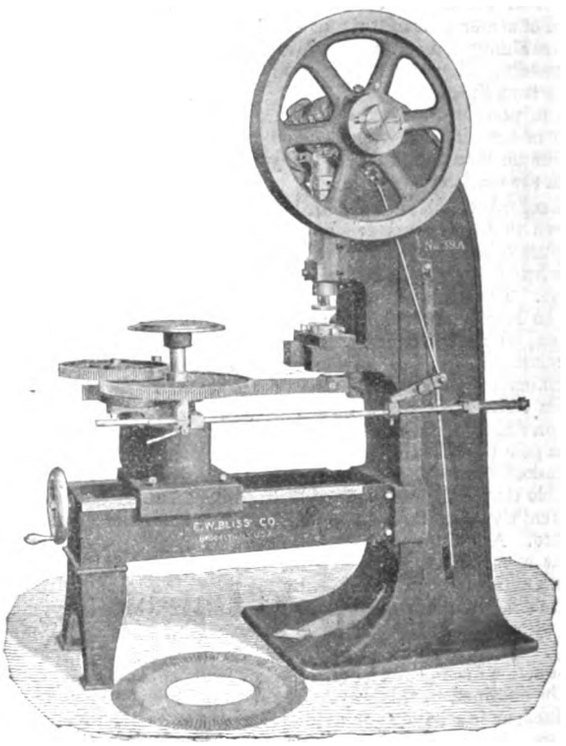

FIG. 1.—"Bliss" Automatic Notching Press for Armature Core Discs, without Clamping Arm.

demand for special tools and machinery for the accurate and economic production of the various parts entering into their construction. The most advanced American ideas in automatic presses

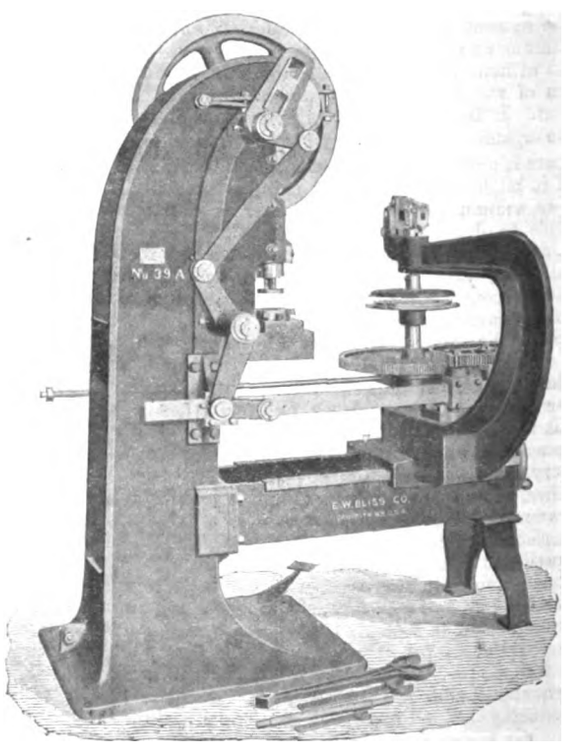

FIG. 2.—"Bliss" Automatic Notching Press for Armature Core Discs, with Clamping Arm.

for notching core discs for armatures are represented by a new machine introduced by the E. W. Bliss Company, of Brooklyn. This Company has, for a number of years, built presses with automatic

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index feed for this purpose, many of which are in use by the leading manufacturers in the United States and Europe. The present machine, however, is of entirely new design, and its makers claim for it important advantages over other machines directed to the same purpose. Its general appearance and mechanical principles may be seen from the accompanying illustrations (Figs. 1 and 2).

"The adjustment for different diameters is made by simply turning the hand-wheel shown, no alteration or readjustment of pawls or indexing parts being necessary. The number of notches is effected by means of chain gears, instead of the usual pawl and index-plate device. One gear only need be substituted to obtain any desired alteration in the number of notches. This obviates the necessity of using a special indexing plate for each style of disc, and effects a considerable saving, as the change gears are comparatively inexpensive. If one notch is punched at each stroke, the number of teeth in the gear corresponds with the number of notches in the disc. If two or three notches are punched simultaneously, the number of teeth in the gear is made one-half or one-third respectively of the number of notches. The index-feed is effected by means of a rack-and-pinion movement, which is more reliable and durable than the pawl-and-ratchet feed usually employed, and does not call for any adjustment for different diameters or numbers of notches. An automatic stop is provided, which throws out the clutch, thereby stopping the machine as soon as the disc has made one complete rotation. To start the machine the operator depresses the foot-treadle, after which he can attend to any other machines that may be under his charge, as the work goes on automatically and stops when the last notch is cut. This makes it possible for one operator to attend to several machines.

"A spring stripper is used in connection with the punches in this machine, so as to leave a clear space over the die, making it easier to introduce a new disc, and holding the disc under pressure while being punched. This obviates the necessity of using a clamping-plate over the centre of the disc, so that the time is saved which, in other machines, has to be spent in clamping and unclamping the disc. Such discs as have no key-notches or bolt-holes by which to carry the disc in feeding, of course, require a clamping-frame. In the few cases where the clamping of the disc is desirable, the machines are furnished with an arm, as shown in Fig. 2, which carries a device enabling the operator by a single movement of the hand-lever to do the clamping. This arm connects at its lower end with the frame carrying the mechanism for revolving the disc from notch to notch. The upper clamping-plate, instead of having to be taken off or put on by hand, as in machines of older design, is always ready for action without handling. Two regular sizes are made. One of these weighs about 1,500lb., will notch discs from 3in. to 36in. in diameter, and is designed to make from 100 to 200 strokes per minute, according to the work being done. The other weighs about 2,800lb., will take discs from 5in. to 48in. in diameter, and is intended to be run at about 100 revolutions per minute. This latter is also made, when so required, with extra large clamping and indexing frame, for discs of from 10in. to 60in. in diameter."

## MEASUREMENT OF ELECTRIC CURRENTS THROUGH AIR AT DIFFERENT DENSITIES DOWN TO ONE FIVE-MILLIONTH OF THE DENSITY OF ORDINARY AIR.*

BY LORD KELVIN, J. T. BOTTOMLEY, AND MAGNUS MACLEAN.

The apparatus used in these experiments consisted of (1) a cylindrical tube 13cm. long and 1½cm. diameter, with two aluminium wires as terminals ground to points 1·5cm. apart; (2) a large Wimshurst electrostatic machine of 24 plates; (3) a high-resistance mirror galvanometer to measure the current between the aluminium-point terminals inside the tube; (4) an electrostatic voltmeter, to measure the difference of potential between the terminals of the tube; (5) a five-fall Sprengel pump, by means of which the density of the air inside the tube could be reduced to any desired extent. The galvanometer was placed on a block of paraffin between one terminal of the electric machine and one terminal of the glass tube. Its deflections were read by a telescope, and its sensibility was arranged by external magnets, so that one division of deflection corresponded to 0·3 mikroampere. Our method of experimenting was to keep the density of the air constant while we varied the difference of potential between the terminals of the tube, and taking simultaneous readings on the voltmeter and on the galvanometer. The electric potential was varied either by varying the speed of rotation of the machine or by varying the distance between the needle-point terminals of the machine, or by a combination of both.

We found that at ordinary atmospheric density it requires a difference of potential of between 2,000 and 3,000 volts at the terminals of the tube before the galvanometer indicates any current. As the difference of potential is now increased, the current through the galvanometer increases at a greater ratio, so that if a curve be drawn with differences of potential as abscissæ and galvanometer readings or currents as ordinates, the curve is always concave towards the axis of current. Through this particular tube the currents at 3,000, 5,000, and 8,000 volts difference of potential were 7·2, 17·6, and 63·2 mikroampere respectively. As the density of the air was diminished, the difference of potential necessary to start a current, as indicated by the galvanometer, gradually diminished also, till, at a density of about $\frac{1}{1000}$ of the ordinary density, a few score volts were sufficient to start a current. For the same difference of potential the current increased as the density of the air diminished; or otherwise, the same current was obtained by smaller differences of potential as the density of the air was reduced. Thus a current of about 56 mikroampere was obtained by differences of potential of 7,400, 1,090, 700, 370, 405, 570 volts, when the densities of the air were 1 (ordinary density), 0·058, 0·0093, 0·0007, 0·00006, 0·000024 respectively; or otherwise, when the air pressures were 750, 44, 7, $\frac{1}{2}$, $\frac{1}{22}$, $\frac{1}{55}$ millimetres of mercury respectively.

As the air density was still further reduced, the difference of potential necessary to start a current increased, and the current for the same difference of potential diminished. Thus, when the density of the air was reduced to one five-millionth of the density of air at ordinary atmospheric pressure and temperature, differences of potential of 3,000, 5,000, and 8,000 volts gave currents of 1·3, 4·4, and 14·6 mikroampere respectively. If a curve be drawn for a constant difference of potential, with air densities as abscissæ and currents as ordinates, we find the curve rising as the air density is diminished to about $\frac{1}{1000}$ or $\frac{1}{1500}$ of ordinary density; then falling again as the density is still further reduced to about a five-millionth of ordinary density. This is the lowest density we have experimented with; but we have no reason to doubt that at very much lower densities we would still be able to get measurable currents through the tube. We are now experimenting with a tube 13cm. long and 1½cm. diameter, having ball terminals of ½cm. diameter and about 2mm. apart. The investigation is not complete enough for publishing any results.

[* Abstract of a Paper read before the British Association at Liverpool, Section A. We regret that some of the figures supplied to us, and used in our abstract of September 25th, were incorrect. The above abstract contains the revised data.—ED. *E.*]

## THE LIGHTING OF SINGAPORE.

A Singapore correspondent has directed our attention to the interest which is being shown in Singapore in the matter of electrically lighting the streets of that city. Considerable dissatisfaction with the gas supply seems to exist; and as the gas company has announced its intention to raise the price charged for street lighting, the time seems ripe for activity on the part of electrical engineers. Our correspondent informs us that there is an extremely limited amount of private lighting by gas, owing to the high price, which ranges from 6s. 6d. to 8s. 8d. per 1,000 cub. ft. The *Straits Budget* has taken the matter up, and has published a series of articles in which the actual facts in regard to the cost of electric lighting are laid before the Singapore public. The following is the estimate published :—

*Estimate for 220 arc lamps of 1,200 c.p. each, and 450 incandescence lamps of 25 c.p. each.*

| | | | |
|---|---|---|---|
| (*a*) Land and buildings | £605 | 12 | 6 |
| (*b*) Plant | 13,597 | 16 | 3 |
| (*c*) Mains | 4,303 | 2 | 6 |
| (*d*) Miscellaneous | 1,041 | 5 | 0 |
| Total | £19,546 | 16 | 3 |

*Estimated cost of upkeep—burning 11 hours per diem.*

| | | | |
|---|---|---|---|
| Fuel—cost at 18s. per ton | £1,199 | 1 | 10 |
| Staff—salaries and wages | 793 | 1 | 0 |
| Stores | 1,132 | 11 | 0 |
| Interest and depreciation, 6 per cent. on capital | 1,172 | 15 | 9 |
| Total | £4,297 | 9 | 7 |

This estimate represents a capital outlay of about £3. 10s., and an annual expenditure of about 15s., per 8 c.p. lamp, or its equivalent—figures which, when the peculiarities and difficulties in Colonial engineering are allowed for, are seen to be quite reasonable. It must be remembered that the colonist is accustomed to pay a high price for artificial light; and it should not be difficult to find a sufficient revenue to more than cover a cost which in England might be considered large.



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## SPECIALIST SOCIETIES.

A few weeks hence, when the latest batch of recruits to the Grand Army of Science will have settled down steadily to the scientific analogues of the goose-step and the manual exercise, their sergeant instructors will find a little time to look around them; in other words, the scientific society season will have begun. And before the regular round of Papers, discussions and informal gatherings over the tea-cups and coffee-cups commences once more, it may not be without interest to take note of a latter-day tendency observable among members of such societies and noticeable more especially among contemporary electrical engineers; we refer to a certain *penchant* for ultra-specialism. The scope of a society, it may be quite freely admitted, can be too comprehensive. A Royal Theological and Geological Society would probably tend to inanity, if not to profanity, and it is questionable whether an amalgamation of the Royal United Service Institution with, say, the Peace Society, would conduce to quietude. On the other hand, it is quite as undoubted that a too narrow specialism spells cliquism. An everlasting discussion on "Speculations on the Source of the Hampstead Ponds, with some Observations on the Theory of Tittlebats" breeds a certain incapacity to measure a man's worth except in relation to his knowledge of these recondite subjects. Of course, to broaden the basis of a society is not of itself enough—management is required. Probably one of the main attractions possessed by the Institution of Civil Engineers for engineers whose bringing-up has been nine-tenths electrical is its judicious eclecticism. If one is bold enough to write a Paper for "daws to peck at," one is certain that at the Institution of Civil Engineers it will, at any rate, be pecked at by a wide variety of "daws," and not merely cawed at or despitefully used by a single avian family circle. The opinions of a hoary-headed mill-engine owner or builder as to the class of engine proper to dynamo-driving may or may not be intrinsically valuable; but the mental effort required to rebut the heresy, and still more the extreme lucidity of expression which is necessary in order to

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make one's train of reasoning intelligible to the heresiarch himself, are distinctly advantageous. And all this, and much more besides, is lost if the separatist spirit is allowed unrestricted play. To many minds the chief charm of the annual scientific celebration known as the meeting of the British Association lies in the fact that physicists jostle chemists and chemists rub up against engineers in a manner a trifle uncomfortable it may be at times, but always bracing to the jostling atoms.

All of the foregoing is, of course, the most threadbare commonplace; nevertheless, the eagerness with which the advantages—and naturally there *are* advantages—of like always congregating together with like is so frequently insisted upon, inclines us to the belief that the obvious benefits of more catholic gatherings are often overlooked. Only a day or two ago, at the inaugural meeting of the Committee formed for the purpose of deciding upon some appropriate mode of commemorating the inception and extension of submarine telegraphy, a much-loved veteran of the Old Guard of telegraphists spoke with evident emotion against the bright idea voiced by Prof. SILVANUS THOMPSON, that a suitable way of perpetuating the memory of one of the greatest scientific triumphs of the century would be to erect an edifice in which all the members of the great electrical engineering family might meet together to discuss from various points of view the many interesting problems awaiting solution. We were told that the Society of Telegraph Engineers, founded by telegraphists, had become a mere electric lighting concern —electric lighting engineers, after having been received into the fold as an act of grace, had, with base ingratitude, turned out the old bell-wethers. This allegation has been raised on previous occasions, once eloquently in the hall of the Institution of Electrical Engineers by Mr. ANSELL himself, and, we had thought, had been completely refuted. The difficulty is and has been to induce those connected with submarine telegraphy and with telephony to come on to the Council and to take an active part in the affairs of the Institution. Even as it is, there are, excluding past-presidents, three submarine-telegraph men upon the Council, two of whom are Vice-Presidents; and if we include the military and postal and railway services, there are no less than seven telegraphists on a Council numbering only 20: no unfair proportion, if we consider how little the telegraph branch of the industry contributes in the way of Papers, and how seldom telegraphists lift up their voices in the discussions which are the salt of a live Society. We have, however, no desire to travel over old ground once again, and for a third time to fully state the case for the defendants in Ansell *v.* the Institution of Electrical Engineers. What we do wish to point out, nevertheless, is that this resentful attitude is entirely the outcome of living apart from the main stream of progress. Alternate-current engineers, not to speak of telephone engineers, are confronted by transmission problems strikingly similar to those now puzzling the average submarine telegraphist who is "working automatic"; the ideas, remedies, methods of the one would at least prove stimulating, and in all likelihood useful to the other; and if Mr. OLIVER HEAVISIDE could be persuaded to assist we should all be the gainers. But instead of discussing their mutual difficulties, the members of the electrical family are scarcely on speaking terms. What opportunities of progress are lost by reason of this grotesque antagonism! And the same remark applies to other and less excusable examples of latter day fissiparism. Unless we have a care, England will soon be dotted all over with single-member societies, as well as with single-member constituencies.

## REVIEWS.

**Electricity in its Application to Telegraphy.** By T. E. HERBERT. (London: F. H. Goldspink and Co., 1896.)

This work is calculated to be of assistance to those in the service of the Postal Telegraph Department who intend to improve their acquaintance with the apparatus and systems of working in use in this country. Departmental examinations are periodically held for the purpose of selecting men to fill higher posts in the service; and the questions put, besides covering the routine work and use of apparatus, are framed to test the knowledge of what should be done in the case of a breakdown of either instruments or lines. Mr. Herbert, in dealing with each instrument and system of working in turn, has brought in his own practical experience in their adjustment and working; and this, from one engaged in the service, should prove very useful to those to whom the work is addressed. The book is a somewhat tedious one to read, on account of the long undivided paragraphs, several whole pages being written without a break. There is an absence also of good illustrations. The few rough sketches and outlines given are printed indistinctly, and need an effort of the sight and mind to take in; but the work is evidently meant for those who have ready access to the instruments described, and therefore do not need illustrations. The phraseology is telegraph technical; thus a "B Q" is talked of, a "perfect" current, "dis," "700-ohm block," &c., while Chapter XVIII. on localisation tests, and Chapter XXV. on the making up of special circuits, are thickly studded with the two or three capital letters used as abbreviations for towns.

The subjects undertaken in the first four chapters, viz., magnetism, Ohm's law, the chemical action in ordinary cells, the grouping of cells, and the tangent galvanometer, are so much written about in text-books that it seems only multiplying words to introduce them in a new work. Continuing, the author gets to work with the direct sounder, single needle, and standard relay. The description of the latter instrument is evidently meant for those having the Post Office form of relay before their eyes, as neither the text nor the illustrations are clear. The Post Office double-plate sounder is next described, this instrument now taking the place of the single needle on all but short circuits. Operators first read the single-needle instrument by looking at the needle, and then found it possible to read by the slight difference in sound made by the needle in touching one side or the other. This led to Neale's sounder, in which the needle was made to hit against metal tubes, emitting distinctly different sounds; but it was soon seen that for the production of two different sounds something more sensitive and more compact than the time-honoured piece of cabinet furniture containing the single-needle was desirable. Accordingly, the double-plate sounder, with a relay and local battery, was introduced, and the author points out that the present instrument is the result of evolution from the original Bright's bells.

In the next three chapters the single-current sounder, condenser and double-current systems are described, followed by chapters on differential and double-current duplex, the latter being fully dealt with, and hints given on the adjustment to balance. Quadruplex and diplex are next described, and then follow descriptions of the Wheatstone automatic and Wheatstone duplex. Test-box arrangements are next considered with the routine morning tests of the lines on the effective and simple system devised by Mr. Eden. The theory of the test is well explained by a suitable arithmetical example. Fault localisation, the Wheatstone bridge, and the universal battery system are next considered, followed by the Delany multiplex system, repeaters and bridge duplex. The work concludes with chapters on the making up of special circuits, miscellaneous notes, and a set of examination questions. The book is mainly to assist in qualifying for answering these and similar examination questions; but we are pleased to notice that the author has not alone followed this line, but has maintained throughout his work a healthy tone in the treatment of practical difficulties as they occur in maintaining the instruments and lines in efficient condition.

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## LIVERPOOL OVERHEAD RAILWAY.*

BY S. B. COTTRELL, M.INST.C.E., M.I.MECH.E.

For many years before this railway was constructed, the want of proper facilities for conveying passengers to and from the Docks was badly felt, the only direct means of conveyance being by means of omnibuses, which badly met the requirements. In 1852 a proposal was made to have a High Level Railway from the Mersey Forge to the Huskisson Dock—a length of about four miles—but nothing came of the proposal. About 17 years ago the Mersey Docks and Harbour Board felt that the question of better means of communication to the Docks required to be seriously considered; and after careful investigation of the elevated system in New York, Mr. Lyster, M.Inst.C.E., prepared estimates and plans. In 1882 an Act was obtained by the Dock Board for the construction of the railway at an estimated cost of about £585,000, which was subsequently reduced to £466,000 for a system worked by electricity. In 1888 the power to construct the railway was taken over by the present Overhead Railway Company, under the chairmanship of Sir Wm. B. Forwood; and the works, as designed by the engineers, Sir Douglas Fox and J. H. Greathead, Esq., M.M.Inst.C.E, were commenced by the contractor (the late Mr. Willans) in 1889. The railway extends the full length of the Docks, and with the Northern Extension opened in 1894, and the Southern Extension (under construction) will connect the suburbs of Seaforth and Waterloo with those of Prince's and Sefton Parks. The construction decided on was wrought-iron girders, placed 22ft. from centre to centre, at a normal span of 50ft., at a height of 16ft. above the roadway, supported on columns which are built of two steel channels and two plates. The columns are grouted into cast-iron shoes, which are held down by bolts to concrete foundations, the size of which varied according to the nature of the ground, the weight being distributed at one ton to the square foot. The bottoms of the columns are protected against injury from passing waggons by cast-iron bumpers. The longest span on the present railway is a bowstring span of 98ft. The main girders carry a light projecting parapet, and a curved plate is put on the flange to form a continuous foot plate. Between the girders is fixed a continuous flooring made of arch plates $\frac{5}{8}$ of an inch in thickness, bent to a radius of 12in., with a foot surface 16in. wide on the top, riveted to intervening T bars. The flooring is made watertight by means of asphalt between the arches, which are drained by outlets into longitudinal gutters which discharge into down spouts fixed on the columns. The keeping of the structure watertight was one of the obligations the Company were under. The flooring combines great strength with lightness and a minimum of riveting, and at the same time is comparatively noiseless under traffic.

The structure was so designed that the girders and flooring were put together and riveted, and then transported over the structure after it was completed (a few spans being first erected in the ordinary way), and placed in position without interfering with the traffic underneath. For this a special form of erecting apparatus was provided, consiting of lattice girders supported on legs, the front pair of which travelled on the ground and hind pair travelled on the viaduct that was already built. On these lattice girders suitable cranes were erected, so that the completed span could be launched forward into position. As many as twelve spans, ranging from 50ft. to 70ft. each, were fixed in five and a half working days, representing 650ft. of finished viaduct. At four different places along the line opening bridges had to be provided. At the Stanley Dock a hydraulic swing bridge is built to enable vessels to pass to that dock, which is the only dock on the east side of the railway. This bridge is a double-decked one, carrying the Overhead Railway on the high level and the dock traffic on the lower level. The low level bridge is arranged with bascule leaves, so that barges and small craft can pass through without swinging the bridge. At three other points bascule bridges, worked by hydraulic power, are provided, to permit the passage of boilers, &c., which are too high to go underneath the main girders.

The permanent way, which is laid to a gauge of 4ft. 8½in., consists of flat-bottomed steel rails weighing 56lb. per yard, fixed on longitudinal sleepers, held down to the flooring by lugs riveted on to it and keyed in with oak keys. The rails are fixed to the longitudinal sleepers by spikes and fang-bolts.

After careful consideration electric traction was decided on, and trains were built consisting of two carriages each 45ft. long, 8ft. 6in. wide, on two bogies 32ft. apart from centre pin to centre pin, with 2ft. 9in. wheels. Each carriage contains seating accommodation for 16 first-class and 41 second-class passengers. The carriages have side doors and passage from end to end. Each carriage is fitted with electric motor, and the train is controlled by a driver from either end; this avoids all shunting at the terminal stations, the driver simply changing from end to end. The armatures for the motors are series wound (on the Eickemeyer system) and built directly upon the axle. The tractive force of each motor at rim of wheel, 2ft. 9in. diameter, with 120 amperes, is about 1,790lb.—equal to about 107lb. per ton of train. The motors are started up first in series, and then switched into parallel through a resistance with each motor, which is cut out to increase the speed.

The trains pick up the current from a conductor consisting of a steel bar, having an area of 4 sq. in., supported on insulators carried on cross timbers between the two running rails. The conductor is laid in 32ft. lengths, connected with rigid copper fish-plates with flexible joints every 96 feet. The running rails which are used for return electrical circuit are, in addition to the fish plates, coupled together with a bent wrought-iron bar. Short trains, as described, run at frequent intervals, have proved up to the present time the best means of meeting the requirements. The trains are fitted with the Westinghouse automatic brake supplied with compressed air, at 80lbs. pressure, from reservoirs on trains which are charged at the terminal stations; they also have an emergency hand brake. A train fully loaded weighs 38 tons, of which the motor equipment is 6 tons 7 cwt. The carriages are lighted by 32 c.p. incandescent lamps supplied from the main conductor.

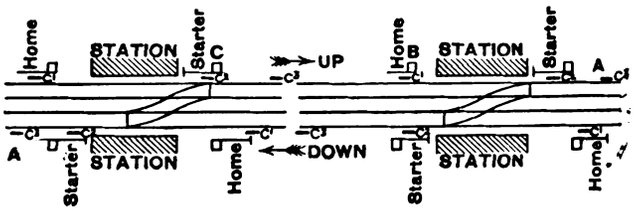


FIG. 1.—Signal Arrangements.

The generating station was put as near the centre of the line as a site could be obtained, and the first equipment consisted of six double flue Lancashire boilers, 30ft. long by 8ft. diameter, with a pressure of 120lbs. The feed water is circulated through Green's economisers, and all steam pipes are in duplicate. The engines are four in number, consisting of horizontal compound condensing engines, by Musgrave and Sons, of Bolton. The high-pressure cylinders being 15½in. and low-pressure 31in. diameter fitted with Corliss' valves, driven by trip gear acted on directly by the governor. Each engine develops 400 I.H.P. at 100 revolutions per minute, with 120lbs. boiler pressure. The engines exhaust into surface condenser, the circulating air-pump for which is driven by a no-dead-centre vertical compound engine. The condensing plant is in duplicate. Each engine drives an Elwell-Parker dynamo, 500 amperes, 500 volts (of the double-limb type), with magnetic circuit above and below the armature, the poles being cut through horizontally along the centre to allow the top half to be lifted readily; they are shunt-wound of drum type. The

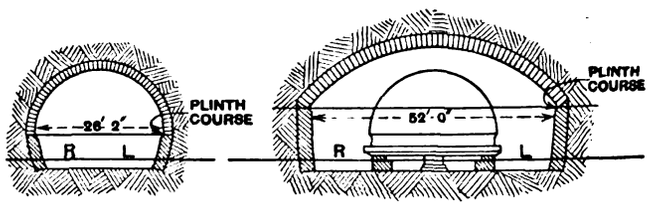


FIG. 2.—Sections of Tunnel.

efficiency of the dynamos and engines is about 85 per cent. at full load. The current from dynamos is controlled by a switchboard which is equipped with magnetic cut-outs and works automatically in case of a short circuit, by which the current is conveyed to the centre conductor, and is picked up by collectors of cast iron fixed underneath the trains. The stations on the original line, 13 in number, subsequently increased to 16, are lit by electricity from batteries in duplicate on a 50-volt circuit, which also supply the current for working the signals.

*Signals.*—The signals are automatic (Tenmis system), the arms being operated by magnets, which are controlled by *makers* and *breakers* operated on by a striking board fixed on the last coach. The train in passing either *breaks* the circuit and puts the arm to danger, or *makes* the circuit and lowers the arm. Each station is equipped with a "Home" and a "Starter," the latter acting as a "Distant." The circuit to lower the signals for the section in the rear of any station can only be completed if the "Starting Signal" is at danger, thus forming "Absolute Block." A train on leaving a station passes a *breaker* and puts the "Starter" to danger, and after moving about 150ft. passes a *maker*, which completes the circuit and clears the section in the rear, leaving itself protected by the "Starter." $C^1$ $C^2$ $C^3$ are contacts placed

* Abstract of a Paper read before the British Association at Liverpool, Section G.

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on brackets alongside the girders. A train passing over $C^1$ puts Home Signal to danger. A train passing over $C^2$ puts Starting Signal to danger. A train passing over $C^3$ pulls off Home Signal and Starting Signal of the Section in the rear. This system dispenses with signalmen, they only being employed where shunting operations are carried on. Each station is equipped with a crossover road interlocked with the signals. The total cost of the first portion of the railway, 5¾ miles in extent, was £90,000 per mile. The earning power of the railway as at first constructed, and which was only worked for traffic as far as the Alexandra Dock, was limited, as passenger traffic on the Docks practically ceases at 6 p.m.; and this the Directors foresaw, and in 1892 obtained powers to extend the railway both in a northern and southern direction. The Northern Extension, a quarter of a mile in extent, but opening up another three-quarters of a mile for traffic, was opened

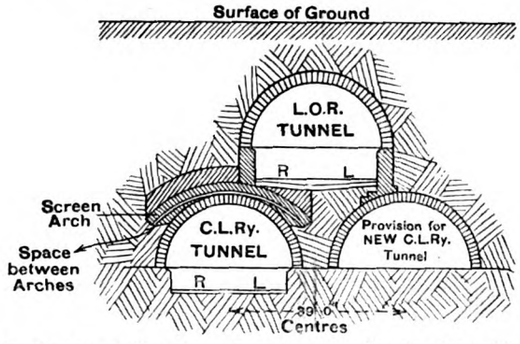


FIG. 3.—Section of Tunnels at Cross-Over on Cheshire Lines Tunnel.

as far as Seaforth in 1894, and fully justifies its construction, the number of passengers carried having increased from 2,475,639 for the six months ended December 31, 1894, to 3,780,375 for the six months ended December 31, 1895.

*Southern Extension.*—The Southern Extension, five-eighths of a mile long, which is now in course of construction, commences about 150 yards north of the present terminus of the railway, with a viaduct 250 yards long, crossing Sefton-street and the Brunswick goods yard of the Cheshire Lines Railway, a portion of the Dock Board estate, and entering the hill side at the north-east corner of the Herculaneum Dock, and proceeds in a south-easterly direction to Park-road. To meet the requirements of the Dock Board, their land is crossed by one span of about 200ft., the main girders, from the bottom of which headings 11ft. and 12ft. were driven in each direction, and the greatest error in line and level was under ¾in. The tunnel portion—about 800 yards—is almost entirely through red sandstone rock, which, like most of the rock in the neighbourhood of Liverpoool, is of a very treacherous character, heavy backs and wet clay beds being frequently met with, necessitating heavy timbering, a large number of the crown bars had to be built in; the tunnel has therefore had to be lined throughout its entire length; all the lining is faced with brindle bricks built in cement. Black powder has been the chief explosive used in the excavation.

At about 170ft. from the entrance the tunnel crosses at an angle of 28°—27′—40″ over the tunnel of Cheshire Lines Committee Railway, through which the trains of the M.S. and L., G.N. and Midland Railways run, and the greatest distance that could be allowed between the Overhead rails and the crown of the Cheshire Lines tunnel 2ft. 9in. After careful consideration the engineers decided that the only safe way to effectually make the crossing was by turning a segmental screen arch five rings thick, built with brindle bricks in cement over the Cheshire Lines arch, and to build side walls of the Overhead tunnel on this screen arch. This was carried out as follows:—A top heading 120ft. in length was driven along the crown of the Cheshire Lines tunnel, and then 8ft. lengths were excavated, baring the Cheshire Lines arch for that length. The exposed arch was then haunched with concrete, and the screen arch turned on sand, with ½in. narrow boards placed on it, and when the arch was set the sand and boards were withdrawn, leaving a clear space of 6in. over the Cheshire Lines arch, so that no additional weight could come on the Cheshire Lines tunnel arch. During these operations all the rock above had to be carried on timber.

To guard against possible fall of rock which might crush through the Cheshire Lines arch, before commencing the above operations, a shield was put inside the Cheshire Lines tunnel. This shield was made of 8in. by 5in. H steel joists at 4ft. 3in. centres, bent to the radius of the tunnel, and carrying 4in. laggings, and keyed up tight by means of folding wedges to the soffit of the arch. The Overhead Railway Company had also to provide for the Cheshire Lines, at some future time, having to construct another tunnel on the east side of their existing tunnel; and, to avoid any interference with the traffic during the future, it was decided to build a length of tunnel arch seven rings thick, on which arch the Overhead Railway side walls are carried. All the excavation for this crossing has been done entirely by hand labour, and has proved a most expensive and anxious piece of work. Further on the tunnel passes under a 5ft. by 3ft. sewer, and to avoid disturbing this, the arch was altered from semicircular to segmental, which just permitted with care the sewer to be underpinned.

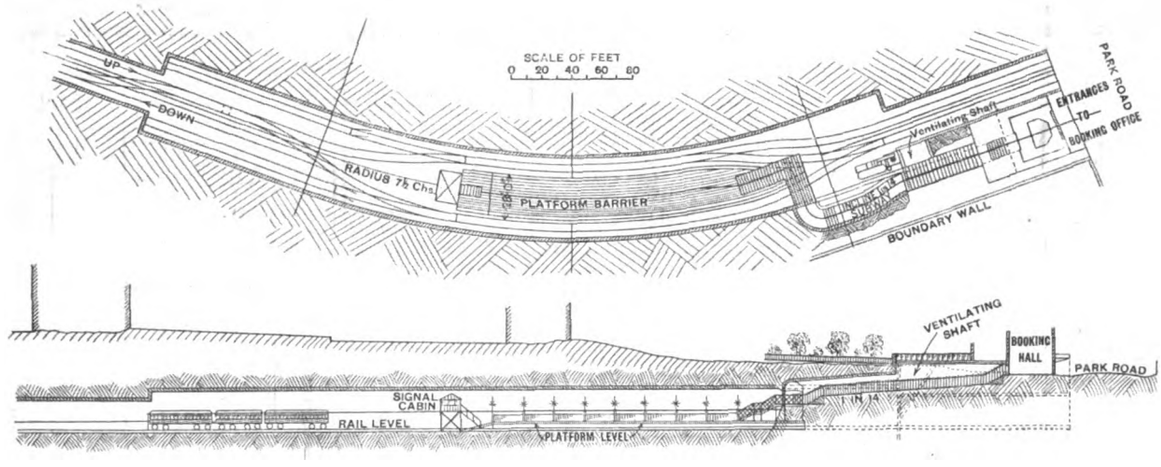


FIG. 4.—Plan and Vertical Section of Park-road Terminus.

(which are of lattice type with parallel booms) being 220ft. and 225ft. respectively, and the whole of the span will weigh about 212 tons. Underneath, where these big girders will rest at the face of the tunnel, are casements for storing petroleum, belonging to the DockBoard, extending about 60ft. into the hill, and to distribute the weight of the span about these, a bearing girder weighing 10 tons has been let in, and on this girder the east end of the span will rest. The west end will rest on a pier provided with rollers and rockers. The normal tunnel has a span of 26ft. 2in. springing to springing, and 25ft. 6in. between side wall with a splayed plinth course; the arch is semicircular. The tunnel for the station ground is 52ft. span, the arch being segmental, having a quarter-span rise. The tunnel is under house property the entire length, and it was, therefore, not always possible to sink shafts where they were desired. Five shafts 10ft. square were sunk,

The trains on entering the tunnel will be automatically lit up from copper conductors suspended from the roof of tunnel, collectors being fixed on the roofs of the carriages. These lights will be fed off accumulators, so that if a train should be stopped in the tunnel due to short circuit on the line, the carriages will not be in darkness. The terminal station of this extension is situated at Park-road, otherwise called the Dingle, below the road level. The underground station will consist of an island platform about 27 feet, with suitable sidings for accommodation of the trains. The station will be ventilated by a large upcast shaft. The access to the station will be by means of a subway at a gradient of 1 in 14. The booking offices will be on the road level. The station will be lit throughout by electricity, the underground portion by arc lamps at 110 volts, supplied by a transformer off the main current. Battery lights will be provided in the event of a short circuit on

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the line. The permanent way and main conductor will be of the same section as on the present railway, but the rails are laid on the usual cross sleepers with cast-iron chairs to distribute the pressure.

As more generating plant will be required to work the additional number of trains, it was decided to increase the size of the present generating station, and to run feeding cables a length of about two miles so as to regulate the E.M.F., instead of building another generating station, as it was found that this method would cheapen the working costs. The addition to the generating station consists of two engines, built by Messrs. Hick and Hargreaves, and two new dynamos and switchboard, built by Messrs. T. Parker and

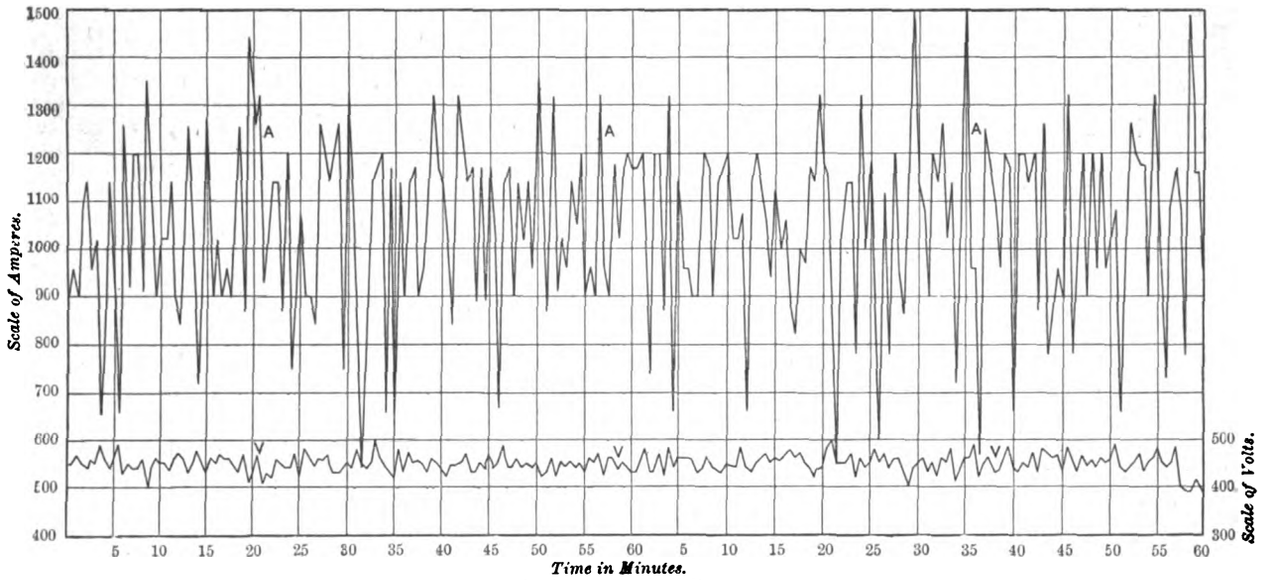
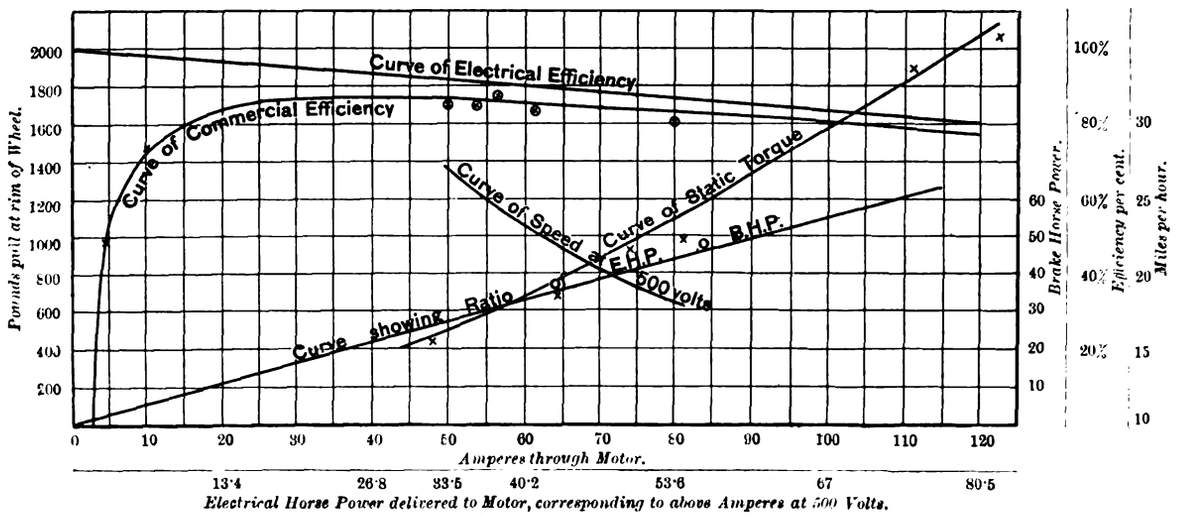



FIG. 5.—Load Diagram at Generating Station.
Average Amperes, 998·0 ; Average Volts, 448·8 ; 13 Trains on Line.

Co., of Wolverhampton. The two new engines are Corliss valve engines, each of the horizontal surface condensing type, having cylinders 15½in., 31in. by 3ft. stroke, each intended to give 400 I.H.P. as an economical load when running at 100 revolutions per minute, with a boiler pressure of 120lb. per square inch. The engines are of ample proportions throughout, and are fitted with a steam jacketed receiver between the cylinders containing boiler pressure steam. The beds are of the box type, and of heavy

each built up of four principal castings, namely, a working barrel, a jacket, and two end pieces containing the circular steam and exhaust valve chambers, thus substituting four comparatively simple castings, which can each be cast of the mixture most suited to its purpose for a single casting of so complicated a character that it can only be cast of a comparatively soft mixture, and it is even then liable to failure from initial stress aided by unequal expansion. This subdivision not only reduces the chance of disablement, but should such occur the defective part may be replaced with much less expense and delay than a complete cylinder. Both cylinders are thoroughly steam-jacketed, the steam traversing the jackets on its way to the respective cylinders. The governors are rope-driven, and are of a new design, especially intended to combine the powerful governor with one of great sensitiveness, for dealing with great variations of load.

The output of each dynamo is 500 volts, 500 amperes, at a speed of 420 revolutions per minute. The armatures are so arranged as to be interchangeable, identical in the matter of external dimensions with the existing ones, the resistance from brush to brush




STATIC TORQUE CURVE, taken in usual way, by bolting lever on shaft, and weighting it at measured distances along it, till pull of current through motor is balanced.
ELECTRICAL EFFICIENCY CURVE takes into account the C²R losses in the copper only. Resistance of armature and magnets in series is ·83 ohm, at a temperature of about 70°F. above atmosphere.
COMMERCIAL EFFICIENCY CURVE shows actual efficiency of motor at wheel, and is obtained by estimation of all the losses separately. The motor was made to drive a dynamo by a belt. The small discrepancy between these points and the Commercial Efficiency Curve is accounted for by the necessarily approximate allowance made for belt, though this was as accurate as circumstances would permit.

FIG. 6.—Curves of Torque, Efficiency and Speed of Liverpool Overhead Railway Motor.

section. The flywheels are 14ft. diameter, and are grooved for 19 ropes, each 1¼in. diameter. The condensing apparatus is a separate plant, having its own air and circulating pumps. Among other features of the new engines are, first of all, the construction of the cylinders, which are of the four-valve Corliss type, and which, instead of being cast in one piece, as is usual, are

measures 0·010 ohm. The magnets, however, instead of being of the double horse-shoe type as in the present machines, are of a single horse shoe, with the poles at the top. This has resulted in an increase of efficiency, the shunt resistance being now 100 ohms as against 75, making an *electrical efficiency* of 98 per cent. The loss in hysteresis, eddy currents, windage, &c., amounts to 6,000

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watts, so that the *commercial efficiency* at full load will be about 95·7 per cent. The magnets are of special magnetic steel of the highest permeability, and are arranged with the patent hinged pole-pieces. This allows of ready access to the armature for inspection, cleaning, or lifting without the necessity of unsetting the bearings. The dynamos are rope-driven by 19 1¼in. ropes, the rope pulley running between two bearings, and the pulley shaft being connected to the armature by a coupling, so that the armature can be changed without disturbing the ropes. The bearing at the commutator end of the machine is of the spherical type. The diameter of the shaft through the bearings is 5in., the length of each bearing being 1ft. 5in. The bushes are of phosphor bronze lined with white metal, the top brasses of each bearing being slotted to receive *two* lubricating rings, the bottom brass being continuous. The total weight of the machine is 24½ tons, the armature being 3 tons 2 cwts.; the steel magnet casting alone, without winding, is 12 tons.

The main switchboard consists of six slate panels, with sets of switches and instruments, one set for each dynamo in generating station. Each panel is fitted with :—(1) One patent double-pole automatic magnetic cut-out, with plate glass shields to protect the attendant from the arc, in case a short circuit on the line causes the cut-out to open with excessive load. These cut-outs are also employed as main dynamo switches, being made and broken by hand for connecting the individual dynamos to the omnibus bars. The magnets of the cut-out are compound-wound, so that the circuit is broken immediately in case of a reversal of current. (2) One single-pole throw-over switch for connecting the dynamo circuit (beyond the automatic cut-out) either to the omnibus bar, which feeds into the central conductor at the nearest point to the generating station, or through a feeder to a distant point on the line to equalise the E.M.F.; (3) One 33-way sliding, regulating switch to vary the resistance in the dynamo shunt circuit for maintaining the E.M.F. of each dynamo constant; (4) One set of double-pole plugs for connecting voltmeter to dynamo before paralleling; (5) One "Weston" ammeter, indicating the current passing from each dynamo to the line.

The slate slabs are held on wrought-iron framework, all connections at the back being of heavy cast bronze rods, supported on pillars, so that all straps and connections are accessible, no insulated cable being employed. The front of the board is finished off with massive teak carved pillars and panels.

Besides the instruments already described there are four "Weston" voltmeters, with illuminated dials, and an engine-room clock supported on panelled framework above the slate slabs. The voltmeters are arranged as follows: One connected directly across the omnibus bars, one for connecting at will to any dynamo by means of plugs to take E.M.F. before paralleling, one for connecting across brushes of the dynamo running on the feeder circuit, one as pilot voltmeter connected to the distant point in the line where feeder is coupled.

To meet the increased traffic that is expected from the Southern Extension, new rolling stock is being built by Messrs. Brown, Marshall and Co.; and as the number of passengers carried is now over 7½ millions a year, the Directors have found it necessary to increase the size of the trains by composing them of three carriages instead of two. In fact, last half year (excluding bank holidays) an average of 60 per cent. of the seating accommodation of the trains was occupied. The new motors built by the Electric Construction Company are very similar to those at present in use, their strength being increased to meet the additional weight of trains. The following table and Fig. 6 give particulars :—

| Weight of armature Ex. wheels. | Weight magnets and attachments. | Draw Bar Pull. With 120 amps. | Draw Bar Pull. With 60 amps. | Speed with 50 amps. | Maximum efficiency. |
|---|---|---|---|---|---|
| lbs. 2,184 | lbs. 6,066 | lbs. 2,030 | lbs. 680 | 26 M.P.H. | 85% |

As this new rolling stock will only be a small portion of that owned by the Company, it will be necessary to increase the number of carriages in the present trains, but as the first motors were only designed for two carriages, experiments have been made with a train fitted with a new and very ingenious form of roller bearings designed by the Roller Bearing Company. It has been shown by the falling weight test that this train will start at a reduction of more than 80 per cent. in starting effort over a train fitted with ordinary bearings, and therefore the Company will be able by slightly modifying their present motors and adopting roller bearings, to increase the carrying capacity of all their trains by adding an additional carriage.

The engineers for the Southern Extension have been Sir Douglas Fox, M.Inst.C.E., and J. H. Greathead, M.Inst.C.E., and the author has acted as resident engineer, assisted by Mr. Norman and Mr. Fright, and the contractors have been Messrs. Pearson and Knowles for the viaduct portion, and Messrs. H. M. Nowell and C. Braddock for the tunnel portion. The railway has now been working for over 3½ years, and it has proved that working on the zone system as regards fares and having only two classes is the best for railways of its character, the value per passenger being 1·97d., as against 1·75d. on the Metropolitan Railway in London, whose fares are very much higher than on this railway. The zone system allows an economy of about 25 per cent. on the staff, and as tickets are only used for first-class passengers there is a considerable economy in printing.

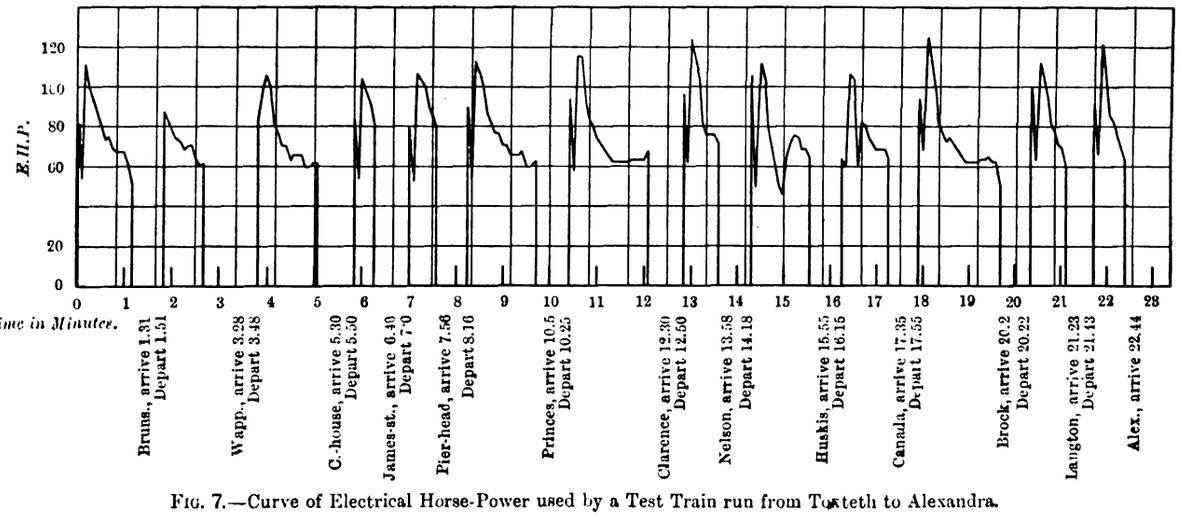


FIG. 7.—Curve of Electrical Horse-Power used by a Test Train run from Toxteth to Alexandra.

The maintenance of the line is naturally very heavy, as there is alone over 80 acres of surface to be protected from corrosion, of which 20 acres are painted with an oxide paint and remainder

*Liverpool Overhead Railway.—Dissection of Cost per Train Mile.*

| Half-year ending June 30, 1896. | Lbs. per train mile. | Lbs. per kilowatt. | Pence per train mile. | Pence per kilowatt. |
|---|---|---|---|---|
| Train mileage, 313,010 .. | ... | ... | ... | ... |
| Kilos generated (exclusive of battery charging), 1,343,129... .. ... | ... | ... | ... | ... |
| Generating Station—Coal | 18·24 | 4·253 | ·491 | ·115 |
| Ashes | .. | ... | ·016 | ·003 |
| Stores | ... | .... | ·164 | ·039 |
| Wages | ... | ... | ·763 | ·176 |
| Repairing Department— | | | | |
| Stores | ... | ... | ·425 | ·099 |
| Wages | .. | ... | ·321 | ·074 |
| Drivers' Department— | | | | |
| Wages | ... | ... | 1·220 | ·287 |
| | | | 3·400 | ... |



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APPENDIX.—*Liverpool Overhead Railway and City and South London Railway. Half-years' ending June 30, 1896, and 1895.*

| | Liverpool Overhead Railway. | | | | City and South London Railway. | | | |
|---|---|---|---|---|---|---|---|---|
| | Dec., 1894. | June, 1895. | Dec., 1895. | June, 1896. | Dec., 1894. | June, 1895. | Dec., 1895. | June, 1896. |
| | d. | d. | d. | d. | d. | d. | d. | d. |
| Value per passenger | 1·67 | 1·92 | 1·97 | 1·96 | 1·66 | 1·73 | 1·71 | 1·72 |
| Expenditure to revenue | 66·84% | 66·43% | 59·97% | 63·05% | 60·87% | 61·55% | 59·62% | 60·22% |
| Loco. expenditure to gross expenditure | 24·78% | 24·26% | 26·05% | 22·51% | 39·24% | 37·95% | 38·98% | 36·30% |
| " " " revenue | 16·56% | 16·12% | 15·62% | 14·19% | 23·88% | 23·36% | 23·24% | 21·86% |
| Traffic " " expenditure | 38·88% | 37·54% | 35·33% | 36·05% | 38·70% | 39·13% | 38·69% | 38·91% |
| " " " revenue | 25·99% | 24·94% | 21·19% | 22·73% | 23·56% | 24·09% | 23·07% | 23·43% |
| Expenditure per train mile | 13·10 | 14·38 | 14·11 | 15·10 | 15·36 | 16·07 | 15·45 | 15·96 |
| Revenue per train mile | 19·59 | 21·65 | 23·53 | 23·95 | 25·24 | 26·11 | 25·92 | 26·30 |
| Locomotive expenditure | 3·25 | 3·49 | 3·68 | 3·40 | 6·03 | 6·10 | 6·02 | 5·75 |
| Number of passengers conveyed | 3,641,379 | 3,460,060 | 3,780,375 | 3,739,575 | 3,275,649 | 3,113,199 | 3,172,438 | 3,192,672 |
| Train mileage | 314·472 | 311·346 | 321·417 | 313·010 | 230·604 | 224·259 | 227·350 | 225·554 |
| Number of stations | 16 | 16 | 16 | 16 | 6 | 6 | 6 | 6 |
| Percentage of train punctuality | 95% | 96·8% | 98·4% | 98·3% | — | — | — | — |

with black varnish, and at the present it is being painted at the rate of once in two years. During this year experiments have been made with a pneumatic painting machine, which blows the paint on, the result being to reduce the cost from 2·25d. per square yard to 1·24d. per square yard, including all materials. The motors now run an average of 40,000 miles before requiring repairs, in which time they earn over £200 and can be rewound at a cost of £25. The Company has at the north end of the line fully equipped workshops, where they carry out all their own repairs. In the Appendix will be found a comparative statement of receipts and expenditure, and dissection of locomotive expenses, and Fig. 7 gives curves of electrical horse power for one train. Further detail of the first portion than I have described to you will be found in the publication of the Institute of C.E., Vol. CXVII., in papers read before the Members by Sir Douglas Fox, Vice-President, M.Inst.C.E., and Mr. Greathead, M.Inst.C.E., and also by Mr. Thomas Parker.

## PROPOSED INTERNATIONAL SUBMARINE TELEGRAPH MEMORIAL.

A meeting was held on Tuesday, at Winchester House, Old Broad-street, London, to promote the establishment of an international submarine telegraph memorial, which it is proposed to identify with the names of Sir John Pender, Sir James Anderson, and Mr. Cyrus Field. Lord Selborne, Under Secretary of State for the Colonies, was voted to the chair, at the instance of the Marquis of Tweeddale; and among those present were Sir A. Leppoc Cappel, Sir Eyre M. Shaw, Sir Henry C. Mance, Sir J. R. Robinson, Mr. F. A. Bevan, Mr. W. S. Cunard, Mr. C. W. Earle, Mr. Edmund Etlinger, The Hon. A. G. Brodrick, Mr. George Draper, Mr. Willoughby Smith, Mr. Spenser B. Todd, Mr. T. A. Bullock, Mr. W. Shuter, Mr. Richard Collett, Mr. G. von Chauvin, Mr. A. R. Hardie, Mr. C. Gerhardi, Mr. T. H. Wells, Mr. T. Finnis, Mr. R. T. Browne, Mr. W. T. Ansell, Mr. Alexander Siemens, Mr. A. R. H. Mackay, Mr. C. S. Colvin, Mr. Latimer Clark, Mr. W. H. Maw, Mr. F. Moll, Mr. O. Moll, Mr. Louis Floersheim, Mr. W. O. Smith, Mr. W. G. Bond, Mr. H. Alabaster, Mr. Charles W. Stronge, Rear Admiral W. J. L. Wharton, Capt. William Henry Davies, Capt. G. Pattison, Mr. B. T. Ffinch, Dr. J. A. Fleming, Mr. G. G. Ward, Mr. Fred. Ward, Mr. Walter Peace, Mr. Frank Dawes, Mr. F. C. C. Nielsen, Mr. G. B. Stacey, Mr. J. H. Carson, Mr. J. T. Crowe, Mr. W. H. Burman, Mr. C. Burt, Mr. W. Beaumont, Mr. John Newton, Mr. Robert K. Gray, Mr. F. Le B. Bedwell, Dr. Alexander Muirhead, Mr. John G. Griffiths, Dr. T. Wholey, and Mr. A. G. Low.

The CHAIRMAN said: Lord Tweeddale, and gentlemen,—I have been asked to take the chair on this occasion, and I confess that I do so with much diffidence, because, as you may well suppose, submarine telegraphy is not a subject which I have profoundly studied. However, I feel greatly the honour that has been done me, and I have much pleasure in acceding to your request. The business before you to day is, I understand, to inaugurate the actual work of this international submarine telegraph memorial, as to which you have already had circulars, and of which you have already heard certain proposals. I would dwell especially on the point that this is not only a national but an international memorial. It is a memorial in which all the civilised nations of the earth propose to take part in order to put on record their respect—I might almost say, their veneration for this great invention, which they feel is having such a tremendous effect upon the present and future of humanity and the history of the world. This memorial it is proposed especially to connect with the names of three men—names most familiar to you all—Mr. Cyrus Field, to whom, I believe, belonged the possession of the first conception of this great idea; Sir John Pender, the man who risked his capital, and who threw into the work of the extension of submarine telegraphy a force of character and an ability best illustrated by the fact that he was the prime mover in covering the face of the earth with this network of cables, which now connects the different ends of the earth together; the third name which it is proposed to connect with this memorial is that of Sir James Anderson, who, as the captain of the "Great Eastern," proved among other things that some of the scientists were wrong, and that whereas they had proved it to be impossible to raise a cable in deep water when it was once laid, he demonstrated that it could be raised by raising it. This is only one of the respects in which submarine telegraphy has the distinguished honour, along with some of the greatest triumphs of the human race—such as the formation of the Suez Canal—of having originally been proved by scientific demonstration to be impossible. Now I should be merely wearying you and wasting your time if I were to repeat any of the commonplaces as regards the effects of submarine telegraphy which are to be read in almost every newspaper article. You may, however, like to hear the statistics up to date of this great movement. Whereas the first Channel cable was only laid in the year 1851, there is now a mileage of submarine cables of no less than 162,000 miles; and the capital invested in them is not far short, if at all short, of £40,000,000. Now, gentlemen, all those who have any connection with commercial undertakings know the importance and the value of submarine telegraphy, and all those who are concerned with the administration of governments also know its value; but I doubt if any of us are able to conceive or imagine what the final effect on the human race of this great invention is going to be. We see it work, but how it is going to work out we have very little idea. Consider the revolution that it has caused in the science of government. Formerly when generals led their armies into the field, responsibility was on them only; they had to make the best of the materials which their governments put at their disposal. Diplomatists had to evolve a policy on general lines for themselves, and work it out. The governors of Colonies—pro-consuls of modern empires—when once they had landed on the shores to which they sailed, had a perfectly free hand, and if they committed any serious error of judgment or crime of action it would be years before they could be brought to account. Now, however, all these men—generals, diplomatists and governors of Colonies—are at the end of a wire which terminates in the capital of the country to which they belong; and sometimes I doubt if they join in the chorus of jubilation over the invention of submarine telegraphy. There is one effect which I think may be foreseen, and it may be disastrous, but I hope it will not be an experience which we may be the first to undergo. I understand that the best naval and military authorities of all the great Powers say that the first Power which engages in war will find all the cables upon which it relied for communication cut by its opponent. Consider the position of generals, diplomatists, and especially of governors, who, from their first entrance into their careers, have been in the happy position of being able to communicate with their governments whenever they found it necessary to do so. They have received replies in a few hours, and from their training they have been able to divest themselves of all individual responsibility. Fancy their finding all the leading strings by which they have been tied torn away from their nurses' apron! Again, we are told that all modern organisation, whether of government or private enterprise, strives more and more in the perfecting of their functions to decentralise and to cast responsibility on the leading factors in the centre of each unit of decentralisation. It is a struggle with which we are familiar in the government of this country: but the more man struggles, the stronger is the influence of electric telegraphy in overcoming his desires; and, as centralisation leads in every instance to the aggregation of human beings, it may possibly be that submarine telegraphy, and telegraphy generally, is one of the agencies most responsible for those great aggregations of human beings—that exodus from country to the town—which is taking place all over the civilised world, and which thinkers throughout the civilised world concur in deploring. I have only one further observation to make, and it is a reminder in case you know it already. Most strictly is submarine telegraphy and telegraphy generally a coronation gift of Queen Victoria to the British Empire and the human race. The first patent—that of Coke and Wheatstone—for what I think they called magnetic telegraphy, was taken out on the 12th June, 1837; so it was, practically speaking, an accession gift of Queen Victoria to her people, and it is certainly one of the greatest triumphs of her reign and one of the principal achievements of the human race which will make her reign for ever memorable. I will now invite you to proceed to the order of the business, and I will ask the Secretary to read various letters which have been received.

Mr. G. R. NEILSON then read letters, all of which were addressed to Lord Tweeddale, from Dr. von Stephan (Secretary of State for Telegraphs,

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Germany), M. Ernst Dániel (Royal Hungarian Minister of Commerce), M. J. Depelley (of the Compagnie Française des Cables Télégraphiques), and from Gen. Eckert (President of the Western Union Telegraph Company).

*Dr. von Stephan wrote:* "Whilst having the honour of acknowledging your favour of July 31st, permit me to congratulate you on your intention of honouring those men who, with great foresight and untiring energy, founded the submarine telegraphs and continued to develop them with such success. I feel honoured at being asked to join the Committee which is to carry out this plan, and place, with great pleasure, my name and person in the service of this matter; at the same time I shall be glad to know in what way I can be of use."

*M. Dániel wrote:* "By your letter of July 31st you have been good enough to inform me that it is proposed to form a Committee to inaugurate a memorial in honour of the inception and extension of submarine telegraphy, and have done me the honour of asking me to become a member of the Committee. In our century of steam and electricity submarine telegraphy being without doubt one of the greatest triumphs of science by which all humanity benefits, my office approves your proposal, and on my part I accept with pleasure the distinction which you have been good enough to offer me. Waiting with lively interest your further communications on the subject, I wish to say that so far as other engagements prevent me taking part in the deliberations of the Committee, I shall be replaced by a member of the Imperial and Royal Legation of Austria-Hungary in London."

*M. Depelley wrote:* "Absence has delayed my reply to the letter which you have done me the honour to send, asking me to join the Committee which is being formed to promote the inauguration of an international memorial to commemorate the inception and extension of submarine telegraphy. I accept your offer, and am glad you have thought of permitting me to associate myself with a project destined to recall the services of submarine telegraphy, and to render homage to the men who have created and brought it to its present development. May I add that my Company is desirous of participating in this work, and you may, therefore, include it amongst those who promise support."

*Gen. Eckert wrote:* "I am in receipt of your esteemed favour of July 31, 1896, advising me that it is proposed to form a Committee in London for the purpose of inaugurating an International Memorial to commemorate the inception and extension of submarine telegraphy, *à propos* of the recent deaths of Sir John Pender, Sir James Anderson and Mr. Cyrus Field, and asking me to become a member of that Committee. I need not say that I take pleasure, not only personally but as representing the Western Union Telegraph Company, in giving such encouragement as I can to every dignified recognition of the great services of the telegraph to commerce and to the intimate intercourse between the nations of Europe and America. You may, therefore, add my name to your Committee."

Letters regretting their inability to attend the meeting were also sent by Mr. J. C. Lamb, Mr. Spencer Bridges Todd, Sir J. Drummond Hay, Sir Donald Smith, Admiral Sir A. Hoskins, Mr. W. H. Preece, Sir George Richards, the President of the Institution of Civil Engineers, and other gentlemen.

The Marquis of TWEEDDALE then said: I have been asked to submit the names of gentlemen who, we believe, will make not only a good business committee, but a good representative committee. The object has been to secure the names of gentlemen representing every class of the community. Of course, it is not necessary to adhere to this particular list, and we shall be very glad to receive any suggestions respecting other names. The first name on the list is Viscount Peel, whom we all know as the late Speaker. I have a wire from him regretting his inability to be present to-day on account of a previous engagement. The next name is that of Lord Kelvin. Lord Kelvin has shown great interest in this movement, and in answer to a letter and a telegram which I sent him (he is now engaged in the North of Scotland) he expressed his regret that he would not be able to be present. I suggested to him that it would be very acceptable if he would take the place of Chairman of the Executive Committee; but he replied that the claims on his time in Glasgow during the winter make this impossible, but that he will attend the first meeting of the Executive Committee, which will be held towards the end of the month. I am sure that that intimation will be very agreeable to you. Then the other names are the Most Hon. the Marquis of Tweeddale, Lord Sackville Cecil, Sir Robert Herbert, G.C.B.; Sir Eyre M. Shaw, Sir John Robinson, Mr. J. C. Lamb, C.B., C.M.G.; Mr. William Andrews, Mr. F. A. Bevan (who, I hope, will also be our treasurer), Mr. G. von Chauvin, Mr. C. W. Earle, Dr. J. A. Fleming, Mr. Robert Kaye Gray, Mr. John Newton, Mr. F. C. C. Nielsen, Mr. J. Denison Pender, Mr. William Shuter, Mr. J. H. Tritton, Mr. E. M. Underdown, Q.C., the President of the Institution of Civil Engineers, Mr. W. G. Bond (*The Electrician*), Mr. H. Alabaster (*Electrical Review*), Mr. W. H. Maw (*Engineering*), Mr. J. Pendred, Mr. W. H. Baines (who with Mr. Newton represents the interests of shareholders), and Mr. C. Bright.

On the motion of Lord TWEEDDALE, seconded by Mr. VON CHAUVIN, the list of names read was approved, as forming the Executive Committee, with power to add to their number.

Resolutions were afterwards passed appointing Messrs. Barclay, Messrs. Glyn, and Parr's Bank, as bankers to the fund; electing Mr. F. A. Bevan treasurer, on the motion of Lord Tweeddale, seconded by Sir A. J. Leppoc Cappel, and appointing, at the instance of Mr. F. A. Bevan, seconded by Mr. Fritz Moll, Mr. G. R. Neilson honorary secretary.

The CHAIRMAN said he had been requested to state that that would be an opportunity for making suggestions respecting the form which the memorial should take. A letter had been received on this subject from Prof. Silvanus Thompson.

Mr. NEILSON read the letter, which was dated the 5th inst., and addressed to the Marquis of Tweeddale. It was as follows:—"I greatly regret that other engagements of long standing will prevent me from attending the meeting of the Submarine Telegraph Memorial Committee to-morrow. It is needless to say that the movement has my most hearty support. May I be allowed to make a suggestion as to the objects on which the Memorial Fund should be expended? The old Society of Telegraph-Engineers has now expanded into the Institution of Electrical Engineers, with a membership of near 2,000, and an annual income which is every year growing. It has already created the nucleus of a fund to provide itself with a suitable building—a fund to which a portion of its annual surplus is to be allocated. But that building fund cannot for some years be adequate for the purpose unless other means are available. I would, therefore, urge upon the Committee that there could be no more appropriate object on which to expend a portion, at least, of the Memorial Fund than in the erection of a permanent home for the Institution whose inception began amongst telegraph engineers, and which cherishes the progress of submarine telegraphy as a foremost branch of its aims."

Mr. ANSELL said he did not think the proposition contained in Prof. Silvanus Thompson's letter would meet with approval at the hands of telegraph men. He had no doubt that if funds could be raised to found a home for the institution referred to it would be very much in the interest of electricians generally, but that was a matter which had nothing to do with submarine telegraphy.

Sir HENRY MANCE asked whether any idea could be given as to the form the memorial was to take. If there were any funds to spare it might be agreeable to them to remember that the inventor of submarine telegraphy, Mr. Jacob Brett, was still in existence. The memorial might also take the form of scholarships.

Mr. BURT said he took it for granted that the Committee which had been appointed would have to consider all the schemes and plans which might be proposed in connection with the memorial. He suggested that there should be a meeting of the subscribers, or at all events that a report should be issued to them by the Committee, stating what was proposed to be done before actually deciding on any scheme.

The CHAIRMAN stated that when the Executive Committee had thrashed out all the suggestions which might be made to them, and had decided on a recommendation of their own, the matter would come before the general Committee, to whom it would be submitted for final approval.

Mr. BURT, continuing, said that the sooner expected subscribers were made acquainted with the form the Memorial was to take the sooner would the money come in.

On the motion of Sir EYRE M. SHAW, seconded by Sir A. LEPPOC CAPPEL, a cordial vote of thanks was passed to the Chairman, the proposer remarking that Lord Selborne had placed before them succinctly, but briefly, as best suited business men, the whole of the circumstances connected with the Memorial so far as it was necessary to deal with them on that occasion.

The proceedings then terminated.

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*The following is the letter received by the Marquis of Tweeddale from Lord Kelvin on the subject of the International Submarine Telegraph Memorial:—*

Netherhall, Largs, Ayrshire, October 2, 1896.

Dear Lord Tweeddale: I am very sorry that I cannot be with you at the meeting on Tuesday, as I have an important business engagement at the aluminium factory (Foyers), which requires me to go to Inverness on Tuesday, and which cannot be postponed, as I must return from the North on Saturday to be ready for my University duties, which begin on Monday.

I feel strongly with you, that the most suitable form for the Pender Memorial would be some foundation for the advancement of electrical science in London or Glasgow. There seem to me to be strong reasons for choosing Glasgow, irrespectively of my own bias, in favour of either the University or the West of Scotland Technical College (formerly the Andersonian College), which is in close alliance with the University.

I shall be very glad, if the meeting on Tuesday will excuse my absence, and will elect me as one of the Executive Committee, to do all I can to help you to find the best and wisest way of spending the money subscribed. I shall be in London for a few days about the end of October, and, if convenient for the Committee to hold a meeting about that time (would Friday, the 30th be convenient to you, or the 27th or 28th?) I could attend.

Yours very truly, KELVIN.

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## TECHNICAL EDUCATION.*

Some eight or nine years ago that excellent gentleman Mr. John Bull made a great and startling discovery. The good, easy-going fellow had inherited from his father the magnificent business which had practically no rivals in the markets of the world. Repeated experience had given him a supreme contempt for the efforts of rival houses; and, in fact, his position seemed so secure that he thought he might be permitted to take matters easily, whilst quietly enjoying the vain, if strenuous, attempts of his rivals to enter into competition with him. After some years of this blissful repose, he awoke one afternoon to the fact that his dividends were less substantial than they ought to be, and that foreign firms, if they had not succeeded in diminishing his turnover, had at any rate very substantially affected his rate of profit. The good gentleman could not be bothered just then into examining the matter closely, so simply gave instructions to cut down unremunerative expenditure, as he was pleased to consider experimental work of every kind, and went on as before. The next time he went through his accounts,

* From *Engineering*.



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matters appeared to be still more alarming, and this time he determined to find out something as to the cause of his rivals' success. He was soon struck by the fact that abroad every factory had a technically-trained chief, whilst he had been rather priding himself on the fact that there was no theory about his business, that his works-manager and chief draughtsman were "thoroughly practical" men, inasmuch as whilst they could show a fitter or turner how to do his work, they were often incapable of fixing, for instance, the proper thickness of wall for a hydraulic cylinder, or of determining the strains in a simple lattice girder or workshop crane. For any work requiring calculations to be made, a consulting engineer was called in. The latter in some cases was incompetent, whilst in almost all he was more concerned in maintaining a reputation for infallibility than in endeavouring to execute the work in the most economical manner. In short, money—other people's money—was no object to the consulting engineer, as witness many of the bridge designs which have emanated from Westminster in the past.

After a survey of the whole question, Mr. Bull decided that he also must have technical education, and he determined to outdo his competitors, if not in the quality of it, at least in the matter of quantity. Every man, from the drilling machine tender to the chief draughtsman, was to have a smattering of scientific knowledge. Technical institutions arose like magic throughout the country, and were in the aggregate heavily endowed both with imperial and local resources. In London alone it is estimated that £500,000 represents the capital expenditure on these polytechnics, whilst the cost of maintenance exceeds £120,000 per annum, for a kind of work which might very well have been done by evening classes held in the various Board schools. Some ill-conditioned grumblers did indeed suggest that they could not perceive that research in the chemical trade, for instance, was likely to be much advanced by the yardmen learning to perform a simple inorganic analysis. Important discoveries are not usually made by tyros, they ventured to remark; but in the general enthusiasm their warnings have passed unheeded, whilst the fantastic views of their opponents have found fitting expression in the remarks of the Chairman of the London County Council, who was eloquent on the advantages to a bricklayer of a knowledge of the chemical qualities of clay. Reasoning is, of course, wasted on a gentleman who can make a remark of that nature; but when the hot fit is over, a sad awakening lies before the public. In every industry the vast majority of employés must be content to simply obey orders, thankful if the acquirements and abilities of their chiefs are sufficient to secure to the district a fair share of the world's work. In commercial as in national warfare it is the leaders that count. Change leaders, and the body of men defeated before at every engagement may become as uniformly victorious. To supply such leaders should be the aim of our technical schools, in place of which they fritter away their resources in the attempt to give every private in the ranks a smattering of higher strategy. The City and Guilds of London have been amongst the few public bodies who have not been carried completely away by the existing craze, though the pressure has been so great on them that even they have yielded somewhat. In their Central Technical College each department is under the control of a thoroughly competent professor, and it is doubtful if at any foreign school a better training can be acquired than here. Four more such colleges, at most, would fill all the requirements of the kingdom, and if the local and imperial authorities would expend their resources in instituting scholarships to such, instead of squandering them on "smatter" shops as at present, such scholarships would give every lad fitted to climb, or lead, his opportunity, whilst with the money saved, the equipment of the laboratories of the leading schools would soon be unexcelled in the world. At present a lad gets a smattering of the differential calculus, for instance, at some polytechnic, and immediately feels he is fitted for something better than running a planing machine. If he is, well and good; he will not mind that machine long before he has the offer of more remunerative employment; but if every lad in the country is given this smattering, whilst only a small fraction are worthy of promotion, the ninety and nine left in the workshop wilderness are possibly spoilt for mechanics without being fitted for anything better. Every facility should be given for the exceptions to rise from the ranks, but any attempt to establish an educational dead level is likely to be disastrous. As the mass cannot be raised to the level of the leading men, the alternative of degrading the latter to the lower plane must in such a case be adopted.

So far as the middle classes are concerned, some sort of excuse may be made for the existence of many of these low grade schools of science. The whole of our middle-class educational establishments are still overshadowed by the classical tradition. At the public schools a modern side has in many cases been grudgingly instituted, but the modernists are looked down upon not only by the general body of masters, but also by the bulk of the boys themselves. The consequence is that the average youth leaves one of our public schools with a more or less plentiful knowledge of Greek and Latin words, but with very little acquaintance with the facts of natural science. Our private schools are still worse, being pretty frequently controlled by a head master who has failed as a parson, a state of affairs which has long been traditional in these islands, as Sir Walter Scott refers to it as a common practice in the Scotland of his day. This being the case, the polytechnics undoubtedly do assist the sons of the bourgeoisie to get some fragments of scientific knowledge which they are, as yet, too often denied at school, but it was scarcely with this object in view that half a million has been expended on the London institutions alone.

Though unconnected with matters of general policy, one excellent feature of American technical schools is worthy of imitation here; that is, courses of lectures delivered by practising engineers. These lectures have in many cases been very valuable, attention being concentrated on small details usually neglected in text-books, rather than on general principles which can be quite as well set forth by a pure bookman. On this side of the Atlantic, technical school managers do not, as a rule, encourage practicians in their professorial chairs, to the distinct disadvantage of the pupil, who is too often regaled with a fare of what Mr. A. says that Mr. B. has said. In mechanical engineering, for instance, the lectures of Dr. Coleman Sellars delivered to the students of one of the American colleges of engineering teem with information of a practical nature. Business and commercial matters also receive attention, and the student is reminded of the well-known American method of defining an engineer as a man that can do well with one dollar what any fool can do badly with two. This question of cost is always kept carefully in view on the other side of the Atlantic, and in this respect it would be difficult to surpass much of the recent work on the Canadian Pacific, where thoroughly substantial structures have been erected at a remarkably low cost. In American text-books the importance of giving some idea as to costs has always been kept in view. Even the engineers' pocket books published there, follow suit, very many approximate prices appearing in Trautwine, for example.

Technical education is only one weapon, though an important one, in the industrial battlefield. Common sense and courtesy in the counting house and business offices are at least equally essential. In dealing with countries using the metric system, quotations should not be made in English weights and measures, whilst the advantages of a set of standards generally recognised in the trade are well shown in the recent orders sent from Johannesburg to the States for iron piping. Formerly this was obtained entirely from the Clyde, but the different makers had all their own standard sizes for couplings, unions, &c., with the result that a batch of such goods received from one Scotch firm could not be used interchangeably with the goods supplied by another. American makers have agreed on a set of standards, to which all work, and for this reason only they are getting a large share of the South African trade. When complaints were made the Scotch firms defended themselves by the inane remark that their own fittings were interchangeable *inter se*, and they professed to be unable to understand why this was insufficient. Not so very long ago certain makers held similar ideas as to screw threads. In short, they rather thought they scored a point in having their own standards, as they fondly imagined that then all repairs must be returned to them for execution. Experience has, however, shown that a careful colonial importer avoids placing his orders with such firms, as the annoyance of having to send some thousands of miles to replace a broken bolt can only be balanced by a very substantial saving in the original cost of the goods. No amount of technical training in the designing department is likely to affect the practice of such firms, who can only be brought to take a common-sense view of the matter by the hard logic of facts.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September 25, 1896.*

**Telegraph Competition.**—The Western Union Telegraph Company's strength in the telegraph business of this country lies to a very large extent in the contracts between itself and the various railroad companies, by which the Western Union controls and operates the latter's lines. As these contracts expire, the Postal Telegraph Company appears in the field as a competitor of the Western Union, and the success which the Postal Company has had in many cases recently in outbidding its great rival for the privilege of operating the railroad telegraph lines has been so marked as to attract considerable attention. Quite recently the Postal Company has taken over the telegraph lines of the Chesapeake, Ohio, and South-Western railway system, which were heretofore operated by the Western Union. The system covers about 400 miles of railway, and includes 1,500 miles of wire and 50 offices. The Postal Com-

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pany also came into possession recently of the lines of the Yazoo and Mississippi River railroad, and it is stated that the Company is gaining a considerable foothold by reason of its railway alliances.

**Renewing Burned Out Lamps.**—A Company has been organised in Lynn, Mass., for the purpose of renewing burned-out incandescent lamps on a novel principle. By the new method the collar or base end of the lamp is not disturbed at all, the old filament being removed and the new one placed through a small hole in the top of the lamp-bulb made by removing the tip. The aperture is subsequently closed exactly in the same manner as in the case of the original lamp. The filament is inserted into the bulb through the hole in the top by a skilful twist of the hand, and secured in place by carbon paste. The black deposit on the inside of the bulb is removed by fitting the lamp to a holder and revolving it in a gas furnace, the effect of which quickly removes all trace of previous use. The lamp is then removed with the glass perfectly clear. Immediately following this operation a small glass tube is fused to the opening in the bulb, through which the air is exhausted in the usual manner. When a sufficient vacuum has been obtained, the throat of the tube is melted and closed, and the finished repaired lamp does not differ at all in appearance from a new lamp. The repaired lamps are subjected to the usual tests. It is stated that lamps may be repaired in this manner five or six times.

**Races of Electric Motor Carriages.**—Races of horseless carriages were held at the Rhode Island State Fair at Providence, R.I., on September 7th and 8th, and on each day a vehicle propelled by electric power was the victor. The electric carriage, entered by the Riker Electric Motor Company, Brooklyn, New York, won the race on both days. The distance was five miles, and according to the conditions of the race the carriages were not allowed to run at a speed of less than 15 miles an hour. The Riker carriage on the first day made the distance in 15·1¾, and the second day the distance was covered in 13·6. The fastest mile was made in 2·47½, which was accomplished by the Riker machine. The Electric Carriage and Wagon Company, of Philadelphia, entered an electric carriage, which came in second on the first day and third on the second day.

**The Armington and Sims Engine Company.**—This well-known concern, whose head-quarters are in Providence, R.I., has emerged from its financial difficulties on a basis which will enable it to conduct its business without interruption. The threatened suspension, therefore, has been averted, and the sympathies of the electrical trade are entirely with the Company in its efforts to continue the business. Under the new arrangement some prominent electrical men will render the Company valuable aid, and it is stated that by careful handling of the plant the creditors' committee can bring it out of the troubled waters and establish it on a solid basis.

## CORRESPONDENCE.

### A DIRECT-READING WHEATSTONE BRIDGE.

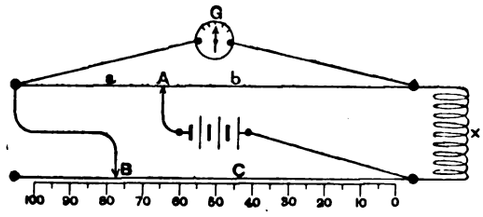
TO THE EDITOR OF THE ELECTRICIAN.

SIR: The mention by Mr. A. P. Trotter,* in his Paper on the above subject, of "a simple bridge on an emergency, or for amateurs," recalls a form of temporary bridge I employed some time back. Whether the method is new, I am unable to say. As, however, it served my purpose admirably, and as I have never, so far as I know, seen it described, I venture to think the arrangement may prove of use to others under similar conditions.

The problem was to measure, as rapidly as possible, a number of resistances ranging from about 0·1 ohm to, say, 30 ohms. The only standard resistance at hand was a one-ohm coil.

The Figure shows the arrangement adopted. From this it will be seen to be merely a modified Post Office bridge, in which the resistance boxes are replaced by slide wires. The ratio arms consist of a slide wire, the length and resistance of which are immaterial. The wire is divided into two parts, $a$ and $b$, by the sliding contact A. The unknown resistance is placed at $x$, and its value is then read off directly on the scale, under the slide wire $c$.

We have $a/b = c/x$ $\left(\text{or } x = c \times \frac{b}{a}\right)$, and hence the various points, such as A, have to be so determined, that $x$ may be the required multiple of the reading $c$. This is, of course, done by introducing the known resistance (in my case 1 ohm) at $x$. Suppose the scale $c$ divided into 100 parts. The sliding contact B is placed on the mark 100, and the position of the other slider A, for no deflection of the galvanometer, is marked under the wire. This is the point 1:1, or better, as suggested by Mr. Trotter, "one ohm maximum reading." B is next placed on the point 10, and the position of A for no deflection, again found and marked. The 100 on the scale now denotes 10 ohms. By next placing $b$ on the point 5, a maximum reading of 50 ohms is obtained, and so on. Of course, had it been necessary for the 100 mark to stand for 0·1 ohm, the required position of A could have been calculated from the other known points.




For permanent use the several points, such as A, would probably be connected to the contacts of a three or four-way switch, so that the various ratios could be quickly and accurately obtained. Trusting that some of your readers may find this arrangement of use.—Yours, &c.,

KENELM EDGCUMBE.

### TESTS OF GLOW LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As one who has had experience in the testing of incandescent electric lamps, I was pleased to read your comments on Mr. Preece's recent Paper on "Electric Glow Lamp Tests."

The points you particularise are very important, *i.e.*, the position of the lamp filament relatively to the photometer bar, and the standard of comparison, details as to these being omitted in the Post Office specification. In photometry the reddish colour of the Hefner standard is very objectionable, as I believe Dr. Fleming also pointed out in the discussion on Mr. Preece's Paper. The Pentane (16 c.p.) standard is much better in colour and every way. Surely, too, in so important a matter the standard consumption of sperm should be given with the specified English standard candle.—Yours, &c.,

Hastings, October 5, 1896. CHARLES F. BOTLEY.

**Gearless Tramcar Motors.**—The time has come, says the *Street Railway Review*, when we may expect to see the gearless railway motor come into use in its proper field. As is well known, the gearless motor was given a good trial in street car service several years ago, and was abandoned. At the time it came to be generally accepted that the single-reduction motor was the best for any electric railway service existing at that time. The single-reduction motor has become so universally accepted as the proper thing that there is perhaps a little danger that it will be used on high-speed work where a gearless motor would be better. With the ripened experience designers now have, such a motor ought to be a decided improvement over those designed several years ago; and for high-speed work where there are four on a car, which can be connected in series for starting (thereby keeping the starting current required down to a reasonable amount) they will probably find much use.

* See *The Electrician*, September 25, 1896, p. 691.

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# TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d.; abroad 9s.**

**The New Edition for 1897 is in active preparation, and circulars and full information will shortly be forwarded. The Subscription price remains 5s., postage 9d.; abroad, 6s. 6d., post free.**

## NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A Fleming, M.A., D.Sc., F.R.S. *The New Edition is now ready.* Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

"MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY."—By E. Tremlett Carter, C.E., M.I.E.E. *Ready in a few days.* Price 12s. 6d., post free; abroad, 13s. 6d.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth. *s also ready; price 7s 6d. (abroad 8s.).* Prospectus on application.

TENDERS INVITED.—By command of the Postmaster-General, tenders will be received until 10 a.m. on Monday, Oct. 26th, for the supply of red fir poles and for creosoting the poles. Some particulars relating to the conditions of the contract, &c., will be found in our advertisement columns; and all further particulars can be obtained on application to Mr. Chas. E. Stuart, Controller of Stores, General Post Office, London, E.C.

——— The Directors of the Great Western Railway invite tenders for the supply of a quantity of stores, from Dec. 1 next to Nov. 30, 1897. The stores required include:—Telegraph instruments, telegraph apparatus, copper wire, G.P. wire, &c., telegraph iron-work and tools, telegraph drysalteries, carbons for electric light, india-rubber goods, telegraph poles and yellow pine, iron pipes, iron and steel tubes, &c., &c. Samples and patterns may be seen at Swindon from Oct. 12th to the 23rd, and specifications and forms of tender may be obtained at the Office of the Stores Superintendent at Swindon. Tenders must be sent in addressed to the Secretary, Mr. G. K. Mills, Paddington, London, not later than Monday, 26th inst. Some further particulars appear in our advertisement columns.

——— *The Corporation of Glasgow* invites tenders for the electric lighting of the Bazaar. Specifications and forms of tenders may be obtained from the city electrical engineer (Mr. William Arnot), 76, Waterloo-street; and tenders must be sent in to the Town Clerk (Sir J. D. Marwick), City Chambers, Glasgow, by 10 a.m. on Wednesday, the 14th inst. Further information is given in our advertisement columns.

——— *Extension of Time.*—The time for sending in tenders for the electric lighting of the Dundee Royal Lunatic Asylum has been extended to the 16th inst. Tenders should be sent to Mr. Walter H. Tittensor, electrical engineer, Dudhope Crescent-road, Dundee.

——— The Directors of the Lancashire and Yorkshire Railway invite tenders for the supply of stores during the 12 months ending October 31, 1897. Tenders addressed to the Directors must be lodged with the Secretary, Mr. C. W. Bayley, Hunt's Bank, Manchester, by 10 a.m. on Monday, the 12th inst.

——— The Spanish Minister of Marine invites tenders for the laying of a submarine telegraph cable between the islands of Luzon, Panay, Negros, and Cebu (Philippine Islands). Provisional deposit, £2,000; definite deposit, £4,000. All particulars from the Ministerio de Ultramar, Madrid. Tenders by Dec. 13.

——— The Société Nationale des Chemins de Fer Vicinaux invites tenders for the electrical equipment of about 14 miles of suburban railway at Charleroi and elsewhere, on the overhead trolley system. Particulars from the Company, Rue de la Science, 26, Brussels. Tenders by Oct. 28.

——— The Municipal authorities of Werl in Westphalia invite tenders for the construction and working of electricity supply works for the supply of current for lighting and power purposes, including the supply of the necessary energy for the operation of an electric tramway between Werl and Wickede. Tenders to Der Magistrat, Rathhaus, Werl, Westphalia, by Nov. 3.

——— The Belgian Railway, Posts and Telegraphs Department invites tenders for the supply of galvanised iron wire of 2, 3, and 4mm. dia., telegraph cable, with 2, 4, 6 and 7 conductors, and copper wire of 1·mm. and 2mm. dia. Tenders to the Ministère des Chemins de Fer, Brussels, by 21st inst.

TENDERS INVITED.—The borough electrical engineer of Bradford (Mr. Alfred H. Gibbings) invites tenders for 117 Aron, 86 Frager, 24 Edison and 21 Oulton-Edmondson electricity meters. Lists giving details and capacity of the meters may be obtained from the Electricity Office; and tenders should be sent in to Mr. Gibbings, Town Hall, Bradford. Further particulars appear in our advertisement columns.

——— The Municipal Authorities of Medina de Rioseco invite tenders for the concession for the electric lighting of the town for 20 years. Tenders to El Secretario del Ayuntamiento de Medina de Rioseco (Valladolid), Spain.

——— Tenders are invited by the French Post and Telegraph authorities for the supply and laying of a 4-conductor submarine telephone cable between France and England. Tenders to the Sous-Secrétariat, d'Etat des Postes et des Télégraphes, 103, Rue de Grenelle, Paris, by 20th inst.

TENDERS ACCEPTED.—At Tuesday's meeting of the London County Council the Bridges Committee reported that they had invited and accepted tenders for the supply of the plant required in connection with the electric lighting of the Blackwall tunnel. The following tenders were received, and in each case the lowest was accepted:—

*Engines and Dynamos.*

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| Laing, Wharton and Down, London (*accepted*) | £6,579 |
| Crompton and Co., London | 8,291 |
| Siemens Brothers and Co., London | 8,240 |
| Johnson and Phillips, London | 7,815 |
| Electric Construction Co., London | 7,489 |

*Boilers and Fittings.*

| | |
|---|---|
| Fraser and Fraser, London (*accepted*) | £2,882 |
| Davey, Paxman and Co., Colchester | 4,565 |
| Tinkers, Limited, Hyde | 4,350 |
| Robey and Co., Lincoln | 3,351 |
| R. Taylor and Sons | 2,985 |

——— The Belfast Corporation has accepted the tender of the Acme Gas Engine Company for the supply of a new gas engine and dynamo for the electricity supply station, at £1,125.

——— The Cork Corporation have decided to accept, with slight modifications, the tender of the Cork Electric Tramways Company for the transfer of the powers and obligations under the Cork Provisional Order of 1896.

PLANT, &c., FOR SALE.—Particulars will be found in our advertisement columns of the sale as a going concern of the plant, machinery, fixtures, drawings and stock in trade of the Wigston Electrical and Engineering Company (in liquidation). The liquidator is Mr. A. B. Wykes, chartered accountant, Leicester.

——— Messrs. Horne, Son and Eversfield, of 17, Great George-street, S.W., and 85, Gresham-street, E.C., London, will sell by auction on Thursday next, Oct. 15th, at Cadby Hall, Hammersmith-road, West Kensington, a quantity of electric light plant, motors, dynamos, &c., removed from the Trocadero Restaurant. Some further particulars will be found in our advertisement columns.

APPOINTMENTS VACANT.—The governing body of the Haileybury College, Hertford, require a skilled mechanic to act as instructor to boys in general handicraft. A practical electrician would be preferred. The salary is £2. 5s. per week. Applications have to be sent in to the Master of the College. Some further particulars will be found in our advertising columns.

——— A Principal is required for the Victoria Jubilee Technical Institute, Bombay. Salary Rs. 800 per month, rising in five years by annual increments to Rs. 1,000 per month. Applications to Mr. P. Harrower, 134, Bath-street, Glasgow.

BUSINESS NOTICES.—We have received from Messrs. Krupka and Jacoby, of 15, Queen-street, London, E.C., a notification that the Phaeton Electrical Company (late Roothaan, Alewijnse and Co.), of Nijmegen and Brussels, will open a branch office in London on the 15th inst., at 61 and 62, Watling-street, E.C., of which Messrs. Krupka and Jacoby will act as managers pending the formation of this branch into a limited company, after which they will be appointed managing directors. A large stock of Phaeton incandescent lamps and other accessories made by the firm will be kept. Messrs. Krupka and Jacoby will continue the sale of Dr. Lessing's carbons and dry batteries.

———We are informed by the Edison and Swan United Electric Light Company (Limited), that Mr. C. M. Downie has resigned his position as sales superintendent of the Company, and that Mr. Edward Coote has been appointed general manager in his place. Mr. J. Cooper has been appointed accountant to the Company in the place of Mr. Coote.

PERSONAL.—Mr. C. M. Downie requests us to state that, owing to differences of opinion as to the management of the Sales Department of the Edison-Swan Company, he has sent in his resignation, which has been accepted. Mr. Downie has taken temporary offices at Bush-lane House, Bush-lane, E.C.

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LIQUIDATIONS.—It has been decided to wind up the Standard Time Co. (Limited) voluntarily, and Mr. E. L. Bennett, C.A., 56, Bishopsgate-street, E.C., has been appointed liquidator. Claims should be sent in by Nov. 16.

——— At an extraordinary general meeting of the Wigston Electrical and Engineering Company (Limited) on Sept. 25, it was resolved to wind up the Company voluntarily; and Mr. A. B. Wykes, C.A., 24, Friar-lane, Leicester, was appointed liquidator.

PATERSON AND COOPER (in liquidation).—At a meeting held yesterday, at 3, Crosby-square, E.C., Mr. D. H. Barnard, of H. P. Barnard and Sons, metal merchants (creditors of the estate for £350), was elected a member of the committee of inspection, in the place of Mr. Henry Edmonds, who had withdrawn. Mr. Moore, the trustee, stated that the summary of the debtors' assets and liabilities were issued from the office of the Official Receiver on Wednesday, and would be in the hands of all creditors by to-day or to-morrow, and that the public examination was fixed for the 16th inst. Mr. Moore also explained that there was little likelihood of the firm continuing business under its old title; but, for the present at least, they were going to fulfil all contracts of a profitable character that they had in hand, and gradually dispose of the business in sections as *bonâ fide* purchasers came along, there being the goodwill, some good contracts, and certain patents, which undoubtedly would, if gradually realised, bring in far more than would a summary closing of the business and selling at a loss.

The summary of affairs in this failure, referred to above, shows that at the date of the receiving order (Aug. 20) the gross liabilities of the joint estate of Edward James Paterson and Charles Friend Cooper amounted to £19,514. 6s. 3d. 319 unsecured creditors are expected to rank for dividend to the amount of £8,297. 13s. 1d. The securities held by seven full-secured creditors show a credit surplus of £125. 5s. Three partly secured creditors are expected to rank for a balance over the estimated value of securities held of £494. 6s. 9d. Contingent or other liabilities stand for £2,155, of which £805 is expected to rank. Other small sums bring the total amount ranking for dividend to £9,643. 19s. 10d. The total assets are estimated to produce £16,665, or a surplus of over £7,000. The assets appear to have been carefully valued, and should, if the estate is judiciously administered, realise within measurable distance of this estimated sum. The separate estate of Mr. Paterson shows a deficiency of £331. 15s., and of Mr. Cooper a deficiency of £2,927. 5s. 4d. The observations made by the Official Receiver are to the effect that the debtors have been adjudged bankrupt on their own petition, which shows that in 1882 Mr. Cooper joined Mr. Paterson, paying a premium of £1,500 for a fourth share in the business, the capital of which at the time was £18,000. £6,600 has since been introduced by the partners, and their share in the business at the time of the lodging of the petition was equal. In 1886 they became interested in the Hermite electrical sanitation and bleaching process, and, in consideration of their finding funds to pay patent fees, &c., became owners of a half-share in these patents. Since 1886 considerable sums, estimated to amount to £12,000, have been laid out in connection with these processes, for which a company has been formed to take over the patents and plant, a French Company taking over the French and Belgian patents. The debtors attribute their failure to the withdrawal of capital from the business for the purposes of the patents and the flotation of the companies. The books of account appear to sufficiently disclose the business transactions and the financial position of the debtors.

REMOVAL.—The Bristol Electric Safety Lamp Works inform us that they have removed their offices from 63, Queen Victoria-street to the works at 40, Great Smith-street, Westminster, London, where all communications should in future be addressed.

EXHIBITIONS.—We called attention in our last issue to the prospectus of an Exhibition for, amongst others, the electrical and allied trades, which is to be held at the Agricultural Hall, London, in 1897. The Directors of this Exhibition are engaged in the holding of a Show connected with the grocery and provision trades, which closes to-day (Friday), and the management can certainly claim to have scored a remarkable success for the first Exhibition of the kind held in London. The object of these shows is somewhat different to those held in the Crystal Palace and other large buildings, their aim being chiefly to introduce buyers to manufacturers; in fact, the "market" feature is predominant.

TURBINES.—A very handy pamphlet is issued by Messrs. W. Günther and Co., of Oldham, forming an illustrated catalogue of the well-known turbines and water-wheels manufactured by that firm. The book is in its fifth edition. It is well got up, and in an introduction gives some valuable notes relating to the installation of turbines, especially in connection with electric light and power plant. Although the list is unaccompanied by prices, except for Pelton wheels, the tabulated matter accompanying the text gives particulars likely to be required by intending users. The illustrations are well drawn, and pages 50 to 55 are devoted to a list of installations where these turbines are working. The catalogue forms a practical little book on turbine matters. On page 45 there is a picture of what appears to be an intelligent little gadfly making measurements of a river by means of a notch board, and the illustration is so well planned that it is seen at a glance how notch-board tests are made.

WIGSTON ELECTRICAL AND ENGINEERING COMPANY (LIMITED).—A circular, dated 1st inst., is forwarded by Messrs. Owston, Dickinson and Simpson, of 23, Friar-lane, Leicester, solicitors to the above Company, in which they inform us they regret that in consequence of heavy losses sustained during the past year, the Company has been compelled to suspend payment. A petition was presented by a creditor on the 15th ult. for the compulsory winding up of the Company; but at an extraordinary meeting of the Company held on the 25th ult., resolutions for voluntary winding-up were passed, and Mr. A. B. Wykes, of Wykes Bros. and Mantle, of Leicester, was appointed liquidator. It is urged that by this means the assets will be realised to the best advantage and at the least expense for the benefit of creditors. Several of the largest creditors have expressed their approval of this course, and in conjunction with the shareholders intend to oppose the petition for compulsory winding up which is to be heard on the 28th inst. Creditors are advised to forward statements of their claims to Messrs. Owston, Dickinson and Simpson, or to Mr. A. B. Wykes, as above.

ELECTRIC LIGHT FITTINGS.—Messrs. Ames, Garrard and Co. forward a copy of their new catalogue of electric light fittings, of which they are designers and manufacturers. In an introductory statement of the facilities which the firm possess for supplying this class of goods, it is pointed out that an extensive variety of fittings is not catalogued, as the market is already well filled with "stock" patterns. The object of the firm is to design specially for each client wherever possible, and particular attention is paid by the firm to this branch of their business. Many of the designs shown in the catalogue are neat and comparatively inexpensive.

CASSIER'S MAGAZINE.—The October issue of this magazine contains the following articles:—"A Vertical Engine for Stationary Purposes," by C. H. Manning; "The Naval Weakness of the United States," by W. L. Cathcart; "Engineering Notes from Japan and China," by F. F. Prentiss; "A Biographical Sketch of Sir Henry Bessemer" (with portrait), by Dr. R. H. Thurston; "Energy Transmitted by Compressed Air," by Chas. A. Hague; "Maintenance and Repair of Marine Boilers," by J. F. Walliker; "A Few Steam Engine Contrasts," by G. L. Clark; "Unusual Corrosion of Marine Machinery," by H. Maccall; and "Horatio Allen, a Chapter in American Railway History," by Alfred Mathews.

NEW WORKS.—The London County Council have approved the recommendation of the Building Act Committee, "that subject to the provisions of Section 76 of the London Building Act, 1894, the consent of the Council be given to the erection at the telegraph works, Bowater-road, Woolwich, of a building to exceed in extent 250,000 but not 450,000 cubic feet, to be used only for the purposes of the trade of electrical engineers, as shown by the plans and particulars submitted with the application of Messrs. Siemens Bros. and Co. Limited."

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AWARDS.—Messrs. Robey and Co. secured the "hors concours" award at the recent Kiel Exhibition, and Messrs. Babcock and Wilcox (Limited) and Messrs. J. I. Thornycroft and Co. each a gold medal. In all the representatives of British trade at the exhibition secured 43 gold medals, 98 silver medals, 132 diplomas of distinction, and 20 "hors concours."

ALTRINCHAM.—The District Council have approved of a scheme for an electric tramway, at the same time objecting to the overhead system.

BANGOR.—The proposal to extend the gas works in this town meets with considerable opposition from those members of the City Council who look forward to the adoption of electricity for lighting and other purposes. The extensions to the gas undertaking involve an expenditure of about £12,000, and the opposition seems likely to prove successful. At any rate, the recommendation of the Gas Committee to acquire land for the extension of the gas works has been defeated.

BOLTON.—The Town Council has ordered that a Bill should be promoted in Parliament conferring upon the Council powers to extend and work the town tramways, and for supplying electric current for traction and other purposes outside the borough. The Council has also approved a recommendation to borrow £30,000 for electricity supply purposes.

BRISTOL.—The track of the new section of the Bedminster tramway, which extends from the West-street junction to Ashton Gate, has been constructed of heavy girder rails, laid on concrete. This policy has been adopted in order to ensure greater strength and durability, and in view of the early introduction of electric traction,

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BURY.—The minutes of the Electric Lighting Committee, which were approved at the last meeting of the Council, recommend that tenders for wiring the municipal electricity works be obtained.

COSELEY.—At a meeting of the District Council it was decided to erect some additional gas lamps. Several members of the Council, however, pointed out that before any extension of gas lighting was approved steps should be taken to obtain particulars regarding the electric lighting of the district. It was contended by several speakers that the electric light was most desirable in all mining districts.

COUNTRY HOUSE LIGHTING.—The following is from the last number of the *Builder*. the leadieg journal of the building industry in this country :—"People who live in country houses where oil lamps are used often discuss the feasibility of making and using their own electric light. Their discussions seldom lead to anything, as they have only the vaguest notions as to the probable cost. It is, however, in certain cases a much simpler matter than is generally supposed. It is essential that there should be an outhouse about 18ft. long that can be utilised for the plant, which will consist of an oil engine, a dynamo, and accumulators. The accumulators need to be charged three times a week, but this can be done by the gardener without interfering unduly with his ordinary work, as the plant can be made almost automatic. For a house using 30 or 40 16-c.p. glow-lamps there are many first-class firms who would put up the plant, fittings, &c., for less than £250. As the result of working such a plant in a small house where 25 lamps were installed, it was found that a pennyworth of paraffin in the oil-engine lit eight 16-c.p. lamps for an hour, and we think that this rate might be fairly calculated upon. Depreciation and repairs have to be allowed for, but this is not nearly such a formidable item as it was 10 years ago. As accumulators are used, there need be no fear of any sudden failure of the light."

DUDLEY.—The Town Council has decided to apply for a provisional order.

DUNDEE.—The Gas Committee have now elaborated their scheme for electric light extensions, and are about to seek Parliamentary authority for the expenditure of the necessary funds. Mr. Tittensor, the Corporation's electrical engineer, has been instructed to prepare a report showing the capital expenditure involved in the proposed extensions. Mr. Tittensor has also presented a report on the subject of the extension and improvement of the lighting of High-street, the principal thoroughfare of the city. He proposes to discard the lanterns at present in use, and to adopt the canopy type of globe carrier, at an estimated cost of £8. 10s. per lamp, Mr. Tittensor also submitted an extended scheme for the lighting of the principal streets in the town, on lines similar to those adopted at Edinburgh. He proposes to erect 56 extra lamp-posts, with bracket hangers and lamps, and the necessary mains and pipes, at a total estimated outlay of £2,185. The report was provisionally approved, the details to be considered at a future meeting.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from September 30th to October 6th, with the ports of destination :—

*Argentina*—Buenos Ayres, £688 (including £340 telegraph material and £65 telephone wire) ; Rosario, £95 (telegraph material). *Australasia*—Adelaide, £10 ; Brisbane, £33 ; Fremantle, £112 (telegraph material) ; Melbourne, £286 (telegraph material) ; Perth, £228 ; Sydney, £820. *Belgium*—Antwerp, £34 ; Brussels, £892 (including £804 electric light cable and £78 telegraph material). *Canada*—Halifax, £39.000 (telegraph cable). *Chili*—Boca, £305 (telegraph material). *China*—Shanghai, £616. *Egypt*—Alexandria, £500 (telegraph material). *Finland*—Wiborg, £169. *France*—Boulogne, £36. *Germany*—Hamburg, (£115 telegraph apparatus). *Holland*—Amsterdam, £118 ; Rotterdam, £44 (including £22 telegraph material). *India*—Bombay, £54 (telegraph wire). *Japan*—Yokohama, £2,500 (telegraph cables). *Norway*—Christiania, £39 (telegraph material). *Panama*—Santos, £295. *South Africa*—Cape Town, £116 (including £73 telegraph material) ; Durban, £165 ; East London, £739 ; Port Elizabeth, £381. *Straits Settlements*—Singapore, £69 (including £19 telephone stores). *Sweden*—Gothenburg £183 (telegraph wire). *Uruguay*—Monte Video, £540. Total, £49,193.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows :—

*Cuba*—Guadeloupe, £22 (telephone material). *India*—Rangoon, £9. *South Africa*—Port Elizabeth, £124. Total, £155.

FACTORY LIGHTING.—Mr. Thomas Barton, of Blackburn, has, we learn, secured an order for the lighting by electricity of the factory of Messrs. Slaters, of Manchester, as well as of a number of the same firm's shops in Salford, Stretford, Hanley, and Leicester.

GOLD EXTRACTION.—The *Manchester Courier* states that much attention is being called to the Haycraft process of gold extraction now at work in Western Australia. Many advantages are claimed for this method, which is a combination of the two operations of electrolytic chlorination and electro-amalgamation carried on in one vessel at boiling temperature after the ore has been crushed. The whole of the ore is stated to be treated in one operation, as received from the mill, and practically the whole percentage of gold in the ore is extracted in two hours' time, compared with 48 hours' taken by battery and cyanide treatment. Salt water is essential to the Haycraft process, and of 100 gallons per ton of ore the greater part can be used again as against 240 gallons, the minimum for any other process. It is claimed that as high as 97 per cent. of gold has been obtained by this process, and that the great loss of gold in tailings and the percentage of waste or slimes in gold reduction will no longer take place.

INTERIOR CONDUIT INSULATING TUBING.—In reference to the mention made in our last issue of the conduit system used in lighting the Trocadero Restaurant, London, we have received from Mr. F. Bathurst a long list of establishments in which this system is adopted. Mr. Bathurst says the General Electric Company are increasing their stocking facilities for this interior conduit material, in order to meet the increased demand.

LEATHERHEAD.—The General Purposes Committee of the Urban Council have before them a proposal to apply for an electric lighting Provisional Order.

LEVENSHULME (MANCHESTER).—The District Council intend to at once apply for a Provisional Order.

LEWES.—The *East Sussex News* states that a scheme is on foot for establishing an electric supply station at Lewes, the promoters claiming that they will be able to supply electric current at a rate comparing favourably with the charge for gas. The County Hall is already wired, and can take current as soon as available.

LIVERPOOL.—At the meeting of the Corporation on Wednesday a vote for a supplementary estimate of £4,000 for the maintenance and renewal of the tramways of the city, Sir A. B. Forwood hoped that before a large sum of money was expended in repairing the present tram lines, consideration would be given to the slow character of the locomotion adopted. Liverpool, he pointed out, was behind the age with regard to its tramway system, and before any further moneys were spent they should see if some improved method of haulage could not be adopted. Mr. J. T. Wood pointed to the fact that Manchester had already decided to use its tramways for goods traffic, and there was at present a scheme on foot for connecting the tramways of Lancashire towns with the docks of Liverpool. The vote was approved on the understanding that the Health Committee, in whose hands the matter rests, will take steps to obtain from the Tramways Company an assurance that they are prepared to adopt an improved method of haulage on their system.

LONDON SCHOOL BOARD.—An extensive new store for books, apparatus, and furniture is to be provided for the London School Board on the Bowling Green-lane site, Clerkenwell, and is to be lighted electrically.

MOTOR CARS.—A London correspondent says that the London Road Car Company, who have 900 omnibuses on the streets, intend to go in extensively for motor 'buses next month as soon as the law permits it. 100 cars are stated to have been already ordered to be ready by the middle of November, and 300 for the opening of the New Year.

PLYMOUTH.—Colonel Luard, R.E., held a Local Government Board inquiry on Tuesday, for the consideration of the application of the Corporation for sanction to borrow £46,000 for electricity works. The Town Clerk, Mr. J. H. Ellis, in support of the application, said the Corporation obtained a Provisional Order in 1894, after which they consulted Dr. J. A. Fleming on the question, and his report was entirely in favour of the introduction of the electric light. Mr. J. H. Rider, Borough Electrical Engineer, submitted plans and specifications of the scheme, and stated that provision had been made for public and private lighting, and for the supply of energy for traction purposes. The proposed power of the generating station was independent of the system of electric lighting which might be adopted ; but whatever system was adopted the power would be suitable. Mr. Debham contended that a low-tension system of distribution should have been adopted. He also condemned the high price proposed to be charged for current for traction purposes—viz , 3½d. per unit. The effect of such a high charge would, he alleged, be to unduly hamper the efforts of the Tramway Committee to make the tramway undertaking pay ; but the Inspector ruled away this point as outside his inquiry. There was no opposition, and the Town Clerk asked for a period of 50 years for the repayment of the loan for land ; 30 years for the buildings, and the longest possible period for the rest of the work.

RAMSBOTTOM (LANCS.).—The District Council has appointed a committee to consider the advisability of establishing electricity supply works. The Council, who are anxious to have the lighting system in their hands, recently made overtures to the Gas Company for the purchase of their undertaking ; but it was stated at the last meeting of the Council that the Company's price was a prohibitive one—viz , a sum sufficient to secure to the shareholders a maximum dividend in perpetuity. Under the circumstances the Council will endeavour to formulate an electric lighting scheme.

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RAMSEY.—The proposals regarding the construction of an electric railway from Laxey to Ramsey will be discussed before the Tynwald Court on the 28th inst., and the two companies who are competing for powers to construct the line have been invited to lay before the Ramsey Town Commissioners particulars of their schemes.

QUOITING.—This is a sport which has many devotees, and if facilities were offered for playing the game in comfort, there is no doubt quoiting would become as popular as in the pre-golf and tennis days. It is a game usually played in the open air; but there is no reason why, with the advantage of the electric light, structures should not be erected in which the game could be played all the year round. The electric light has been utilised in football, and should be serviceable in re-establishing the popularity of quoiting.

SALFORD.—At Wednesday's meeting of the Town Council Mr. Alderman B. Robinson, Chairman of the Technical Instruction Committee, said that the opening of the technical school had been attended with great success. 1,012 students had already entered, and there were about 2,000 entries in all, as a number of students had entered in two classes. The classes for mathematics, engineering, building construction, electric lighting, and chemistry were crowded to excess. The aggregate of the fees already received was 56 per cent. in excess of the amount the Committee had expected to receive during the whole of the first year.

STRETFORD.—A sub-committee of the General Purposes Committee is considering the question of the establishment of electricity supply works, and Mr. F. Bennett has been instructed to prepare a scheme for the guidance of the Committee.

THE TROCADERO.—We are asked by Messrs. Fred. A. Donnison, Berlyn, Evans and Co. to state that they have specially designed and manufactured the large electroliers and brackets in the grand hall, staircase, grill room and large dining hall of the above restaurant.

TRAIN LIGHTING.—A correspondent of the *Daily Telegraph*, in referring to the railway carriages used by the Emperor and Empress of Russia, describes the exterior electric illumination as one of the most striking features of the train. By means of specially-constructed arc lamps a search light scours the road as the train proceeds on its journey.

WAKEFIELD.—Many of the leading tradesmen in this town are clamouring for the electric light, pointing to the fact that the town of Dewsbury is ahead of them in this respect. At the last meeting of the Tradesmen's Association a resolution asking for details from the Corporation as to the progress of the Wakefield electric lighting scheme was carried.

WALSALL.—Col. A. G. Durnford, R.E., held an inquiry into an application of the Corporation for powers to borrow £2,500 for electric lighting purposes. Interest centered in the statement made by the Town Clerk (Mr. J. R. Cooper) that in December last, when the supply started, there were 42 customers, which have now reached 67. The amount of current sold in July and August represented an increase of 95 per cent. over that sold in May and June. Further machinery will shortly be required to cope with the demand for current, which is chiefly for private lighting.

WIGAN.—The Town Council was informed at its meeting this week that the Electric Lighting Committee have decided to abandon for the present the public lighting scheme, and that this decision was chiefly due to depression of trade, and the fact that great expense had been incurred in connection with the water supply of the town.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

September 10, 1896.

20,095. F. H. ROYCE and E. A. CLAREMONT. Manchester. An improved controlling and reversing switch for electro motors and similar uses.*

20,106. S. A. ROSENTHAL. London. Improvements in secondary batteries. (S. J. von Romocki, Germany.)

20,121. J. M. M. MUNRO. Glasgow. Improvements in overhead conductors for electric traction.

September 12, 1896.

20,217. J. H. TUCKER. Birmingham. Improvements in electrical switches.

20,242. SIEMENS BROS. AND CO. (LIMITED). London. Improvements in appliances for rendering astatic galvanometer needles independent of disturbances by earth magnetism. (Siemens and Halske, Germany.)

20,243. SIEMENS BROS. AND CO. (LIMITED). London. Improvements in appliances for protecting electrical measuring instruments from external influences. (Siemens and Halske, Germany.)

September 14, 1896.

20,261. W. H. SCOTT. Norwich. Improvements in electric hoists or capstans.

20,323. W. MOSELEY. London. Improvements in telephone apparatus.

20,329. M. BLACK. London. Improvements in the method of and apparatus for electro-plating. (W. Webber, United States.)

20,330. THE EDISON-BELL PHONOGRAPH CORPORATION (LIMITED), and J. H. GREENHILL. London. Improvements in or applicable to phonographs.

September 15, 1896.

20,354. J. H. TUCKER. Birmingham. Improvements in electrical couplings.

20,378. G. BYNG. London. Improvements in holding and supporting imitation candles in connection with electric light fittings.

20,416. A. J. BOULT. London. Improvements in or relating to electric alarm bells and like apparatus applicable to cycles and other vehicles. (P. Archat, France.)

20,419. H. DE ROMANOFF. London. Improvements in electric railways.

September 16, 1896.

20,467. H. H. B. DEANE. Birmingham. Improvements in and relating to quick-break, double-pole switches and double-pole fuses for use in the controlling and distributing of electric light and power circuits.

20,505. H. IMRAY. London. An improvement in electrodes for secondary voltaic batteries. (R. J. W. Grindle, France.)*

20,513. J. VAUGHAN-SHERRIN. London. Improvements in electromotors especially applicable to motor carriages and other vehicles.

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

13,958. NEW. Trolley systems of electric propulsion and apparatus therefor.

16,557. ANDREOLI. Electro-deposition of gold, &c.

16,569. EPSTEIN. Electrodes for voltaic batteries.

18,487. HEIBLING. Electrolytic manufacture of "alloys" having an iron base.

18,593. EDMUNDS. Making electric connection between lengths of rail, &c.

19,272. KESTERTON. Steering electric carriages, &c.

20,071. PHILIPPI. Conduits for electric railways.

20,073. Production of sheets, strips, &c., of metal by electro-deposition.

20,335. COLLINSON. Electric arc lamps.

20,636. TRUSS. Telephone instruments.

1896.

10,127. LEIGH (Keithley). Conductors and collectors for electric railways.

10,698. BIRD. Electric time alarum apparatus.

10,817. DEVONSHIRE (Potter). Electric brakes.

11,429. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED) (Potter). Electric brakes.

# COMPANIES' MEETINGS AND REPORTS.

## Willans and Robinson (Limited).

The ordinary general meeting of Willans and Robinson (Limited) was held on Wednesday at the Cannon-street Hotel, under the presidency of Mr. Mark Robinson, M. Inst. C.E.

The SECRETARY (Mr. C. S. Essex) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, in rising to move the adoption of the report and accounts it is happily again in my power to congratulate you, on behalf of the Board, upon the prosperous state of things which they reveal. It is true we have not yet (except to a very small extent) to pay interest on the new Debenture Stock; but neither, on the other hand, has the Debenture Stock yet been given a chance to earn additional money for us. When the chance is given we have no fear but it will earn its interest, and more too. Considering the difficulties we have laboured under at Thames Ditton, so good a result should be a source of double pleasure to us; but we must not forget that difficult times may lie before us, while we are shaking down in our places at Rugby, and therefore we hope all will cordially approve the continuance of a moderate rate of dividend, coupled with a rapid expansion of the reserve fund. One feels, with some pride, that it is no light thing to have put by over £10,000 to reserve, besides what we carry forward in the profit and loss account) in so short a time as 2½ years. You will not fail to notice in the report that we hold to our system of writing off liberal depreciation. Before we begin to talk about profit we write off at the rate of over £8,000 a year from plant and machinery, buildings, and other things which wear out or come to an end. The first item in the balance-sheet to which attention should be called is the liability for Debenture Stock, of which £100,000 has been issued, and of which something over £42,000 had been paid up by the end of June. In some respects the Directors have departed from the views expressed at the last meeting. We thought then that an issue of £75,000 would suffice; but it was represented to us that the round figure of £100,000 was a better sum to offer to the public

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and would command more attention in the money market. A better reason was the increasing evidence of growth in the business; and as we had full authority from the shareholders to issue the larger amount, we decided to do so, and we find it is likely to be none too large. At the last meeting 4½ per cent. was mentioned as the possible rate of interest; we succeeded in making the issue, at par, at 4¼. The issue was, in fact, so successful—the amount being largely over-subscribed—that we begin to doubt if we were very faithful stewards after all, for apparently the issue might have been made at 4 per cent., and perhaps at a premium. But this is wisdom after the event; experts would not take the responsibility of advising 4 per cent. beforehand. One subject connected with the debenture issue remains—the incidence of the expenses connected with it, amounting to £1,151 8s. 2d.—which is believed to be a moderate expenditure for the purpose, advertising and all other charges having been closely looked after. At present it appears in the balance-sheet as a suspense account—a very book-keeping kind of asset, of course, but still of a kind perfectly justifiable under some circumstances, and on the present occasion quite harmless, since we actually carry forward as undistributed profit a balance more than large enough to wipe off the whole of the item in question. As pointed out in the report, we can write it all off at once from the balance just referred to. But that balance is realised profit, and as such has already contributed to the contingent salaries of the Directors and staff—*i.e.*, to that part of their salaries which depends upon the so-called "surplus profits"—profits remaining after the ordinary shares have received 7 per cent. If you apply it to discharging an expense you will excuse the Directors and staff from contributing to it; you will, so far as they are concerned, treat the expense of the debenture issue as a capital charge rather than as an expense—as no doubt would have been done, and properly so, had the issue been made at a premium sufficient to cover the expenses. It would doubtless be agreeable to everyone to write this small matter off at once, but the simplest of the two ways of doing so, namely, out of the balance carried forward, is open to the objection, as we have just seen, that the contingent salaries of the Directors and staff would escape contribution to it. The opposite extreme is reached if we adopt the alternative course of treating the amount as an ordinary expense of the half year, with the effect of reducing the half-year's profit by £1,151, with a corresponding reduction in the contingent salaries. But this plan is open to the grave objection that it misrepresents the true profit of the half-year. The expense in question in no sense belongs to the particular half-year, for if it is not a true capital charge, it is at least spent on securing a capital benefit destined to last 25 years. Theoretical justice requires that it should be written off at a small annual rate over those 25 years; this would be fair both to the shareholders and to those whose remuneration depends upon the profits. It is not fair, then, to these last to make them pay the contributions of 25 years in one, or even in two or three years, because few of them can hope to serve you for so long a period as 25 years, and their successors in office should clearly bear a part of the charge. If, for simplicity's sake, you prefer to write the whole off at once, some consideration for these interests appears reasonable. I fear the subject is a difficult one to make clear; but as the interests of many of the staff are involved, and not only those of the Directors, it has been necessary to trouble you with it. All the Directors wish for is an authoritative expression of opinion, and this we trust you will give. Continuing to refer to the debit side of the balance-sheet you will notice the disappearance of a small item in the previous half-year's account—£1,130 owing upon workmen's bonds. These have been redeemed, the holders having for the most part made application for a corresponding amount of the late debenture issue; we still pay them interest at the rate of the dividend on the Ordinary shares, so long as they remain in our employ. Turning to the credit side of the balance sheet, there is an increase of about £10,500 in the value of the Rugby works. The smallness of this increase is due to the delays in obtaining the structural steel work in the first half of the year, from which we have suffered so much, and which naturally retarded the work of all the other contractors. Plant has risen by some £4,000, mainly representing some of the Rugby tools which have been temporarily installed at Moulsey. Patents have been written down by some £800 net. Work in progress has greatly increased, from £24,647 to £33,203, and the lock-up in stores and stock has correspondingly risen from £26,830 to £34,423. This item is always jealously watched by the Board, and shareholders may feel sure that the increase is due only to the necessities of a greatly expanded business and enhanced output. The orders for the half-year greatly exceeded those for the previous half-year, or for the corresponding half of 1895. But to go on taking orders at this rate, before the new works are in operation, would be unwise, and therefore we have, since the spring, accepted, as a rule, only those orders which came from old and valued customers, or which were of special importance as leading to further work. Even so limited, the orders for the year will show a notable advance, and there is every indication that the fullest use will be found for the greatly increased appliances which will so soon be ready to our hands. The future could have no brighter auguries for us, so far as we can read them. The new machine shop at Rugby is within some three weeks only of readiness for occupation. We have arranged for a gradual change over. Before the end of this month we shall commence to shift a number of tools, and to bring in other new ones. This will give us more room at Ditton, and will in many ways improve the conditions of working. From time to time other tools will go down, and we hope the headquarters of the business will be transferred by about March 1st. After March 1st the Ditton works will be confined to making the lighter standard parts of engines, to template and gauge, under the charge of a foreman. As the new shops have now, though all too slowly, taken final shape, it is apparent that they will form most commodious and convenient works, and the Directors have no fear but they will justify the large outlay upon them, and add greatly to the prosperity of the Company. The present is scarcely the best time for entering into details respecting the new works; these will best be given at our next spring meeting. As you are aware, we have two complete half-yearly accounts in the year, and consequently two general meetings, of equal importance. Now that we are moving away from London, it might be well to inaugurate a system of holding one metting—say the spring, meeting—in London, and the autumn meeting in Rugby, at the works. By this means shareholders might be tempted to take a greater personal interest in the undertaking; in any case the Directors would profit by meeting the shareholders under circumstances a little less formal than those of such a meeting as the present. Perhaps some shareholder will express an opinion upon this question. In conclusion, gentlemen, I beg to move—

"*That the report and accounts for the half-year ended 26th June last submitted to this meeting, be, and the same are, hereby received and adopted.*"

Mr. LAZENBY seconded the motion, and expressed his gratification at hearing that the works at Rugby had made such satisfactory progress. The only thing they had to wish for now was that they might be in full working order as soon as possible. With regard to the question of holding one of the meetings at Rugby, he agreed with what the Chairman had said—that it would give them a more personal interest in the works and make them better acquainted with what was going on if they held one of their meetings there. The only objection he saw to it was the difficulty which the shareholders might find in going there.

Mr. COUSINS thought that those shareholders who attended the meeting at the works should be provided with first-class return tickets and be entertained at an excellent lunch as well (laughter).

Mr. BRYAN DONKIN thought the report was very satisfactory on the whole. He desired to know how matters were going on regarding the Niclausse boiler. He would also like to know that the insurance of their new buildings had been duly arranged for. Apart from the question of holding the meetings at the works or in London, he thought the shareholders should have an opportunity of visiting Rugby when the works were practically completed.

Mr. ANDERSON proposed, as a recommendation to the Directors, that they should write off the expenses of the debenture issue from the balance carried forward in the profit and loss account.

Mr. WILLCOX seconded this. With the amount written off, the shareholders would get what would otherwise be set aside for the purpose, so it came to the same thing. A clean balance sheet, free from suspense accounts, was also an inducement to investors.

Mr. YOUNG thought it would be advisable to pay off the sum in question in two amounts—half now, and the other half next March.

Mr. STOCK approved this suggestion.

After some further discussion on the point—

Mr. YOUNG said he had no desire to press his suggestion; upon which Mr. Anderson's proposal was put to the meeting and adopted.

The CHAIRMAN said the amount would be written off in the next accounts. On the question of insurance, he was happy to say that having spent largely in order to make the new shops practically fireproof, and isolated from each other, they were relieved in very large measure from the necessity for insuring at all. As regards minor buildings with inflammable contents (none of which could separately occasion a very serious loss) they had arranged to start a special Insurance fund, commencing with the next accounts. This matter had received close consideration, and it had been settled in agreement with the Trustees for the Debenture stock, holders, who were satisfied with the arrangements made. There was nothing but good to say with reference to the Niclausse boiler. They had installed several of them, and they had worked exceedingly well, the first order being followed by repeat orders from the users. They were certain they had a very valuable property in the Niclausse boiler. With regard to a visit to Rugby, irrespective of the half-yearly meeting, the Directors had always intended to have some sort of formal opening of the works next spring, to which the shareholders would be invited with others.

The report and accounts were unanimously adopted; and

The CHAIRMAN then proposed—

"*That a dividend for the half-year ended June 26th last, at the rate of 6 per cent. per annum on the capital paid up on the Preference shares, and at the rate of 7 per cent. per annum on the capital paid up on the Ordinary shares, be and the same is hereby declared.*"

Mr. YOUNG seconded the motion, which was carried unanimously.

Mr. ANDERSON then proposed a vote of thanks to the Chairman and Directors.

Mr. COUSINS, in seconding the motion, observed that he lived in the neighbourhood of the works, and he could bear testimony to the able way in which the Directors managed everything, and to the admirable feeling that existed between them and the employés.

The motion was unanimously adopted.

The CHAIRMAN acknowledged the vote on behalf of his colleagues and himself; the cordiality with which it had been received must add, if anything could, to the wish of the Directors to do all in their power to promote the welfare of the Company.

## Brush Electrical Engineering Company (Limited).

The seventh annual general meeting of this Company was held at the Cannon-street Hotel on Monday last, under the presidency of Mr. J. B. Braithwaite, jun.

The SECRETARY read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: The result of the year's trading may appear to the shareholders, and probably also to the general public, to be rather disappointing; and to some extent the Directors share that view. I think, however, that when I have given you the explanation which I shall have to lay before you with reference to the circumstances of the past year,

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you may possibly be inclined to take a somewhat less pessimistic view of the immediate position and prospects of the Company. The gross trading profit for this year amounts to £33,298, compared with £37,858 last year—a reduction of £4,600. The reduction in the expenditure, on the other side, however, diminishes that reduction to £2,900, which is the actual difference in the net profit between this year and last year. In view of the fact that during the past year we have not received one single large central-station order, I personally do not think that that result is as bad as we might possibly have anticipated, because it means that the whole of our profit this year has had to be made up of comparatively small individual amounts, for there have been no large orders going in that period. In the three or four previous years we had an exceedingly good share of the large contracts that were then going for the lighting of central stations for municipalities. We executed orders for the municipalities of Leicester, Worcester, Manchester, and Hanley, as well as many other places; but at the present time there are no orders of that type in the market. It appears as though all those municipalities that were sufficiently enterprising to make an experiment in electric lighting have done so, and that other municipalities, while averse to allow a company to obtain a provisional order and desirous of keeping it in their own hands, are waiting—and this may be natural enough—to see how those municipalities that have entered into the business are going on before they themselves embark any great amount of capital in it. For that reason there have been none of those large orders for £20,000, £30,000 and £40,000 which came out in past years, and we have therefore had to depend on, comparatively speaking, a retail trade—smaller orders of £1,000, £2,000 and £3,000; and it takes a good many orders such as these to make up for the large drought in these block orders. I think, indeed, that it speaks well for the estimation in which our manufactures are held that our net profit this year shows a reduction of only £2,900 compared with that of the previous year. I will now refer to the balance sheet. We are making this year—or are proposing to do so, with your sanction—two rather important alterations in our balance sheet, and it is right, therefore, that you should have the fullest possible explanation with respect to those alterations. On the debit side of the balance sheet you will notice that our capital has been increased by the issue of £76,770 of Second Debenture Stock. This stock we made redeemable at the Company's option at 105, and you will, I think, see that there was good reason for making the stock redeemable, because events have occurred in the past year which we did not at that time anticipate, namely, that we have been approached by certain large Continental firms on the subject, and have accepted an offer that was made to us to purchase the whole of our Vienna business. This has put a large amount of capital into our hands, for which we have no immediate employment. I therefore think we did wisely in connection with this new capital to give ourselves the option of redeeming this Second Debenture Stock. That is the only change with respect to the capital issued during the year. The creditors stand this year at £28,982, against £33,589 last year—a reduction of about £5,000; and the bills payable are £4,602, against £11,499 last year, or nearly £7,000 less. Therefore the total debts we owed on June 30th this year amounted to £33,585, compared with £44,888 last year, being a reduction of about £11,300. I am afraid that I cannot hold out any great hope of getting that amount much lower. We are already paying cash for everything we buy at the shortest possible dates, and we are obtaining the largest possible discounts; but in a business with such a turnover as ours we cannot expect to get our indebtedness down much lower than £33,500. Our loan from our bankers against security amounts this year to £26,775, compared with £78,097 at the same date last year, or a reduction of £52,000. I may also mention that since June 30th this loan has been further reduced to £10,000, and it is probable that we shall shortly either extinguish this item altogether, or reduce it to merely a nominal sum, so as to keep the account open in case of emergency in the future. This year our net profit amounts to £4,615, compared with £7,541 last year. On the other side of the balance-sheet you will see, under the first heading, that we have during the past year been enabled to arrange for what we have long desired, and what I believe the shareholders have also been desirous of—that is, to get the item of property and patents and goodwill divided up. As I have had occasion to remind you on previous occasions, we had before no means in our books of doing this accurately, and I felt that to divide this item in a mere haphazard way would simply have been useless. It would have been of no use to say that our factories were worth £100,000, the patents £50,000, and the goodwill so much more. I therefore came to the conclusion that the only possible basis on which we could divide it was to obtain the services of one of the best firms of valuers of this class of plant and machinery in the United Kingdom, and to get them to go to Loughborough and spend two or three months there if necessary in making a complete valuation of our machinery and plant. This is the course we have adopted; and Messrs. Fuller, Horsey, Sons and Cassell spent between two and three months at Loughborough, going through our buildings, plant, and loose tools, and preparing a complete valuation and inventory of everything we possess. I therefore feel, with their certificate of the value of our stock in our hands, that we have a justification for making a division of this item of property and patents and goodwill. We have, therefore, accepted their valuation, which I regard, as I believe others do, as a very conservative valuation; and you see now for the first time on the credit side of the balance-sheet that our property is entered separately. We say "freehold and leasehold factories at Loughborough, Lambeth, and Southwark, including plant and machinery, as per valuation of Messrs. Fuller, Horsey, Sons and Cassell, £88,847." That necessarily leaves the balance of the account to go to patents and goodwill; and you may, perhaps, ask me why we did not attempt to divide this item of patents and goodwill also. There again the answer which I gave as to the original division equally applies. If we divided that item it would be purely arbitrary. I am not one to take a sanguine view as to the value of patents, and I have never been a party to paying an enormous sum for them. I think the best system is to pay an inventor his out-of-pocket expenses, and then to let him depend for his future profit on a royalty. It would be a mistake for the shareholders to suppose that we have no patents, or that those we have are of no value. On the contrary, the patents which the Anglo-American Brush Company bought for large sums in 1876 and 1877 have naturally now run out through lapse of time; but we are constantly bringing out and developing new patents. At the present time we hold in England about 32 patents of an important character, many of which are bringing us in large orders, and some are giving us a very satisfactory profit. We also hold a large number of foreign patents. The item of stock stands at £100,662 this year, against £100,829 last year, so there is practically little or no change there. With reference to the item of debtors, the amount now owing to us stands at £116,275, to which must be added £1,235 for bills receivable, making the total amount owing to the Company on June 30th last £117,510, compared with £141,432 at the same period last year. You will see, therefore, that the difference between what was owing to us and what we owed on June 30th last represents an amount in the Company's favour of something like £85,000, and you will agree with me that that is a satisfactory balance on the right side. With respect to cash in hand, we had on June 30th £28,714 at our bank, against £3,910 at the same date last year, and we had in addition a balance on account of the sale of the Vienna factory of £61,900. That balance was carrying 5 per cent. interest up to the time when it was handed over to us, so that the combined items of cash were £90,614, against £3,910 at the same period last year. With regard to shares and debentures in other companies, this item stood this year at £56,454, against £61,236 last year. At this point I think it is necessary that I should say something about the change in the balance-sheet this year. The separate balance-sheet which we used to publish for our foreign branch has disappeared, owing to the sale of our Vienna business, which represented by far the larger proportion of that business. We did not think it was necessary to publish a separate balance-sheet for the small amount remaining of our Continental business, and our business in Australia and New Zealand. We have, therefore, carried the whole balance on that account into the general balance-sheet, and that enables you to see in one balance-sheet the whole of the assets and liabilities of the Company. I think this will be the best time for me to turn to the question of the proposal which we are going to make to you at the extraordinary meeting to-day to write down our capital. I think you will see that this balance-sheet, based on the valuation, shows that we have an item of £206,000, on which we are expected at present to earn dividends, but which, nevertheless, does not represent anything that is exactly directly of a revenue-earning character. Of course, our patents are of great value to us in our business; but it is a little difficult to regard them as actual dividend-earners. The orders we obtain and the amount we receive from our pupils represent an acknowledgment of the value of our goodwill, of course; but I do not like to see such an item as this, however valuable it may be, figure at a large sum in a balance-sheet; and the proposal which we make to you to write off £1 a share on the Ordinary shares will enable us materially to reduce the item of patents and goodwill, while it will not reduce by one penny the amount of dividend which the Ordinary shareholders will receive, because whether their shares stand at £2 or at £1 they are still entitled to the whole of the profit which the Company earns after paying the debenture interest and the Preference dividend. I believe that it will at the same time make the balance-sheet very much sounder. In connection with this matter we felt that it was only wise to extract any items under the headings of stock, debtors, or shares and debentures which our managers considered in any way doubtful; and accordingly we have extracted from stock £23,368, from debtors £24,158, and from shares and debentures in other companies £7,912, making a total of £55,439. There is no item there which is known to be actually bad at this moment, or it would have been provided for in profit and loss account. What we have done in view of our recommendation to you to write off this £1 a share from the Ordinary shares is to eliminate from the items I have mentioned anything as to the ultimate soundness of which we had any doubt, so that in the event of any portion of them—or the whole of them—proving bad in future years, the shareholders should not suffer in their dividend by the necessity of writing down these items. I think you will agree that when we were making this change it would have been very unwise to leave in our accounts any items that might turn out bad, and which, therefore, might prevent in subsequent years the distribution of the profits we might earn. Turning to the profit and loss account, you will be able to see, perhaps, more clearly the course of our business in the past year and the degree of success that has attended our efforts to reduce the standing charges of the Company. On the credit side we have £33,298 against £37,858, and it is right to call attention to the fact we point out in the balance-sheet that even that £33,298 includes a small amount of profit realised on the sale of the Vienna business, so that it is not all actual trade profit. I should like shareholders to bear that in mind. We have received by dividends on the securities held £330, and from transfer fees £107, making altogether a total of £33,736, against £37,858 last year, or a decrease of £4,200. On the other side of the profit and loss account we have effected reductions in the general charges [which the speaker detailed], reducing the amount under this heading to £13,116 this year, against £17,027 last year, or an economy of £4,000. The Directors' fees have been reduced from £2,000 to £1,000, and this is an absolute reduction—the amount is given up, and not carried forward, as I have known in the case of some companies, to be liquidated at a future time, and in the salaries there has been a reduction from £8,048 last year to £6,795 this year. The reduction in the item of rent, rates and taxes, from £2,864 to £1,963, is chiefly owing to the letting of our Belvedere factory, which we have been able to let for the remainder of our lease. Of course, you will understand that you cannot in a moment cut down charges to the full extent that may be possible; but I consider that we have made a fair beginning this year, and I hope that we shall be able to carry

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out a further considerable reduction in the course of the present year. The item "further cost of removal to Loughborough," £942, I think it was right to charge as we have done, although some might contend that it should have been debited to capital. We have now removed a very large portion of the account and bookkeeping to Loughborough, which will enable us to save very largely in the rent of the London offices. Maintenance of buildings and plant cost us a little more, but that is an item which you cannot starve, and our engineer certifies at the bottom of the account that the buildings and plant of the Company have been maintained in an efficient condition during the year. Bank interest and commission stands at £2,042, against £2,227 last year. That item will be very largely reduced during the current year, because the loan from our bankers is practically extinguished, and I think we may fairly anticipate an economy of £1,500 in that item this year. Our Second Debenture Stock was not issued until November last, so that four or five months of the financial year we are now reviewing had elapsed before we could apply the receipts from this debenture stock to reducing the loan to bankers. We have, therefore, had to pay this year, to some extent, interest on Second Debenture Stock as well as interest on the loan. The staff bonuses stand at £500, being the amount for the year ended June 30, 1895, against £2,430 for the previous year. That item, I am sorry to say, will entirely disappear this year, because, as we pay nothing to the shareholders, there will be no bonus to the staff. I hope, therefore, that that will be a stimulus to the staff to improve the position. The item of income tax has served us rather hardly this year, and we have a debit on that account of £577. The amount of our bad debts is only £498, which I think is an evidence of the soundness of our business. That brings us to the balance carried to the balance sheet of £4,615. I daresay many of you would like to know what course we intend to take with respect to the Second Debentures in view of the large amount of cash in hand that we have at present. Our Second Debenture Stock amounts to £76,770, and we have in cash at our bankers £90,000. We propose to keep an ample working cash balance in hand, and I think that that is a prudent course for a company like ours, which hopes again to be able to secure, as formerly, large contracts of £20,000, £30,000, and £40,000. Since this financial year closed we have obtained one contract to the value of over £50,000, and such a contract as that requires a large amount of working capital to deal with. Owing also to the great success of our new engine, which Mr. Raworth has invented, and for which there is a considerable pressure of orders, there will probably be an increased outlay on capital account in connection with our works at Loughborough. We shall, however, I think, make some substantial reduction in the amount of our Second Debenture Stock at a comparatively early date. As long as the amount due to us on the sale of our Vienna factory was earning 5 per cent. there was a profit of ½ per cent. on the transaction; but now that this money has come in, I think we shall probably take steps shortly to reduce the Second Debenture Stock to a round sum of £50,000.

A SHAREHOLDER: Is the stock redeemable at par?

The CHAIRMAN: I cannot say precisely at this moment. At the worst we can redeem it at 105, but I think it is possible that we may be able to buy the stock in the open market. It is quite impossible for me to forecast what the result of our trading will be this year, but I can give you our position as to orders up to September 30th this year compared with the position at the same date last year. The orders for that period this year are rather more than double what they were for the same period last year, leaving out this large order of £50,000, which is for the equipment of the North Staffordshire Tramways, and which includes a good deal of expenditure not on account of orders from the Loughborough works. I have simply included in this item the small amount of that North Staffordshire Tramways contract which represents material that will be manufactured by ourselves. There has also been a very great demand recently in the engineering department, especially for the new "Universal" engine. At present there are between 40 and 50 of these engines going through our shops. So far as we have gone at present, therefore, for the first three months of this year the outlook as regards orders is very much better than it was last year. Whether it will be equally good for the remaining nine months I cannot say. With reference to the North Staffordshire Tramways order, I think it shows that we have to be a little patient about these things. I said at our last meeting that we hoped for great things in connection with electrical traction, but in these matters we have to exercise a good deal of patience in England. With the strong financial position we are in now, and all our manufacturing facilities, we ought to get a very considerable share of the large amount of business which will arise in this country in connection with electric traction. He concluded by moving the adoption of the reports and accounts.

Mr. B. H. VAN TROMP briefly seconded the motion.

A long discussion followed, in which several shareholders took part. Some dissatisfaction was expressed at the result of the last year's working; and several shareholders objected to the proposal for cutting down the Ordinary share capital, especially as the Preference shareholders were not asked to make any sacrifice.

The CHAIRMAN, at the close of the discussion, repeated that, notwithstanding the writing off of £1 a share on the Ordinary shares, the holders would get precisely the same amount in dividend as if the shares were not reduced in value, the rate of dividend distributed being in that case greater. So far as it rested with the Directors to induce Local Authorities to adopt electricity, no opportunity had been lost. He advised them in their own interests to consent to the proposed reduction of capital, and to deal with the suspense account as recommended by the Directors. They had no means of wiping out the Preference shares, and they could not buy them in the open market and cancel them. The items in suspense account were not known to be bad, but there was a certain amount of doubt about them, and they wanted those items dealt with as stated, in view of the proposed reduction of capital, so as to ensure the distribution among the shareholders in the future of any manufacturing profits which they might make. The companies in which their capital was invested were all in a solvent position.

An amendment to the resolution having been declared lost on a show of hands,

The CHAIRMAN put the original motion, which was carried. He afterwards proposed—

"*That subject to the adoption at the extraordinary general meeting, to be held at the conclusion of the present meeting, of the resolution to reduce the Ordinary shares of the Company now issued by £1 per share, and to convert the 60,000 Ordinary shares of £5 each now remaining unissued into 90,000 Ordinary shares of £2 each, the proposal of the Directors to pay to the Preference shareholders the balance of dividend due to them for last year, amounting to £2,141. 3s. 8d., be and hereby is adopted, and that the warrants for the said payment of dividend be posted as soon as possible after the meeting confirmatory of the extraordinary general meeting has been held.*"

Mr. VAN TROMP seconded the motion, which was carried; and resolutions were afterwards passed re-electing the retiring Directors and auditors.

An extraordinary general meeting was then held, when the CHAIRMAN proposed the special resolution, which was set out on p. 746 of our last issue.

The CHAIRMAN stated that the Ordinary and Preference shares ranked *pari passu* as regarded capital in the event of the Company going into liquidation. It had been rather difficult to settle on the most equitable way of making the proposed reduction in the capital. If they had proposed to reduce the two classes of shares *pro rata*—which they were entitled to do under the Articles of Association—they would have inflicted an immediate hardship on the Preference shareholders, by cutting their dividend down *pro rata*. On the other hand, if they proposed to reduce the Ordinary shares, they would be inflicting hardship on them in the event of the Company going into liquidation. This, however, they regarded as a remote event, and therefore came to the conclusion that the most equitable course would be for them to make the proposal which they had done.

Mr. A. H. SANDERSON seconded the motion, which, after further discussion, was eventually agreed to by the requisite three-fourths majority.

A vote of thanks to the Chairman and Directors terminated the proceedings.

## Elmore's Patent Copper Depositing Company (Limited).

The annual report of the Directors of this Company to June 30th last is a lengthy and somewhat unusual one. The Directors believe it to be in the interest of the Company to hold the annual ordinary general meeting in London some time in October or November, when further experience of the increased output of the works will have been gained, and more definite information in regard to the copper supply scheme, referred to in the report, and other important matters, will be available. The manufacturing account for the period yields a gross profit of £6.895. 9s. 1d.

After writing off trading expenses, and providing £500 for Directors' fees, a net profit remains from the industrial branch of £4,175. 11s. 1d., which is available for meeting the charges entailed by the Haigh Park Freehold Estate, and the balance of £1,521. 15s. 3d. is carried forward. The revenue receives no benefit from the sheet licence royalties, which for the previous four years yielded £1,250 per annum to the credit of profit and loss. Previous years, to June 30th, show the following balances:—1892. loss of £8,566; 1893, loss of £13,655; 1894, loss of £10,435: 1895, profit of £480, including £1,250 royalties; 1896, profit of £1,521, exclusive of all royalties. This represents a considerable improvement over previous years, and (the report states) proves that the profits would rapidly augment if the Company were properly furnished with capital.

The manufactured stock has been valued on a very different basis from that hitherto adopted, which has been much too high. The works and plant have been maintained out of revenue in a state of thorough efficiency, at a cost of £711. The output, orders, and deliveries, are considerably in advance of those for the previous year, and 65 new customers are added to the books, some of them being the largest and most influential firms in the country. The working expenses per ton continue to diminish with the larger output.

After an exhaustive series of comparative tests the Board of Trade have sanctioned the use of Elmore copper tubes, of any diameter, in passenger steamers built under their survey; and the Admiralty have instructed the Company to supply steam pipes to the Portsmouth Dockyard, and the same are now under test. A licence has been granted for the manufacture of small tubes up to 4in. in diameter, subject to the payment of a satisfactory royalty per ton to this Company. Revenue from this source may be expected before the end of the current financial year. A contract to run for some years has been entered into, whereby the Directors believe that the Company's raw copper supplies will be obtained on extremely favourable terms.

The Directors ask the shareholders to consider the Company's position with regard to capital especially, and dolefully tell the well known story of the early days of Elmore Copper. The Board are formulating a scheme for properly financing the Company, and hope to lay the details before the shareholders at an early date.

Mr. North, the Director who retires from the Board by rotation, does not offer himself for re-election.

This report is followed by one from the auditors and the Board of Directors on the accounts for the year, in which the points at issue among the Directors are referred to together with the views of the auditors thereon, as contained in a voluminous report and statement of accounts presented to the Board. These bickerings have little public interest, except as showing that Elmore Copper is still anything but a happy family. This time it is the Chairman (Mr. John North) who dissents from the views of his two co-Directors (Messrs. J. Marshall and A. S. Elmore).

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## NEW COMPANIES, STATUTORY RETURNS, &c.

**BEACON ENGINEERING COMPANY (LIMITED).**—This Company was registered on Oct. 5th, with a capital of £5,000, in £5 shares, to carry on at Manchester or elsewhere the business of mechanical, electrical and consulting engineers, manufacturers of all kinds of machinery, brass founders, metal workers, machinists, &c.

**COVENTRY MOTOR COMPANY (LIMITED).**—This Company was registered on Oct. 5th, with a capital of £10,000, in £1 shares, to manufacture and deal in auto-motor cars, carriages, &c., and to carry on the business of electrical, mechanical and general engineers, machinists, &c.

**CITY OF BIRMINGHAM TRAMWAYS COMPANY (LIMITED).**—This Company has been registered with a capital of £1,000,000, in £5 shares, to carry into effect an agreement with William McKenzie and James Ross, to construct, purchase, lease, and otherwise acquire any tramway or tramways in the city of Birmingham, or elsewhere in the United Kingdom; to equip, maintain, and work by electricity, steam, gas, water or other mechanical power, all tramways belonging to the Company, or in which the Company may be interested; to carry on business as tramway, railway, and omnibus and van proprietors, carriers of passengers and goods, and as manufacturers of and dealers in carriages, trucks, locomotives, accumulators, dynamos, electric motors, and any other apparatus required for working tramways, to supply electricity for the purposes of light, heat, motor power, telephonic, telegraphic, industrial, or other purposes; and to manufacture and deal in cables, wires, accumulators, lamps, telephones, &c. The subscribers, with one share each, are J. Ross, engineer, R. H. Milward, J. H. Milward, C. F. Crowder, St. J. B. Roscoe, F. W. Warden, and W. Gilliver.

**LA CAPITAL TRAMWAYS COMPANY (LIMITED).**—This Company was registered on Oct. 3rd, with a capital of £100,000, in £1 shares, to acquire the tramway undertaking known as "La Capital," and the benefit of certain tramway concessions granted by the Municipality of Buenos Ayres, Argentine Republic, for the construction of tramway lines in the city of Buenos Ayres, and for the employment of electric traction in regard thereto, and to carry on the business of an electric light and power company in all its branches. The subscribers, with one share each, are:—S. H. Ackroyd, G. D. Clough, G. N. Dickinson, G. D. Colclough, E. G. Flower, R. Cave, and G. A. May.

**STANDARD TIME COMPANY (LIMITED).**—This Company was registered on October 2nd, with a capital of £10,000, in £1 shares, to acquire any patents, patent rights, inventions, concessions and agreements for the regulation of time, time-keepers, or clocks, by electricity or otherwise, for the transmission, accumulation, or dispersion of electric currents or force and the utilisation of electricity, to acquire and manufacture telephones, to establish telephone exchanges, and to manufacture, sell, and deal in clocks, synchronisers, time balls, pneumatic and electric signals, telephones, telegraphs, railway signalling apparatus, electric lights, electro dynamic machines, &c. The subscribers, with one share each, are: L. M. Simon, B. Woods, M. Beadon, J. L. Sherrin, F. Rutherford, W. K. Lemon, and G. E. D. Scott.

**SHROPSHIRE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).**—The annual return of this Company to June 12th has just been filed. The nominal capital is £25,100, in 2,500 Ordinary shares of £10 each, and 100 Founders' shares of £1 each. 295 of the former and 45 of the latter have been taken up, and £2. 5s. per share has been called on the Ordinary, while the full amount has been called on the others.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 3 per cent. (Sept. 24, 1896). Price of silver, 30d. per oz. (Oct. 8th). Consols (2¾ per cent.) 109⅜—109⅝ for money, 109½—109⅞ for account; 2½ per cent. 106—106½ (Oct. 8th). Stock Exchange Settling Days: Consols, Nov. 5th; Stocks and Shares Continuation Days, Oct. 13th and 27th; Ticket Days, Oct. 14th and 28th; Pay Days, Oct. 15th and 29th; Mining Share Carry-over Days, Oct. 12th and 26th.

**ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company have resolved, after placing £6,000 to the credit of the renewal fund, to declare an interim dividend for the quarter ended Sept. 30th of 12s. per cent. on the Ordinary stock and £1. 4s. per cent. on the Preferred stock, less income tax, payable on the 31st inst.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended Oct. 14th were £903, against £887 in the corresponding week of 1895, an increase of £16. The total receipts for the half-year are £12,715, against £11,857 for the corresponding period of 1895, an increase of £858.

**DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).**—Estimated traffic receipts for the month of Sept., 1896, £2,185.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—This Company announce the payment by warrants on Nov. 2nd of interest for the half-year ending 31st inst., on their Four per Cent. Mortgage Debenture stock. The transfer books will be closed from the 27th inst. to Nov. 2nd inclusive.

**EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).**—This Company announce the payment by warrants on Nov. 2nd of interest on their Four per Cent. Mauritius Subsidy Debentures. The transfer books will be closed from the 27th inst. to Nov. 2nd inclusive.

**GREAT NORTHERN TELEGRAPH COMPANY.**—This Company's traffic receipts in September, 1896, were £24,000, and the total receipts during the period from Jan. 1st to Sept. 30th, £212,000; against £207,400 and £231,200 in the corresponding months of 1894 and 1895 respectively.

**HAWAIIAN TRAMWAYS COMPANY (LIMITED).**—The Directors, in their report for the year ended June 30th, state that a change in the motive power to electricity had been under their serious consideration. A report had been furnished by an agent of the General Electric Company of America, who visited Honolulu specially for that purpose, and estimates based on his report had been made. These estimates had been carefully gone into, and, in view of the cost of conversion, the Directors state that they do not feel justified in recommending the introduction of electricity under the existing concession held by this Company. They had, however, approached the authorities, and it was hoped that certain facilities might be granted which would remove the present difficulties, and enable the Company to carry out the suggested alterations. At the meeting of the Company on Tuesday, the Chairman (Col. C. M. Davidson), referring to the question of motive power, said he could add nothing to what was stated in the report; but the shareholders would be summoned to give their approval to whatever might be proposed.

**W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).**—Particulars will be found in our advertisement columns inviting tenders for the whole or any portion of 105 fully-paid Ordinary shares of £10 each in this Company, which are offered by executors and others under very special circumstances. All further particulars and information with forms of application can be obtained from Messrs. Rooker and Bazeley, solicitors Bideford, Devon.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 4th inst., amounted to £1,184. The amount for the corresponding week last year was £1,088. Increase, £96.

**ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED).**—The Directors of this Company have resolved to pay an interim dividend of 4d. per share, free of income tax, payable upon Oct. 31st.

**SUBMARINE CABLES TRUST.**—The sum of £2. 7s. 6d., balance of the coupon due Oct. 15, will be paid on and after that date by Messrs. Glyn, Mills and Co., of 67, Lombard-street, E.C., with whom coupons must be left four clear days for examination.

**VEREINIGTE ELEKTRICITÄTS AKTIEN GESELLSCHAFT.**—The well-known electrical engineering firm of Messrs. B. Egger and Co., of Vienna and Budapest, has been converted into a limited liability company, with the above title.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended Oct. 2nd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £1,775,

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated amount of traffic receipts of this Company for the half-month ended Sept. 30th, is £1,639, against £1,720 in the corresponding period of 1895. The May receipts (estimated at £5,294) realised £5,316.

**WESTERN UNION TELEGRAPH COMPANY.**—This Company have issued their report for the quarter ended September 30, 1896:—The following statement exhibits the condition of the Company at the close of the quarter ended June 30, 1896:—

| | | |
|---|---|---|
| Surplus April 1, 1896, as per last quarterly report ... | | $7,638,957 24 |
| Net revenues, quarter ended June 30, 1896 ..... | | 1,400,199 64 |
| | | $9,039,156 88 |
| From which deducting for— | | |
| Dividend of 1¼ per cent. paid July 15th | $1,191,958 75 | |
| Interest on bonded debt ..... | 223,504 40 | |
| Sinking funds ..... ..... | 20,000 00 | |
| | $1,435,463 15 | |
| Less portion of Sinking Funds for the bonds of 1900 (which was set aside previously) returned to the Company by the sinking fund trustees because of the drawn bonds not being presented for redemption ..... ..... | 40,000 00 | 1,395,463 15 |
| Left a surplus July 1, 1896, of ... ..... | | $7,643,693 73 |
| The net revenues of the quarter ending September 30th, based upon nearly completed returns for July, partial returns for August and estimating the business for September, will be about ..... | | 1,600,000 00 |
| | | $9,243,693 73 |
| From which appropriating for— | | |
| Interest on bonds ..... ..... | $223,500 00 | |
| Sinking funds ..... ... ..... | 20,000 00 | |
| | | 243,500 00 |
| | | $9,000,193 73 |
| It requires for a dividend of 1¼ per cent. on capital stock issued, about ..... | | 1,191,960 00 |
| Deducting which leaves a surplus, after paying dividend, of ..... | | $7,808,233 73 |

In view of the preceding statements, the Committee recommend that a dividend of 1¼ per cent. on the capital stock of the Company be declared, payable on and after the 15th Oct.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price September 30. | Price Wednesday, October 7. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Oct. 3. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 49 52 | 50 53 | 4 14 4 | Jan., Apr., July, Oct. | 50 | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 95 96 | 96 97 | 5 3 1 | " " | 97½ | 94 |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 8⅞ 9½ | 9 9½ | .. | .. .. | 9⅝ | 8⅛ |
| £173,400 | 100 | 4% | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 6 | January and July | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ 9½ | 8½ 9½ | .. | .. .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 14⅜ 15½ | 14⅜ 15½ | 4 11 10 | Mar., June, Oct., Dec. | 15½ | 14⅜ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 6 11 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | 145 150 | 145 150 | 4 13 4 | Jan., Apr., July, Oct. | — | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 13 | 12 13 | 6 3 1 | February and August | 12⅝ | 12½ |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 20½ 21½ | 19½ 20½ | 4 17 7 | " " | 21 | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3½ 4½ | 3½ 4½ | 4 8 11 | April and October | — | — |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% 110% | 107% 110% | 4 2 7 | .. .. | 109½ | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10 | 9½ 10 | 4 10 0 | Jan., Apr., July, Oct. | 9⅝ | .. |
| 400,000 | 10 | 5/6 | Eastern | 17⅞ 18½ | 17⅞ 18½ | 3 11 3 | " " | 18⅛ | 17⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 1 6 | " " | 19½ | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 130 133 | 131 134 | 4 10 11 | May and November | — | — |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 104 107 | 4 13 11 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 17⅞ 18½ | 17⅞ 18½ | 3 16 9 | Jan., Apr., July, Oct. | 18½ | 17⅞ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 5 | February & August | 131½ | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 4 17 1 | January and July | .. | — |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 16 2 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 109 | 106 109 | 3 13 9 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% 114% | 111% 114% | 3 10 11 | May and November | .. | .. |
| 180,227 | 10 | 3/9 | Globe Telegraph and Trust | 10⅜ 11⅛ | 10⅜ 11⅛ | 3 15 7 | Jan., Apr., July, Oct. | 11⅛ | 10⅜ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17⅜ 18½ | 17⅜ 18½ | 3 5 9 | " " | 18 | 17⅜ |
| 150,000 | 10 | 5/0 | Great Northern | 23½ 24⅛ | 23½ 24⅛ | 4 1 8 | Jan., April, and July | 24⅛ | 24 |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 13 8 | March & September | 107 | 104⅜ |
| 17,000 | 25 | 37/6 | Indo-European | 51 54 | 52 55 | 4 10 11 | May and November | 52⅜ | 52 |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 109 112 | 5 7 5 | March & September | — | — |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 7 | .. .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | 7⅜ | 7⅛ |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 138 143 | 138 143 | 4 3 11 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 6 | 5 6 | 5 0 0 | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 105 | 102 105 | 4 15 6 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | ⅛ 1⅛ | ⅛ 1⅛ | .. | January and July | .. | .. |
| £150,000 | 100 | 8% | * Do. 8 per Cent. Debentures, 1902 | 99 104 | 98 103 | 7 19 7 | June and December | .. | .. |
| 88,321 | 10 | 0/6 | West India and Panama | 1½ 1⅝ | 1½ 1⅝ | .. | .. .. | 1⅝ | 1⅛ |
| 34,563 | 10 | 0% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 12 | 5 0 0 | May and November | .. | .. |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £30,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 10 11 | June and December | .. | — |
| 64,248 | 15 | 5/3 | Western and Brazilian | 8½ 9 | 8½ 9 | 5 0 0 | May and November | 8⅝ | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6½ 7 | 6½ 7 | 5 1 0 | — | 6⅛ | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 2⅝ | 2½ 2⅝ | — | — | 2⅝ | .. |
| £165,200 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 107 | 103 107 | .. | February & August | .. | .. |
| £206,400 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 107 | 103 107 | 5 12 8 | " " | — | — |
| $1,177,000 | $1,000 | 7% | *Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 5 12 8 | May and November | — | — |
| £164,300 | £100 | 6% | * Do. 6 per Cent. Sterling Bonds (red.) | 100 105 | 100 105 | 6 4 2 | March & September | — | — |
| | | | | | | 5 14 6 | | — | — |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chili Telephone (fully paid) | 3½ 3⅝ | 3½ 3⅝ | 5 6 8 | — | — | — |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/16 1/8 | 1/16 1/8 | .. | .. | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | ⅛ ¼ | 1/16 ⅛ | .. | .. | .. | .. |
| £84,597 | 5 | 2/6 | National | ⅛ ¼ | 1/16 ⅛ | 6 3 1 | Yearly | .. | .. |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 7⅜ 7⅝ | 7⅜ 7⅝ | 3 17 2 | June and December | 7⅝ | 7⅛ |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 19 | 17 19 | 3 3 2 | " " | .. | — |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 17 19 | 17 19 | 3 8 7 | " " | .. | — |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 6⅞ 7⅛ | 6⅞ 7⅛ | 3 17 2 | — | 6⅞ | .. |
| 58,000 | 5 | 4/0 | United River Plate | 107 110 | 106 109 | 3 4 8 | January and July | 107 | .. |
| £146,737 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 3½ 4 | 3½ 4 | 5 0 0 | July | .. | .. |
| | | | | 101 103 | 101 106 | 4 15 3 | January and July | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| .. | 5 | .. | Birmingham Electric Supply (fully paid) | 8⅛ | 9¼ 9⅜ | .. | .. | .. | .. |
| .. | 5 | .. | Do. (£4 paid) | 6½ | 7 | .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 16 17 | 16 17 | 2 18 10 | February & August | 16½ | 16⅞ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17½ 18½ | 17½ 18½ | 3 4 10 | January and July | 18⅜ | 17⅝ |
| £130,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 131 135 | 131 135 | 3 14 9 | June and December | 133 | 132 |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. | — | .. | .. |
| £30,000 | £5 | 2/6 | Charing Cross & Strand Electricity Supply Corp. | 9½ 10 | 9½ 10 | 2 15 0 | — | 10 | 9⅜ |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | — — | — — | — | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8 9 | 8½ 9⅜ | .. | — | 8⅞ | .. |
| £10,000 | £10 | 5,4½ | Do. Pref. (fully paid) | 13⅜ 14½ | 13⅜ 14½ | 4 4 3 | — | .. | .. |
| 8,322 | £5 | — | House-to-House Electric | — — | .. .. | .. | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | — — | — — | .. | — | — | — |
| 111,000 | 5 | .. | London Electric Supply | .. .. | .. .. | .. | January and July | — | — |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 1 1⅛ | 1 1⅛ | .. | — | .. | .. |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. | 12½ 13½ | 12½ 13⅜ | 2 19 3 | — | 13⅜ | 13 |
| 6,462 | £10 | 4/0 | Notting Hill Electric | 120 123 | 121 124 | 3 13 2 | June and December | .. | .. |
| .. | .. | .. | Rand Electric | 11½ 12½ | 1 1/16 1⅛ | .. | — | — | — |
| 19,980 | £5 | 2/6 | St. James and Pall Mall | 1 1/16 1⅛ | 1½ 1⅝ | .. | — | .. | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 11½ 12½ | 11½ 12⅜ | 3 2 0 | — | 11⅛ | 11⅜ |
| 59,900 | 5 | 3/0 | Westminster Electric Supply (fully paid) | 10 11 | 10 11 | 3 6 8 | — | 10⅞ | 10⅝ |
| | | | | 10 11 | 10½ 11½ | 3 8 2 | — | 11 | 10⅜ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | ¾ 1 | ⅞ 1⅛ | .. | — | 1⅛ | ⅞ |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | — | 1⅜ | 1 5/16 |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 110 113 | 110 113 | 3 19 8 | March & September | 111½ | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1⅞ 2⅛ | 1⅞ 2⅛ | 6 13 4 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 5 9 | January and July | .. | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | .. .. | .. .. | .. | .. .. | .. | .. |
| 110,000 | 2 | 1/0 | Electric Construction | 1½ 1⅝ | 1½ 1⅝ | 2 17 2 | — | — | — |
| 12,845 | 2 | 5/0 | Do. 7 per Cent. Cumulative Pref. | 2½ 3 | 2½ 3 | 4 13 4 | — | 1⅝ | — |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ⅝ ¾ | ⅝ ¾ | .. | September | — | — |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | — — | — — | .. | — | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | .. .. | .. .. | .. | .. .. | .. | .. |
| £200,000 | 100 | 4% | * Do. 4 per Cent. Debentures | 22 23 | 22 23 | 4 6 11 | February & August | 22⅜ | 22 |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | 105 108 | 105 108 | 3 14 1 | March & September | .. | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | ¾ ⅞ | ¾ ⅞ | .. | .. .. | .. | .. |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 40 43 | 40 43 | 4 3 10 | March and July | 42 | 40 |
| £100,000 | 10 | 6/0 | W. T. Henley's Telegraph Works Ordinary | 104 107 | 104 107 | 4 14 4 | January and July | .. | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 18 19 | 18 19 | 4 10 1 | March & September | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 18½ 19½ | 18½ 19½ | 3 11 10 | " " | .. | .. |
| | | | | 110 115 | 1 0 115 | 3 18 3 | February & August | — | — |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1⅜% | City and South London Railway Con. Ordy. | 48 50 | 48 50 | 2 17 6 | January and July | 50 | 49⅜ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14⅜ 15½ | 14⅜ 15½ | 3 5 7 | " " | — | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 138 | 136 138 | 2 18 0 | May and November | .. | .. |
| 37,500 | £10 | 2⅜% | Liverpool Overhead Railway | 13 1/16 13 3/16 | 13 1/16 13 3/16 | 2 4 6 | — | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 16⅜ 17⅜ | 16⅜ 17⅜ | 2 17 9 | — | .. | .. |
| 125,000 | Stock | 4% | Do. 4% Debenture | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July | .. | .. |

In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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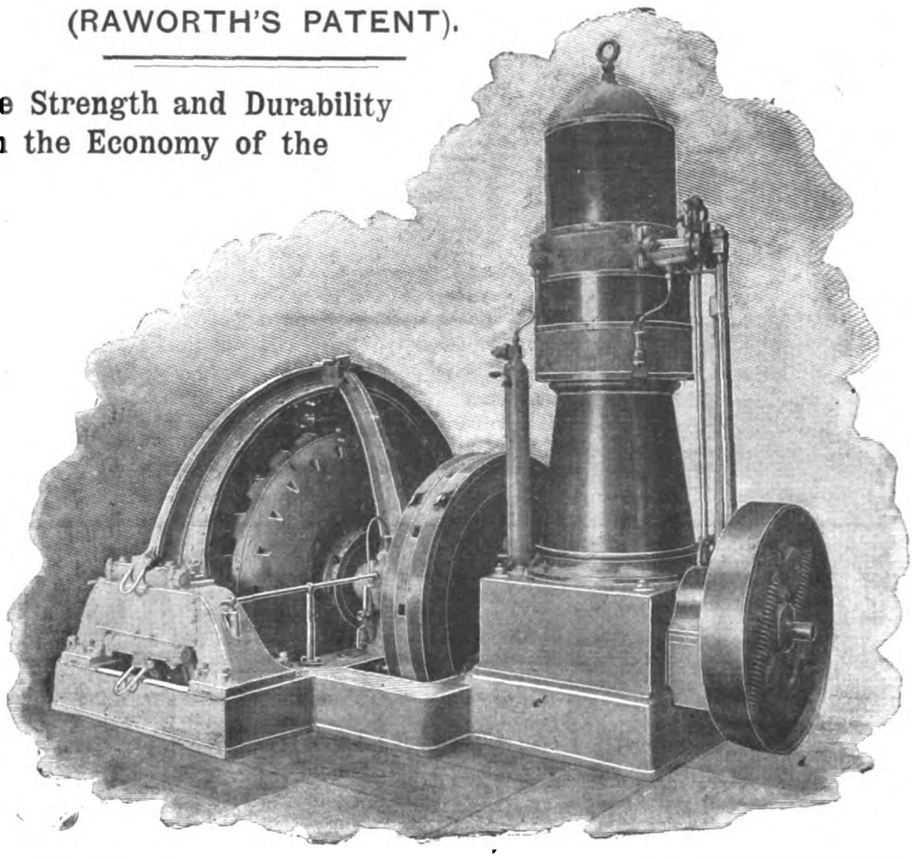

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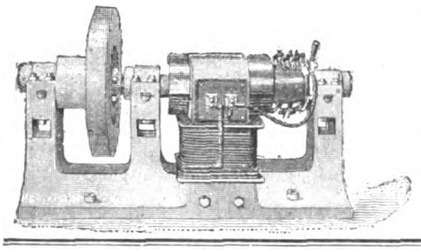

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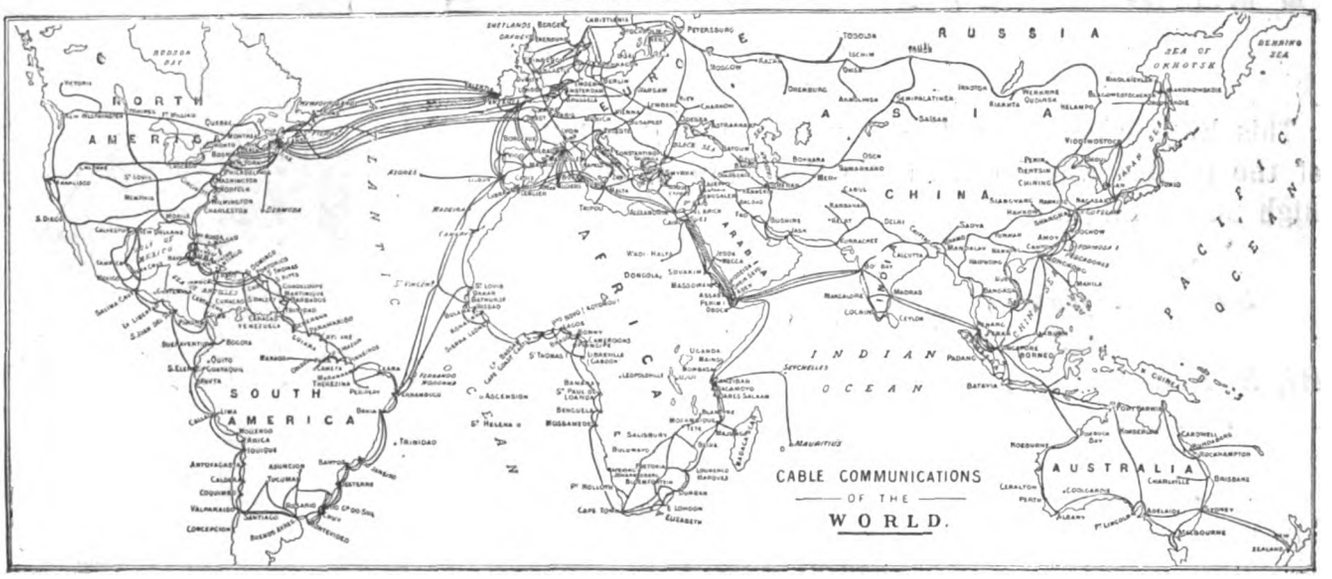
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.

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The Company's Cables are worked by Muirhead's DUPLEX principle upon all its Main Sections.

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## TENDERS INVITED.

### BOROUGH OF TORQUAY.

The TOWN COUNCIL of the BOROUGH of TORQUAY are prepared to receive TENDERS for the SUPPLY and ERECTION of the following PLANT, &c. :—

Section A.—BOILER-HOUSE PLANT: Boilers and Fittings, Forced Draught Apparatus, Feed Storage, &c.
Section B.—ENGINE-HOUSE PLANT: Steam Alternators, Condensers, Pumps, Steam and Exhaust Pipes, &c.
Section C.—SWITCHBOARD, &c.
Section D.—UNDERGROUND MAINS, LAMP POSTS, &c.
Section E.—TRANSFORMERS, &c.
Section F.—METERS.
Section G.—ACCUMULATORS, &c.
Section H.—CRANE, &c.
Section I.—BUILDER.

Tenderers are at liberty to tender for any Section or Sections, but not for part of a Section.

Specification, with Terms and Conditions of Tender and Contract, may be obtained of Mr. W. H. Trentham, the Consulting Engineer to the Council, at 39, Victoria-street, Westminster, S.W., or of the undersigned, on payment of £3. 3s., which sum will be returned on receipt of a bona fide Tender.

Tenders must be addressed to me, sealed and marked "Tender for Electricity Works," at the Town Hall, Torquay, and delivered at or before 3 p.m. on TUESDAY the 3rd November, 1896.

The Council do not bind themselves to accept the lowest or any Tender.

FREDK. S. HEX, Town Clerk.

Town Hall, Torquay, October 15th, 1896.

### COUNTY BOROUGH OF BRADFORD.

The Borough Electrical Engineer is prepared to receive TENDERS for the following METERS, viz. :—

117 ARON METERS.
86 FRAGER METERS.
24 EDISON METERS.
21 OULTON and EDMONDSON METERS

A List giving details and capacity of the above Meters can be had on application to the Electricity Office, Town Hall, Bradford.

Tenders to be endorsed "Tender for Meters," and to be addressed to the Borough Electrical Engineer, Town Hall, Bradford.

All Meters are guaranteed to be in good condition and working order.

ALFRED H. GIBBINGS,
Borough Electrical Engineer.

Town Hall, Bradford,
5th October, 1896.

## APPOINTMENTS VACANT.

### COUNTY BOROUGH OF SALFORD.

ELECTRIC LIGHT DEPARTMENT.

The Gas Committee require a SWITCHBOARD ATTENDANT for their central station.

Salary 35s. per week.

Applicants must have had experience in central station work on high-tension system.

State age, experience, and send copies of three testimonials to the GAS ENGINEER, Gas Offices, Bloom-street, Salford, endorsed "Switchboard Attendant," before 5 p.m., Friday, the 23rd inst.

### MASON COLLEGE, BIRMINGHAM.

APPOINTMENT OF DEMONSTRATOR IN ENGINEERING DEPARTMENT.

The Council invite APPLICATIONS on or before the 24th October, 1896, for the above appointment, vacant in consequence of the appointment of Mr. H. M. Waynforth as Demonstrator in Mechanical Engineering in King's College, London. The duties will commence on November 2nd, 1896.

Particulars of the stipend, conditions, and duties will be sent on application to the undersigned, to whom all applications for the appointment should be sent.

GEO. H. MORLEY, Secretary.

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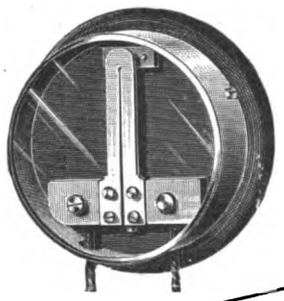
## PATENTS, DESIGNS, AND TRADE MARKS ACTS, 1883 to 1888.

NOTICE is Hereby Given that HELIOS ACTIEN-GESELLSCHAFT FUR ELEKTRISCHES LICHT UND TELEGRAPHENBAU of Köln, Ehrenfeld, Germany, have applied for leave to AMEND the SPECIFICATION of the Letters Patent No. 18,245, of 1888, granted to CARL COERPER, for "IMPROVEMENTS IN ELECTRIC LAMPS OR LIGHTING APPARATUS.

Particulars of the proposed amendments were set forth in the *Illustrated Official Journal* (Patents) issued on the 7th October, 1896.

Any person or persons may give notice of opposition to the amendment (on Form G) at the Patent Office, 25, Southampton-buildings, London, W.C., within one calendar month from the date of the said Journal.

(Signed) H. READER LACK,
Comptroller-General.



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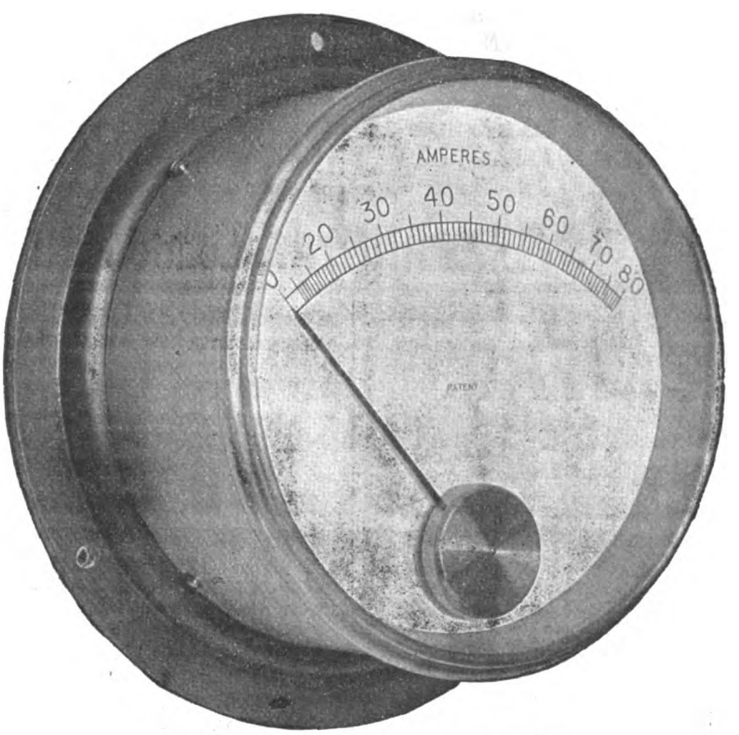


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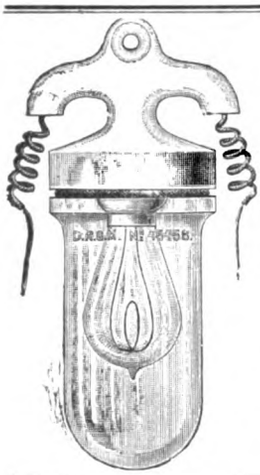

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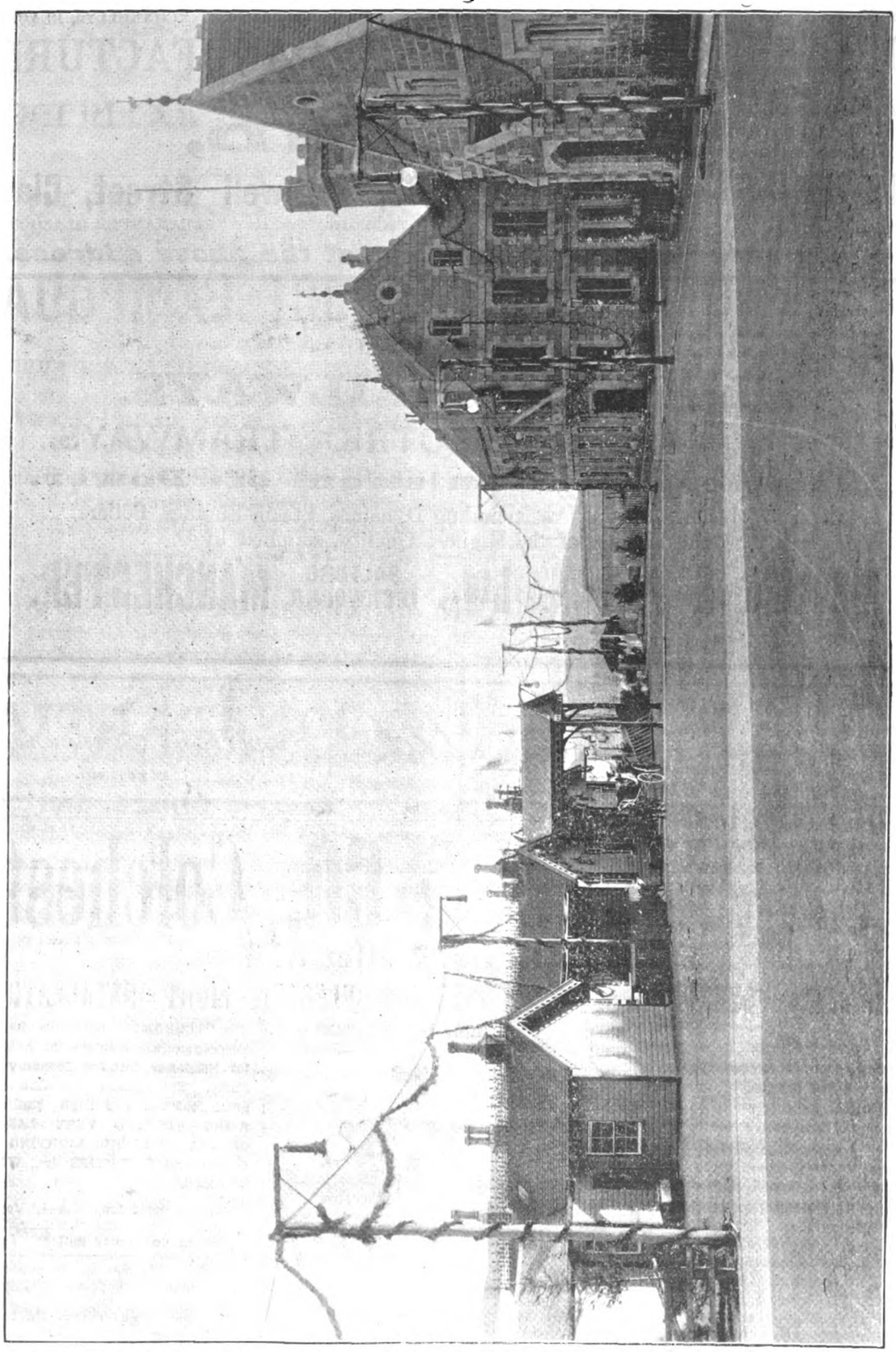

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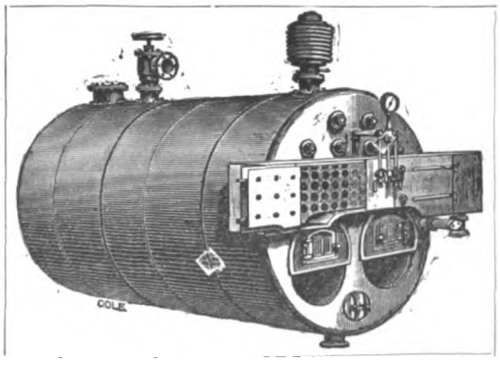

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A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 961. [Vol. No. 25. XXXVII.] FRIDAY, OCTOBER 16, 1896. PRICE SIXPENCE.


## NOTES.

In our "American Notes" will be found a very interesting account of a lawsuit brought by the United States against the Compagnie Française des Câbles Télégraphiques and two American Telegraph Companies, for "combining and conspiring together for the purpose of monopolising a part of the trade and commerce between the United States . . . and foreign nations." To those connected with Cable Companies it has long been known that the Government of the United States has always refused, as being contrary to law, the right to land cables in its territory, so long as the cables start from a place where their owners possess, and persist in maintaining, exclusive landing rights. But this is, we believe, the first time the question has been raised in the Law Courts, and we shall watch with considerable curiosity further developments. If the facts be as stated, however, there can be little doubt as to the result.

The position for the French Company looks uncommonly like a deadlock. It is under contract with the French Government (in consideration of a very large subsidy) to connect France and the French Antilles with the United States, and, of course, in the sacred name of Patriotism, the Company has the monopoly of landing rights on French territory for such a connection, which neither it nor the Government nor the French public, with the fear of English cable enterprise before their eyes, will be willing to relinquish. On the other hand, Uncle Sam says, "Abandon Monopoly all ye who enter here." It is a very pretty dilemma; and the method said to have been selected to avoid a choice of the horns, although it may seem smart to some, strikes us English as rather thin, and pretty sure to aggravate the position.

From another point of view this Free Trade legislation and action of the Union is in sharp contrast with the state of the law and of public opinion, which permit the creation of gigantic trusts, formed to monopolise some of the necessaries of life. It is further not exactly consistent with the proposal, believed to be supported by a large section of the people, to tie silver to gold at a ratio of 16 to 1 by a process of sustained cornering. We suppose, however, the step in question is the application of a sort of Monroe doctrine to submarine cables; and, therefore, even if not sensible in itself would be covered by that sacred name.

The announcement made elsewhere in our columns of the discovery of a new class of compounds—the percarbonates—is of more than usual interest. Not only are such bodies of much intrinsic importance, but, in addition, the manner in which the possibility of their preparation and the process for obtaining them were foreseen, is well worthy of note. Two investigators, Messrs. E. J. Constam and A. von Hansen, working at the Zurich Polytechnic, were impressed by the teachings of the electrolytic dissociation hypothesis in this direction, namely, that it seemed to them probable that the imaginary ions K and $KCO_3$, resulting from a solution of potassium carbonate in a limited amount of water, might be induced to materialise in some sort by subjection to the action of a current under conditions favourable for the persistence of one at least of them. That $K_2$, the molecule corresponding with the ion K, would be formed, could not be hoped for, even in the presence of as limited a quantity of water as is connoted by the employment of a saturated solution of potassium carbonate as the electrolyte to be dealt with. That $K_2C_2O_6$ might be caught appeared not beyond the bounds of possibility. An advantage directly accrued from the fact that $K_2$ is familiar enough as the vapour of ordinary metallic potassium, whereas $K_2C_2O_6$ has been hitherto unknown. Going to work on the assumption that (1) a concentrated solution of potassium carbonate would be the best electrolyte; that (2) the electrolyte should be kept cold; that (3) the current density should be made great at the seat of the formation of a peroxidised product such as $K_2C_2O_6$, that is to say, at the anode, Messrs. Constam and Von Hansen have succeeded in preparing a substance to which, assuming the correctness of their data, there is no reason to deny the name of potassium percarbonate. For the details of the mode of formation and of the properties of this body we must refer our readers to the article already adverted to.

Dealing with the general aspect of the question, we may say at once that, from a chemical point of view, there is nothing so inherently improbable in the existence of $K_2C_2O_6$ as to lead us to reject evidence which is clearly advanced soberly and in good faith. The existence of persulphates—also formed by the electrolysis of ordinary sulphates under regulated conditions—lends much credibility to the announcement. Further, if we mistake not, four or five years ago some indirect evidence was brought forward of the existence of an acid, which may be termed true carbonic

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acid, inasmuch as it stood in relation to the hypothetical-body $H_2CO_3$, much as $H_2SO_4$ does to the equally agreeable fiction $H_2SO_3$. Turning, however, to the details of the dis covery, more caution is necessary. The belief that it has arisen from a consideration of what, according to the hypothesis of electrolytic dissociation, should occur when a normal alkali carbonate is dissolved in water, is, no doubt, genuine; but it must, nevertheless, be independently adopted with some reserve. It is always easy to fit a skeleton theory to the facts—especially if that skeleton be not osseous, but cartilaginous. It is not generally supposed, even by perfervid upholders of the all-present ion, that electrolytic dissociation occurs to a sensible extent in solutions which are highly concentrated. That one so strong as that of potassium carbonate (a very soluble salt) in water, should contain an appreciable number of molecules dissociated into the ions K and $KCO_3$ seems to need much demonstration. In addition, one of the conditions believed to be necessary by the advancers of this explanation—the use of a high-current density to wit—has totally failed of application. Surely it is a little unnecessary to make arbitrary scission of an innocent molecule for the purpose of simplifying in an intangible degree the comprehension of its oxidation to a body of a type somewhat different from itself. It is very much as if one were to promulgate the dogma that oxygen is an allotropic form of chlorine, in order to explain the oxidation of an acid solution of ferrous chloride to ferric chloride by means of potassium chlorate. It is burning down a house to roast a pig. Of course, there is the retort that, as the house is already well alight, the pig may as well be roasted. Putting all doubts aside as to the precise part played by the ionic hypothesis in the conception of the idea of producing $K_2C_2O_6$, the fact remains that Messrs. Constam and Hansen have made a capital discovery, and are to be heartily congratulated thereon.

At length it would seem that the standard screw gauges of the British Association are to be emancipated and provided with a home, or, we trust, several homes, of their own. For some years they have lived under the thraldom of a somewhat theoretical and paper existence. True, indeed, manufacturers on their own responsibility have embodied them in the flesh, or rather metal, and have used them in their works; but there has been a fairly general complaint that screws and dies used by Messrs. A. and B. refuse to associate with taps and nuts turned out by Messrs. C. and D. This lamentable state of affairs arose from the lack of means to standardise and frequently check the taps and dies and screw-plates used by the various manufacturers of apparatus and machinery.

The British Association Committee will change all that; or, at least, we hope so. It has set itself the task of placing on a thoroughly practical footing a system of testing and gauging, whereby every workman may be able to ascertain at any time whether the screw-plates and taps on his bench are up to standard. There is, first of all, to be a central home for the primary standards, wherein accurate template combs of the B. A. screw-threads may be photographically or microscopically compared with the master gauges used by manufacturers. An ingenious method has been devised by Colonel Watkin, and is described at the end of the Report, which we reprint this week, of photographically obtaining a comparison picture containing the standard comb, a scale of ten-thousandths of an inch, and the thread to be tested, as shown in an illustration given with the Report. This method of gauging is applicable only to full screws, and the Committee confesses to having failed to devise a primary test for open screws. On the other hand, it is evident that an accurate gauge for full screws furnishes indirectly a gauge for the corresponding open ones.

Besides this central standards depot, each manufacturer and every workman are to be enabled to check their actual tools on the spot, from time to time, as rendered necessary by wear and tear. For this purpose the Committee recommend the use of a carefully-tested half-nut gauge, as a check upon injury to the pitch of the thread, together with gauge callipers for testing the inside and outside diameters of the screw. A further advance in the practical utility and uniformity of the B. A. screw-threads has been made by the Committee, in its recent Report, in the publication of a "working margin" between full and open threads. It is a well-known and obvious fact, that a mathematically accurate full thread will not pair with a mathematically accurate open thread of the same pitch. A certain clearance, or "working margin," is necessary; but this must be kept within very narrow limits if the two threads are to make a good fit.

The recent communication to the Royal Society of New South Wales from Prof. Liversidge on the composition of sea water gives the result of much careful and laborious work; but probably all that will concern the general reader is the fact that he finds that it contains about 0·5 to 0·8 grain of gold per ton, thus confirming the work of Sonstadt published some years ago. As the comparative test with a gold solution of known strength showed that the method of estimation employed gave low results, the amount of gold in solution in sea water is probably greater than that shown by analysis. The presence of the precious metals in sea water has also been indicated by indirect methods; for instance, thirty years ago Forchhammer discovered silver in coral to the amount of about half a grain to a cubic foot, and it had also been detected some years earlier in seaweed. In both cases the silver could only have come from the waters of the ocean. Now, supposing gold and silver to exist in solution in sea water, one would expect them to be deposited slowly on metal by electro-chemical action. About forty years ago Mr. F. Field investigated the matter from this point of view in the case of silver, and found that old sheathing that had been used on vessels contained a much higher percentage of silver than it did when new. Prof. Liversidge finds that in old sheathings of "Muntz metal" the amount of silver per ton ranges from 2oz. to over 6oz., and that of gold from 4·7gr. to 1dwt. 22gr. Now, in round numbers the amount of gold found in the waters on the Australian coast ranges from 180 to 260 tons per cubic mile; and if the gold is uniformly distributed at the rate of 1gr. per ton throughout the 400,000,000 cubic miles, which are given approximately as the con-

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tents of the ocean, the total amount would be over 100,000,000,000 tons of gold! Gold in such quantities is sure to attract the attention and fire the imagination of the company promoters, more particularly when the figures on which the calculation is based have been supplied by a Fellow of the Royal Society, who is Professor of Chemistry in the University of Sydney, and we are sure to have electrical methods for its recovery suggested. Last year we commented on electrolytic trawling devices for the extraction of the gold contained in sea water; and we still venture to think that it will be some time before their employment increases the dividends earned by ocean liners, or enables our fleet to make any sensible decrease in the Naval Estimates; but possibly old copper sheathing may find profitable utilisation in the form of anodes in electrolytic copper refineries, if it should prove correct that the sheathing of vessels receives a gratuitous deposit of the precious metals from the ocean.

PREPAYMENT meters have proved a gold mine to the gas companies, and now it is proposed by the Electric Lighting Extension Syndicate to tap the same money-yielding social strata by means of an electrical penny-in-the-slot apparatus. Of course, the promoters are very sanguine as to future profits; and if modest starting capital, reasonable remuneration to vendors, and a good idea can ensure success, this little venture should attain it.

MUCH, of course, depends upon the Bastian-Hodges device being cheap, strong, reliable and compact. The penny-in-the-slot mechanism is arranged, of course, to be fitted on to any meter. The penny which is inserted acts as a buffer to two links of a switch, which are shaped respectively as a hollow cylinder and plunger. On pressing the handle of the switch the lights are turned on if the penny is in position; and at the same time a ratchet wheel, which gears into the counting train of the meter, is turned back a pennyworth. A weight, attached to a string passing over a pulley fixed to the ratchet wheel, is thereby lifted a corresponding amount. When the "pennyworth of electric energy" has been consumed, the weight has dropped to its original position, and, ringing an electric bell on the way, switches on an electromagnetic mechanism which allows the bar of the switch to be pulled back by a spring, and everything resumes its original position. The apparatus requires extra energy at the moment only of switching off, and the number of extra watt-hours consumed thereby is insignificant.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique ..... ..... | Dec. 19, 1895. |
| Monte Alegre—Santarem ..... | May 5, 1896. |
| Para—Maranham ..... | Oct. 8, 1896. |

**Lightning Fatality.**—An inquest was held this week on the body of Thomas Watson, 18, Prescot, who was killed by lightning while playing in a football match at Newsham Park, Liverpool, on Saturday afternoon last. Dr. Richardson said that when he was called to the park he found Watson dead from shock from lightning, which had injured both body and clothing.

**The Submarine Telegraph Memorial.**—We understand that at the first meeting of the Executive Committee formed in connection with the above idea, it will be proposed to invite Dr. John Hopkinson, President of the Institution of Electrical Engineers, to allow his name to be added to the list of members of the Executive Committee. At the time the original list was drawn up for the purpose of submitting it for the consideration of the General Committee, Dr. John Hopkinson's acceptance of the invitation to take part in the scheme had not been received.

**Culvert Explosion in Berlin.**—A few days ago, says the *Elektrotechnischer Anzeiger*, an explosion startled the inhabitants of the Spittelmarkt. The double granite cover of a surface box was blown out with a loud report, and a shop window and an arc lamp were shattered. Nobody was injured. A cover some distance off was lifted at the same time. This is the second explosion that has occurred within a short space of time. The cause of this one was said to be a short-circuit, which melted a fuse and ignited the gas in the conduit.

**The Calculus for Engineers.**—The Heriot Watt College of Edinburgh, following the example of Prof. Perry at Finsbury, is making a new departure during the coming session, in adding to their evening classes in engineering a course on the elementary calculus, and its application to engineering and electrical problems, as recommended by Prof. Ewing in his report to the Scotch Council on Education in March last on the technical department of the College. The class meets on Monday evenings, and should prove valuable to the engineers of Edinburgh who have not included this branch of mathematics in their former training. It is under the control of Mr. Lawrence Birks, B.Sc., A.I.E.E., the newly-appointed assistant professor of engineering of the College.

**Electricity in the Navy.**—The following particulars with regard to the electrical equipment of H.M.S.'s "Powerful" and Terrible" are taken from the *Engineer*. The plant consists of three 80-volt 600-ampere direct-coupled dynamos running at 300 revolutions, two sets being in connection with the main engine room under the protective deck, the third being on the main deck amidships. The lighting of the ships is carried out by 800 50 c.p. and 16 c.p lamps on the double-wire system. Mastheads, maintops, semaphores, telegraphs, compasses, sidelights, and signal lanterns are all separately lighted and under control from the deck. Each ship is provided with six search-lights (50,000 nominal c.p.), two lights being on the forward and two on the after bridge, and one on the top of each mast. Electric motors are used throughout, not only for training and elevating the large guns, but also for the ammunition hoists. The submerged torpedos will be fired by electricity from the directing house on the conning tower. Apparently no use has been made of electric motors for ventilation.

**Arc Lamp Patent Amendment.**—The Helios Actien Gesellschaft für Elektrisches Licht und Telegraphenbau, of Köln-Ehrenfeld, Germany, have applied for leave to amend the specification of the letters patent No. 18,245 of 1888, granted to Carl Coerper for "Improvements in Electric Lamps or Lighting Apparatus." Particulars of the proposed amendments were set forth in the Illustrated Official Journal (Patents) issued on October 7, 1896. The patent in question is for improvements in the well-known "Helios" arc lamp, and the amendments refer to details which were not in themselves novel at the date of the patent, though the patentees claim that the lamp which is made up of these details is novel. Thus the number of claims has been reduced from eight to two. The first now is: "The construction of an electric arc lamp substantially as herein described, and illustrated by the drawings hereto annexed"; and the second is the construction of the bridge-piece to serve as a reflector, or the fixing of a reflector to the bridge-piece. The other claims for details in the construction of the guiding and brake mechanism are to be struck out.

**Search for Solar X-Rays.**—The *American Journal of Science* for October publishes a Paper by Florian Cajori, which describes experiments made to ascertain whether X-rays are present in solar radiation. During preliminary experiments made in Colorado Springs, it was found that a sheet of aluminium would allow certain solar rays to pass through. These were not Röntgen rays, for the reason that black paper placed between the aluminium and the photographic plate seemed to cast as deep a shadow as did a strip of iron. After-

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wards a photographic plate was placed in a water-and-light-tight tin box, fitted with an aluminium window, and so arranged that the rays had to penetrate a sheet of aluminium 0·29mm. thick, a few layers of paraffin and black paper, and 100 pages of a book. Seven pages above the plate thin metallic plates from 5mm. to 20mm. wide were placed between two leaves, which were gummed together to hold the plates in position. The box was taken to the summit of Pike's Peak (elevation 14,147ft.), and fastened by wires upon a roof sloping southward. The box was left in that position from June 27th to August 10th. When subjected to the usual process of development the plate failed to show any action of rays, and presented a uniform surface, without traces of shadows from the metallic strips. Another plate, similarly exposed from July 7th to August 28th in Rosamont Park, near Pike's Peak, at an altitude of 9,200ft., gave the same result. Thus, even in high altitudes, no evidence of the presence of Röntgen rays in solar radiation was obtained.

**"Atlantic Telegraph Cables."**—This is a brightly written *brochure*, briefly describing the accomplishment and present resources of Atlantic telegraphy; and a glance through its 24 quarto pages enables one to praise the legible printing as well as the unusually successful reproduction of the illustrations. Mr. Oscar Moll's command of the English language is, for one not to the manner born, to say the least striking. It has been said that the judgment of contemporary nations is the best immediate approach possible to the verdict of history. We hope as Britons that this is not so, in view of recent continental criticisms of this country; but if it be, it is curious to notice that under the heading "The Cable Triumvirate" are given portraits of Sir John Pender, Sir James Anderson and Mr. Cyrus Field, by-the-by without acknowledgment. This also applies to the reproduction of the fine picture of the "Great Eastern" by Mr. Robert Dudley. Altogether, this booklet will convey to those unfamiliar with the subject a better idea of the essential facts relating to ocean telegraphy than might be gathered from a much larger work. Nothing is so difficult as to tell the truth historically, and one slip is noticeable. On page 6 it is said that Sir Samuel Canning was placed in charge of the *engineering department* of the 1865 Atlantic cable; as a matter of fact, he was in charge of the expeditions of 1865-6. Somewhat unaccountably, however, like others of the pioneers, he took little part in the subsequent extensions of submarine telegraphy. Mr. Moll's book is published by Messrs. Waterlow and Sons.

**A Method of Reading Galvanometer Deflections.**—Mr. C. B. Rice, in the *American Journal of Science* for October, describes a method of reading galvanometer deflections devised by Prof. Hastings, which, though not employing such a long index arm of light as the usual mirror or telescope methods, yet enables a much more accurate reading to be taken than does an ordinary pointer. The suspended mirror is plane, and has a small hole at its centre, or else has the silver removed in a small circle of about 1½mm. diameter. The case of the galvanometer and the coil frame are cut away behind this hole if necessary, so that one can look right through the mirror. Facing the mirror, but at a slightly higher level, is placed a small lens, and directly under the lens is a scale. The distance of the lens and scale from the mirror is adjustable, say, from 5cm. to 7cm. On the opposite side of the mirror to the scale, and at a similar adjustable distance, is fixed a fine point of dark material on a white background. On looking through the lens an image of the scale is seen, and the black point is also seen through the hole in the mirror. In the instrument Prof. Hastings has constructed, the magnet is a circular steel disc of 1cm. diameter, polished on both sides for convenience, serving as a mirror, hung between two coils of wire, with a silk suspension of about 5cm. The coils are of number 39 S.W.G., with an outside diameter of 2·5cm., and have a resistance each of six ohms. The brass covers which fit over the coils are provided with openings closed by glass, so that there is a clear view of both faces of the magnet, while air currents are excluded. There is a small aperture of 1·4mm. diameter in the centre of the steel mirror. It seems to us that a similar galvanometer would be very useful for street work. When the distances of the lens, scale and index from the mirror are once adjusted, the instrument can be set up anywhere and used at once. In this respect it is much more convenient than the reflecting or the telescopic arrangement, and it is manifestly considerably cheaper. It might be used in many instances where only a moderately high sensibility was required.

**High Carbon Steel Rails for Tramways.**—In a Paper recently read before the New York Street Railway Convention, Mr. C. L. Allen states that rails of hard steel, the analysis of which showed a greater percentage of carbon than the standard specification of rail-steel, have been advocated by some of the steam railway systems for some years, and their use has been a success in every way. The most notable instance of high carbon rails, he stated, is on the New York Central Railroad on the Hudson River Division near Spuyten Duyvil. These rails have been subject to as heavy traffic as any rails laid in America. They have been under traffic for nearly six years, and up to this time, he believed, none had broken. When these rails were first delivered by the makers, so certain were they that the rails would become broken under traffic, that due warning was given the railroad company by the makers, that they would not be responsible for the damage which would most certainly occur from breakage. Early this year Mr. Allen consulted with one of the firms of inspectors of steel in regard to the wearing quality of high carbon rails as compared with that of rails known as standard Bessemer rail-steel; and their judgment was that high carbon rails will give from 40 to 60 per cent. greater life than rails of standard Bessemer steel. When steam roads began to ask for steel rails the composition of which called for high carbon, an extra price, from $2 to $4 per ton, was asked by the rail makers; but to-day these rails are obtainable for the same price as those of standard rail-steel specifications. In Syracuse this year rails 60ft. in length, 9in. in height, with the half-groove section, are being laid. The joint is the ribbed or corrugated 12-bolt, 36-in. joint. The contract with the rail makers calls for rails the composition of which is as follows:—Carbon from 0·53 to 0·63 per cent., phosphorus not to exceed 0·095 per cent., sulphur not to exceed 0·07 per cent., manganese 0·80 to 1·09 per cent., silicon 0·10 to 0·12 per cent. Five miles of track with rail of this specification have been laid, and it is hoped this year to lay 20 miles. Mr. Allen has noticed that the wear on the head of the rail by car wheels in the course of a month does not make any impression other than brightening it at this point, while in rails of standard specification under the traffic of two weeks the metal in the head of the rail rolls to the outside of the head to a very perceptible degree. The fact that there is a longer life to rails of hard steel will appeal to every railway and tramway man as an economy which cannot be sacrificed.

**Contemporary Electrical Science.**—In the *Journal de Physique* for October, M. LIPPMANN describes a pendulum absolutely free from the disturbance caused by all the usual escapements. Its motion is electrically maintained, and is based upon the law that the algebraic sum of the disturbances produced by equal impulses delivered when the pendulum has arrived at the same point on the upward and downward path is zero. The only difficulty is that of making these two impulses strictly equal. This is done not by a short ordinary current traversing the coil which attracts the bob, but by sending a discharge from a condenser through it. This depends only upon the capacity of the condenser and the E.M.F. of the battery charging it. The latter remains constant from one swing to the next, and the result is a pendulum free from the residual errors hitherto attached to even the best pendulums.——L. BENOIST gives instructions for making the gold leaf electroscope with three leaves, already referred to in these columns (see *The Electrician*, July 31st, p. 433).——PIERRE WEISS writes on the magnetism of crystalline magnetite. He cut some dodecahedra from brozzo in various directions, and found the greatest residual and the least total magnetisation in the direction of the quaternary axis. The Paper is illustrated by some interesting diagrams, showing the distribution of magnetisation in the direction of the field, and perpendicular to it.

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# THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS.*

BY F. C. RAPHAEL.

(*Continued from page 723.*)

SERIES ARC LAMP CIRCUITS.

*The Potential Method.*—Suppose a circuit of 20 lamps in series, supplied at 1,000 volts pressure. We can consider that each lamp with its connection causes a fall of potential of 50 volts. Thus, in Fig. 55, the difference of potential between the + pole on the switchboard and the point 3 would be 150 volts; between the + pole and the point 19-950 volts. If every part of the circuit is equally well insu, lated, the potential of the + pole will be $+\frac{V}{2}$, and that of the – pole $-\frac{V}{2}$, if V is the potential difference between the terminals. Thus, in the example just cited, the potentials of the switchboard terminals will be +500 and –500 volts respectively, if the insulation of the machine, switchboard and outside circuit be in good condition. But now, if a fault exist at point 3, say, the potential of this point will be 0, that of the + terminal 150 volts, and of the – terminal –850 volts.

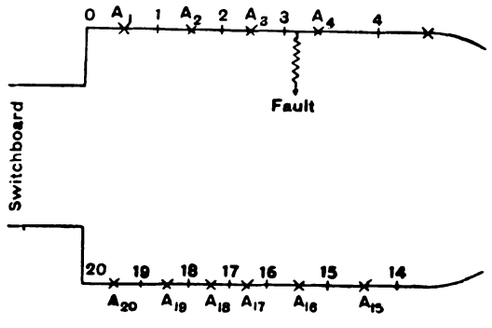


FIG. 55.

To give this simple rule as an algebraical formula:—

If V be the potential difference between the switchboard terminals, $n$ the number of lamps, and $v$ the drop of volts per lamp $v=\frac{V}{n}$.

If V′ be the potential of the + pole, and V″ the potential of the – pole, and if the sections be numbered from 0 to $n$ (as in Fig. 55 from 0 to 20), the number of the faulty section will be $\frac{V'}{n}$ or $\frac{V-V''}{n}$ (V – V″ being here the arithmetical difference).

To measure V′ and V″ either a high-resistance voltmeter or an electrostatic one may be used, one terminal being connected to earth, the other to the end of the cable. It is preferable to make this latter connection at the point where the cable leaves the switchboard, as there is usually a considerable fall of pressure in the regulating device.

At the Londonderry central station this method is used in conjunction with a Kelvin electrostatic voltmeter. There is a drop of potential of 50 volts per lamp, and the circuits have each 50 lamps, so that the normal pressure of the switchboard terminals should be + 1,250 and – 1,250 respectively. The voltmeter is adjusted to give a reading of 1 scale division per 50 volts. Thus, if one day the normal reading 25 is not obtained, the reading from the + pole will be the uumber of the faulty section. The circuits should be tested daily in the ordinary way as well (or during working by one of the methods described in the chapters on Insulation Testing during Working), as a fault in the middle section (No. 25 at Londonderry or No. 10 in Fig. 55) will not alter the normal reading.

Having determined between which two lamps the fault lies, a galvanometer may be taken to the circuit and connected in turn between each end of the faulty section and earth. Suppose the fault is in the section A B (Fig. 56). If $d_1$ is the current through the galvanometer when it is connected between A and earth, and $d_2$ the current through it when between the point B and earth, the distance of the fault from A is $l\frac{d_1}{d_1+d_2}$

$d_1+d_2$ being the arithmetical sum of the readings, and $l$ being the length of the section A B. The readings of the galvanometer are assumed to be proportional to the current through it.

This localisation is only approximate, however. For it to be accurate the current through the lamp circuit would have to be absolutely constant during the test. The resistance of the galvanometer must be so high that the variations in the resistance of the fault do not materially affect the reading. The instrument need not be very sensitive; if it is found to be too sensitive to the variations of the main current, more resistance must be put in series with it.

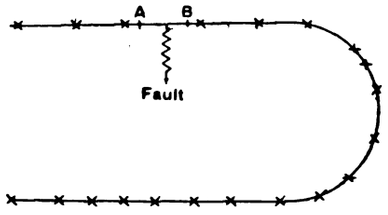


FIG. 56.

*The Loop Method.*—The connections are shown in Fig. 57. $I_1$, $I_2$, $I_3$.... are incandescent lamps, all of the same size, connected in series. There are as many of these as there are arc lamps in the circuit. The galvanometer G has one terminal connected to earth. The other terminal is connected with different points of the incandescent-lamp circuit until the position of least deflection is found. This point corresponds to the position of the fault on the outside circuit. Thus, if it is between $I_2$ and $I_3$, the fault in the outside circuit is between $A_2$ and $A_3$.

A nearer localisation may now be obtained, if desired, by testing in the street with a high-resistance galvanometer, as described just above. One might, instead, take a loop test in the street by connecting a bridge to the ends of the section between the two lamps $A_2$ and $A_3$, and thus localise the fault more accurately. But the author considers this too dangerous on a high-pressure circuit. The faulty part of the cable would be at a low potential, it is true; but there is always a possibility of the fault getting momentarily sealed up, or of another and worse fault developing somewhere else in the circuit, so that the tester might receive a severe shock.

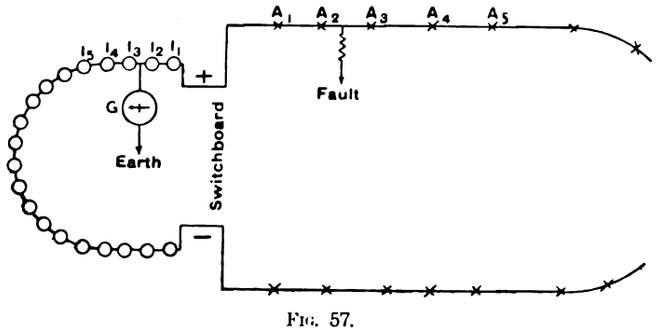


FIG. 57.

Altogether one must be exceedingly careful in carrying out these tests on high-pressure series circuits, though they may not be so dangerous as tests on high-pressure networks on the parallel system. It must, however, always be borne in mind that parts of the mains are at a high potential, and before touching any wire the tester must satisfy himself that he is well insulated and cannot make contact with earth by a slip of the hand. These recommendations are perhaps unnecessary here; the engineer of a central station knows exactly where the danger is in handling high-pressure wires and

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

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apparatus. But such words of caution cannot be repeated too frequently. Although the engineer may feel hurt by their reiteration, it is better than that their omission should contribute to the same result in its literal instead of its figurative sense.

For clearness' sake the figures have all been drawn as if the go and return cables do not run together. In practice the lamps are almost invariably all on the one cable,* and either the section from $A_1$ to the station or that from $A_{20}$ to the station (Fig. 55) includes the whole return cable.

Faults in series incandescent circuits may, of course, be localised in the same way as faults on series arc systems. The locality of a short circuit on a series circuit is determined by noting which lamps are out or not burning properly.

The methods for localising during working have now been fully described, and their good and bad points have been noted. The methods best adapted for the network of any particular station may be picked out, and a programme or "plan of compaign" may be made out for each of the contingencies that may occur. So as to be ready for an emergency, such a scheme should be written out and kept handy; sketches of loops likely to be used, with the "equivalent lengths" of their component sections already marked on, are also useful. The instruments necessary should always be ready for use long before there is any suspicion of a fault; the

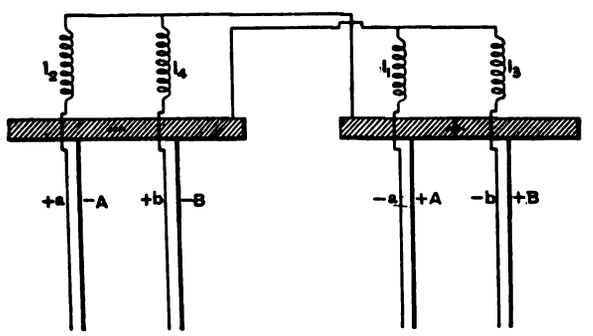


Fig. 58.

wires for the connections should be ready cut to length, trimmed and scraped, including two wires of known length, section and resistance, to connect to the cable loop in case one be needed. Faults very often occur without warning, and usually have to be removed without the slightest loss of time.

### Fault-Signalling Networks.

It is possible to design a network of "test wires," which is laid alongside of the cable network, and which, when connected to suitable indicators in the station, will automatically signal not only the occurrence of a fault, but also, within a certain limit, its position. The author proposes to call such systems of test wires "fault-signalling networks," until a better name has been suggested for them. This employment of test wires to signal faults was introduced by Herr Agthe and Dr. Kallmann, of Berlin,† and it has been found of great service on the distributing network there.

The following is the principle of Herr Agthe's original method, which can be used on any low-pressure system:—

Fig. 58 shows two pairs of cable, +A, −A, +B and −B, connected to the 'bus bars at the station; these may be considered as two different portions of the network. Laid up with each cable is a test wire, $-a$, $+a$, $-b$ or $+b$. These are insulated wires of small gauge, say No. 14 or 7/22, occupying the position in the cable shown in Fig. 59. The wires $-a$ and $-b$ are connected through indicators $I_1$ and $I_3$ to the − 'bus bar, and $+a$ and $+b$ are connected through indicators $I_2$ and $I_4$ to the + 'bus bar. For the present these indicators may be supposed to be of the type ordinarily used for bells or telephones, but having coils of exceptionally high resistance; the details of their construction will be entered into later.

Now suppose the cable +A be damaged in such a way that the wire $-a$ is brought in contact with the conductor of the cable. A circuit is formed from the + 'bus bar through A to the fault, then back through $-a$ and the indicator $I_1$, to the − 'bus bar; and the flap of the indicator $I_1$ drops, signalling a fault on the + cable in the portion A of the network.

Fig. 59.

It often happens that through mechanical damage a contact between the main and test wire is established at once. But in any case an arc is formed at the fault, and in almost every instance this suffices to melt the insulation of the test wire and make the connection required.

Putting this principle into practice it must be remembered that it is the original function of the test wires to indicate at the station the pressure that exists at the feeding points. To effect this, each test wire must be connected with the opposite

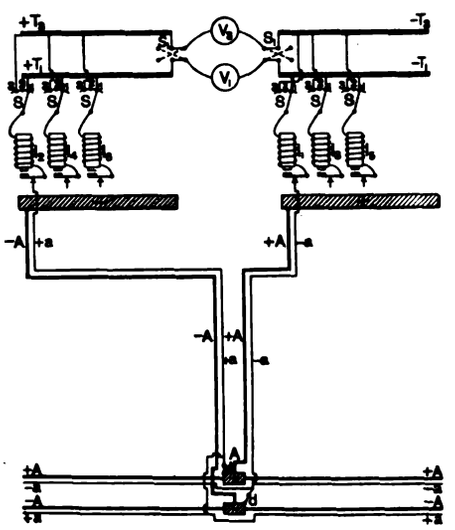


Fig. 60.

main at the feeding points, instead of at the station. This is done through a fuse *d*. The station end of the test wire is connnected through the indicator to what we will call the test-wire 'bus bar, $-T_1$ or $+T_1$, and a voltmeter $V_1$ is connected between the two test-wire 'bus bars. This will be clearly understood on examining Fig. 60.

*(To be continued.)*

## ON A COMPLETE APPARATUS FOR THE STUDY OF THE PROPERTIES OF ELECTRIC WAVES.*

BY J. CHUNDER BOSE, M.A., D.SC.

The work of Hertz and his eminent successors, both here and in the Continent, has opened out for study a new region of ethereal vibration, bridging over the gap that hitherto existed between the comparatively slow electric vibrations and the quick oscillations which give rise to radiant heat. In the vast range of possible ether vibrations we recognise only a few octaves by our senses; the rest are beyond our perception.

* In modern concentric systems on the inner conductor, though several concentric series arc networks still exist with the lamps on the outer conductor.

† See a Paper read before the Elektrotechnischer Verein, by Dr. Kallman, *Elektrotechnische Zeitschrift*, March 17 and April 28, 1893; translated in *The Electrician*, Vol. XXXI., p. 103.

* Abstract of a Paper read before the British Association at Liverpool, Section A. See also *The Electrician*, Vol. XXXVI., pp. 289, 290, 291.

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Many unexpected properties of these little-known ether waves are now being gradually discovered. Confining our attention to the electric waves, we find that there are many important problems which may perhaps be better attacked with these comparatively slow ether vibrations; among which may be mentioned the determination of the indices of refraction of various substances which are opaque to visible light, but are transparent to the electric ray; the relation between the dielectric constant and the refractive index when the rates of oscillation are made comparable in the two determinations; the variation of the index with the frequencies of vibration. Then there are the phenomena of double refraction, polarisation, and the magnetic rotation of the electric ray; the determination of the wave-length and other problems of a similar nature.

The fascination of the subject drew me to its study, though the investigations were rendered exceedingly difficult in India from want of facility for making the necessary instruments. I ultimately succeeded in constructing a few instruments with which I was able to obtain the values of the indices of refraction of various substances for electric waves, the wave-length of electric radiation, and to demonstrate the phenomena of double refraction and polarisation of the electric rays. The simplified apparatus with which many of the properties of electromagnetic radiation may be studied is here exhibited. This is a duplicate made by Messrs. Elliott Brothers of the somewhat rudely constructed apparatus which I brought from India. I also take this opportunity of thanking Mr. Bolton, F.R.A.S., of the Mathematical Instrument Department, Calcutta, for the divided circle in my apparatus.

The following are the experiments which may be carried out with this apparatus:—

A. Verification of the laws of reflection. 1, Plane mirrors; 2, Curved mirrors.

B. Phenomena of refraction. 1, Prisms; 2, Total reflection; 3, Opacity caused by multiple refraction and reflection; 4, Determination of the indices of refraction.

C. Selective absorption. 1, Electrically-coloured media.

D. Phenomena of interference. 1, Determination of the wave-length by curved gratings.

E. Double refraction and polarisation. 1, Polarising gratings; 2, Polarising crystals; 3, Double refraction produced by crystals; 4, Double refraction produced by other substances; 5, Double refraction produced by strain; 6, Circular polarisation; 7, Magnetic rotation; 8, Electro-polariscope and polarimeter.

In the list of experiments above mentioned, the determination of the wave-length by curved gratings has been carried out with a larger apparatus (*see* the *Proceedings* Royal Society, September, 1896). Experiments with circular polarisation and magnetic rotation are still in progress. All the others have been repeated with the apparatus to be described below.

The complete apparatus consists of—(1) A radiating apparatus emitting electric waves of short length; (2) A receiver used as a detector of electric radiation; and (3) Various accessories for the study of the different phenomena.

*Radiating Apparatus.*—Electric oscillation is produced by sparking between two beads of platinum and an interposed sphere of the same metal. The discharge ceases to be oscillatory when the ball is roughened, and a platinum ball resists, to a great extent, the disintegrating action of the sparks. Two jointed electrodes carry the two beads at their ends. The distance between the beads and the interposed sphere can thus be adjusted. This is a matter of importance, as the receiver does not properly respond if the spark length is too large. It is more convenient to use short electric waves, and this is obtained by making the radiating spheres very small. The shortest wave-length produced is about 6mm., and the corresponding number of oscillations is about 50,000 millions in a second. The frequency of vibration in this case will be seen to be about thirteen octaves lower than that which produces visible radiation. The intensity of radiation in the above case is rather feeble, and I use in general electric waves of about half-an-inch in length.

The jointed electrodes carrying the beads are in connection with a small modified Ruhmkorff's coil, actuated by a small storage cell. The usual vibrating interrupter is a source of trouble; the contact points get worn out, and the break becomes irregular. I have, therefore, discarded it in favour of a simple interrupting key. The great objection to the continuous production of secondary sparks is the roughening of the surface of the radiating ball, by which the spark ceases to be oscillatory. It is very troublesome to be obliged to take out the radiator, in the middle of an experiment, for polishing. The flash of radiation produced by a single break is enough for an experiment, and it is a mere waste to have a series of useless oscillations. To economise space, I wind the condenser (a long strip of paraffined paper with tin foil on opposite sides) round the secondary of the coil, appropriate connections being made with the interrupting key. The coil and a small storage cell are enclosed in a tinned iron box. Iron is used to screen the space outside from magnetic disturbances due to the making or breaking of primary circuit of the coil. A sudden magnetic variation disturbs the receiver. The iron box is placed inside a second box of thick brass or copper. These precautions are taken to prevent straying of electric radiation. Through a small opening behind the box, the stud of the press-key projects. In front of the box is the radiator tube, which may be square or cylindrical. Inside this tube is mounted the radiating vibrator. A flash of electric radiation is produced by proper manipulation of the interrupting key. The radiating apparatus may thus be made very small and portable, and requires very little attention. After the storage cell is once charged, experiments may be carried on for days, a flash of radiation being produced at any time by merely manipulating the key.

*Spiral Spring Receiver.*—The receiving circuit consists of a spiral spring coherer, in series with a voltaic cell and a dead-galvanometer. The receiver is made by cutting a narrow groove in a rectangular piece of ebonite, and filing the groove with bits of coiled steel springs arranged side by side in a single layer. The spirals are prevented from falling by a glass slide in front. The spirals are placed between two pieces of brass, of which the upper one is sliding and the lower one fixed. These two pieces are in connection with two projecting metallic rods, which serve as electrodes. An electric current enters along the breadth of the top spiral and leaves by the lowest spiral, having to traverse the intermediate spirals along the numerous points of contact. The resistance of the receiving circuit is thus almost entirely concentrated at the sensitive contact surface, there being little useless short-circuiting by the mass of the conducting layer. When electric radiation is absorbed by the sensitive surface, there is a sudden diminution of the resistance, and the galvanometer spot is violently deflected.

By means of a very fine screw the upper sliding piece can be gently pushed in or out. In this way the spirals may be very gradually compressed, and the resistance of the receiver diminished. The galvanometer spot can thus be easily brought to any convenient position of the scale. When electric radiation falls on the sensitive surface the spot is deflected. By a slight unscrewing the resistance is increased, and the spot made to return to its old position. The receiver is thus re-sensitised for the next experiment.

The sensitiveness of the receiver may be increased by a proper adjustment of the E.M.F. acting on the receiving circuit. The receiver at each particular adjustment responds best to a definite range of vibration lying within about an octave. The same receiver could, however, be made to respond to a different range by an appropriate change of the E.M.F.; very careful adjustment of this is necessary to make the receiver respond at its best to a particular range of electric vibration. For simple experiments the adjustment of the receiver is not difficult, but for delicate experiments careful manipulation is necessary.

The proper adjustment of the E.M.F. is effected by taking a derived current from a circular potentiometer slide, fixed at the base of the galvanometer. A simpler way is to take a U-tube, the two limbs being respectively filled with copper sulphate solution and dilute sulphuric acid. Mixture of the two solutions is prevented by an interposed plug of asbestos. A rod of copper and a rod of zinc are plunged in the two electrolytes, the whole forming a modified Daniell cell. The

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cell is shunted by a suitable resistance, the receiving circuit being connected to the ends of the shunt. The current flowing through the shunt, and therefore the derived E.M.F. from its ends, is varied by plunging the rods more or less in the solutions.

The leading wires from the ends of the receiver are enclosed in layers of tinfoil; the galvanometer and cell have a metallic cover with a slit for the passage of reflected spot of light. The receiving circuit is thus shielded from the disturbing action due to stray radiations. The receiver is provided with a *collecting funnel*. This prevents lateral waves from acting on the receiver. The funnel has two hinged side-doors by which its area—and, therefore, the amount of radiation collected—may be varied. When angular deviation is to be measured, the doors are made parallel and perpendicular to the layer of spirals. The aperture is reduced, and the receiver then only responds when the funnel points to the direction of the deviated ray. In polarisation experiments it is necessary to adjust the receiver carrying the analyser in a crossed position. This is done by a tangent screw, the rotation of the analyser being measured by means of an index and a graduated vertical disc.

*Arrangement of the Apparatus.*—The radiating apparatus and the receiver are mounted on stands sliding in an optical bench (Fig. 1). Experiments are carried out with divergent or parallel beam of electric radiation. To obtain a parallel beam, a cylindrical lens of sulphur or ebonite is mounted in a square tube. This lens tube fits on the radiator tube, and is stopped by a guide when the oscillatory spark is at the principal focal line of the lens. The radiator tube is further

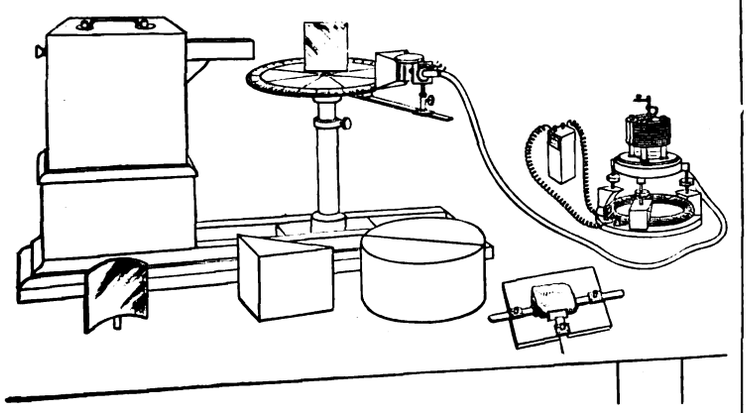

FIG. 1—General Arrangement of Prof. Bose's Apparatus for the Study of Electric Waves.

provided with a series of diaphragms by which the amount of radiation may be varied.

For experiments requiring angular measurement, a spectrometer circle is mounted on one of the sliding stands. The spectrometer carries a circular platform on which the various reflectors, refractors, &c., are placed. The platform carries an index, and can rotate independently of the circle on which it is mounted. The receiver is carried on a radial arm (provided with an index) and points to the centre of the circle. An observing telescope may also be used with an objective made of ebonite with a linear receiver at the focal plane. But an ordinary receiver provided with a funnel is all that is necessary for ordinary experiments.

*Double Refraction and Polarisation.*—The spectrometer circle is removed, and an ordinary stand for mounting the receiver substituted. By fitting the lens tube the electric beam is made parallel. At the end of the lens tube there is a slot, in which is dropped the wire-grating polariser. A crystal holder, provided with three sliding jaws, is fitted on to the lens tube, and is capable of rotation round an axis parallel to the direction of the electric ray. The receiver carrying the analyser is also capable of rotation round a horizontal axis by means of a tangent screw. The angular rotation is measured by means of an index fixed to the analyser, and a graduated vertical disc. The gratings are made by winding fine copper wire, parallel, round square frames. Other forms of polariser will be described later on. The spark gap is placed vertical, and the polariser is adjusted with wires horizontal. The emergent beam is now completely polarised, the vibration taking place in a vertical plane passing through the axis. The analyser, fitted on to the receiver, may be placed in two positions:—(1) Parallel position: when both the gratings are horizontal. (2) Crossed position: when the polarising grating is horizontal, and the analysing grating vertical. In the first position, the radiation being transmitted through both the gratings, falls on the sensitive surface, and the galvanometer responds. The field is then said to be bright. In the second position the radiation is extinguished by the crossed gratings, the galvanometer remains unaffected, and the field is said to be dark. But on interposing certain crystals with their principal planes inclined at 45° to the horizon the field is partially restored, and the galvanometer spot sweeps across the scale. This is the so-called depolarisation action of double refracting substances.*

*Experiments with Wire Gratings.*—A wire grating at 45° interposed between the crossed analyser and polariser partially restores the field, but ordinary wire gauze does not transmit any radiation, the action of one set of wires being neutralised by that of the other set at right angles.

*Double Refraction Produced by Crystals.*—The crystals to be examined are mounted on the holder, and properly inclined. Double refraction is shown by all crystals belonging to the Rhombic, Rhombohedral, Triclinic and Monoclinic systems. The effects exhibited by the following are very marked.

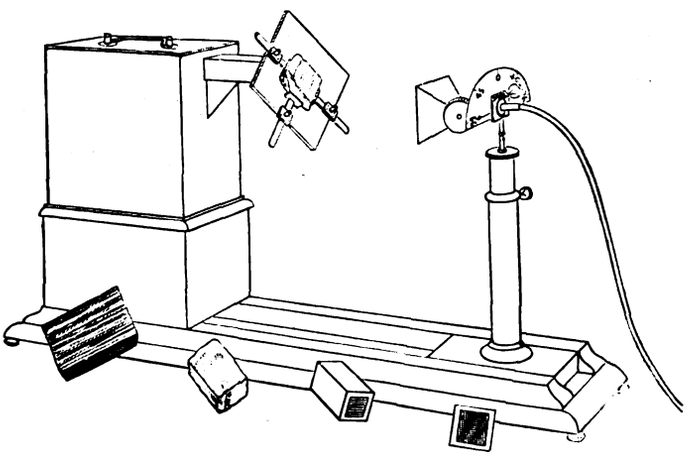

FIG. 2—Arrangement of Prof. Bose's Apparatus for the Study of Polarisation of Electric Waves.

(1) Serpentine. This crystal, which appears fibrous, transmits the ordinary and the extraordinary rays with unequal intensity. A fairly thick piece would absorb vibrations parallel to the fibres, and transmit vibrations perpendicular to the fibres. Ordinary radiation, after transmission through a thick piece of serpentine, would be plane polarised, the vibration taking place perpendicular to the fibres.

(2) Nemalite. This crystal exhibits this effect in a still more marked degree.

(3) Tourmaline also produces the depolarisation effect. The difference in absorption of the ordinary and the extraordinary rays is, however, not so great as in the case of light.

(4) Beryl is also very good crystal for exhibiting the depolarisation effect.

*Polarisation Produced by other Substances.*—I found many other natural substances producing polarisation, the most interesting being vegetable fibres. Common jute (*Corchorus capsularis*) exhibits the property in a very marked degree. I cut fibres of this material about 3cm. in length, and built with it a cell with all the fibres parallel. I subjected this cell to a strong pressure under a press. I thus obtained a compact cell 3 × 3cm. in area, and about 5cm. in thickness. This was mounted in a metallic case, with two openings about

* For a detailed account of experiments on the polarisation of the electric ray, I would refer to my Paper read before the Asiatic Society of Bengal, May, 1895, and two subsequent Papers published in *The Electrician*, 27th December, 1895.

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2 x 2cm. on opposite sides for the passage of the radiation. This cell was found to quench vibrations parallel to the fibres, and transmit vibrations perpendicular to the fibres. Jute cells could thus be made to serve as polarisers or analysers.

*Effect Due to Strain.*—Could be exhibited by stratified rocks, the plane of stratification being inclined at 45deg. to the horizon. Effects similar to that produced by unannealed glass can be imitated by a block of unequally chilled paraffin. The polarisation apparatus above described may also be used as a polarimeter, the rotation of the analyser being measured by the graduated disc.

## NOTE ON A CATHODE RAY SPECTRUM.*

BY M. BIRKELAND.

In the Norwegian paper *Elektroteknisk Tidsskrift*, I recently described some experiments on cathode rays, which showed that the cathode in a discharge tube emits various groups of different sorts of rays, which from outside the tube, appear to behave in a manner analogous to the various notes emitted by a vibrating string.† I have now been able to separate out these groups in a simpler manner by making use of the fact that they are all differently deflected by magnetic force.

My discharge tube is of the shape shown in Fig. 1. The anode A is an aluminium disc, in which a narrow slit, 15mm. long and 0·25mm. wide, is cut. This disc prevents the rays emitted by the cathode C from passing into the spherical portion of the tube by any other path than through the slit.

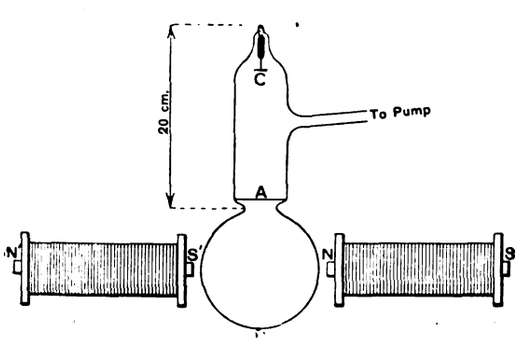
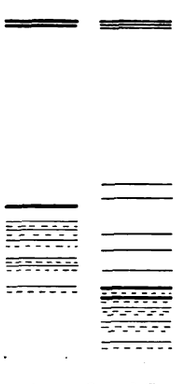



FIG. 1.



FIGS. 2 and 3.

The cathode rays, falling on the spherical base of the tube, produce a yellow line of phosphorescence which is very distinct when the anode A is connected to earth. It may be mentioned that the width of this line changes with the pressure in the tube. It is extremely narrow when the pressure is low, but it increases to a width of 2mm. or even 3mm. with greater pressures. At low pressures I was often able to distinguish two or sometimes three fine lines almost covering one another, when using discharges of rather high potential. On touching the glass bulb with one's finger, preferably in the neighbourhood of one of the poles of the great circle A B A, one of these lines moves nearer to the finger (a movement of nearly 2mm. was obtained), the others remaining fixed. In order to effect a fair deflection of the pencil of rays after passing through the slit, two little electro-magnets of equal size were arranged as in the figure. In the measurements detailed further on, the magnets were connected in series, and excited by a constant current of two amperes.

When the discharge tube is in action at the same time as the magnets, one can usually see, on the spherical wall of the tube, a complete spectrum of diffused lines or yellow bands more or less distant from the original yellow band.

To study the influence of the discharge current on the spectrum, I introduced a rheostat in the primary circuit of the large Ruhmkorff coil I employed, thus enabling me to vary the primary current from 2 to 21 amperes without interrupting it. The first observation was remarkable. The consecutive bands of the spectrum appeared *suddenly* one after another as the primary current increased. The following table gives the time the various bands appeared in a series of experiments :—

| Primary current. | Length of *parallel* spark. | Pressure of air in tube. | Band. | | | |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| Amperes. | Mm. | Mm. | Deg. | Deg. | Deg. | Deg. |
| 5·6 | 20·0 | 0·0036 | 47—49 | 59—(?) | ... | ... |
| 6·8 | 24·5 | 0·0038 | 43—45 | 51—54(?) | 60—(?) | ... |
| 8·4 | 26·0 | 0·0043 | 42 | 46·5—49 | 53—55(?) | 60—(?) |

The first band could already be clearly seen with a current of 2·8 amperes and a spark length of 5mm. The angles are reckoned on the glass sphere from the original yellow line. The *parallel* spark was always measured between spheres of 1cm. diameter. Fig. 2 shows, half size, the spectrum corresponding to a primary current of 8·4 amperes and a pressure in the tube of 0·0043mm. On increasing the current I certainly observed more than ten bands, but they were too close to one another to be distinguished clearly. The different bands are no doubt caused by one or more lines in motion. At all events, it is certain that the first band consists of a line oscillating perpendicularly to its length. On increasing the primary current the oscillations diminish, so that with a current of 7·5 amperes the band becomes one perfectly distinct and very intense line. If one moves the mercury contact-breaker by hand one can distinguish more clearly the lines of the different bands, and one can see that they change their position a little for each discharge, but even with a single discharge the lines oscillate.

*When the primary current is continuously increased, the magnetic deflection of all the bands diminishes*, so that they draw nearer to one another.

*When the pressure in the tube is diminished, the primary current remaining constant, the magnetic deflection of the cathode rays also diminishes continuously*, first quickly, then slowly, as if towards a limit.

Without entering into details I will merely state that with a primary current of 6 amperes and a pressure of 0·0251mm., the front of the spectrum was deflected 96deg., whilst at a pressure of 0·0001mm. the deflection was only 46·5deg. This dependence of the magnetic deflection on the primary current and vacuum in the tube, might conduce to the idea that it depends entirely on the spark parallel to the tube, that is to say, *on the electric pressure* between anode and cathode. This is verified as far as can be expected when we measure the electric pressure by the length of the spark *parallel* to the tube. On connecting a spark-gap micrometer in series with the discharge tube, one notices that faint but fairly distinct lines come out of the first band of the spectrum, these lines corresponding to those cathode rays which are less deflected by magnetic force than others. The distance between these lines and the principal or fixed portion of the spectrum increases as the length of the spark gap increases. Fig. 3 shows, half-size, the discharge spectrum of my tube when it is connected in series with a spark micrometer formed by two brass spheres 2·7cm. diameter and 25mm. apart, the primary current being 12 amperes, and the pressure in the tube 0·0079mm.

Using a more volatile cathode of platinum, instead of aluminium, as I did at first, I have endeavoured to examine whether the particles of metal torn from the cathode are deposited on the bottom of the tube on one of the lines of the spectrum. Up to the present I have obtained no definite results.*

**Trolley Span Wires.**—Trolley span wires are usually an intolerable nuisance, and are rarely, if ever, essential; but where they must be used it is just as well that they should be of durable material. In the United States silicon bronze is being tried, and appears to give more satisfaction than galvanised iron.

* From the *Comptes Rendus*, No. 13, Vol. CXXIII.

† This Paper appeared almost in full in the *Archives de Genève*, June, 1896, and in the *Zeitschrift für Electrotechnick*, Nos. XIV. and XV.

* Want of space prevents me from mentioning Lenard's results in researches analogous to those I have just given an account of.

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## THE ELECTROLYTIC PRODUCTION OF POTASSIUM PERCARBONATE.

A sufficiently startling announcement has been made by Messrs. E. J. Constam and A. von Hansen, of the Zurich Polytechnic, to the effect that they have succeeded in preparing a new salt, of high theoretical interest—viz., potassium percarbonate, $K_2C_2O_6$. This discovery is made public in the *Zeitschrift für Elektrochemie* for October 5th, from which we excerpt the present account.

It appears that the possibility of the existence of bodies of the type named presented itself from a consideration of the probable result of the dissociation into its ions of an alkali carbonate when dissolved in water. On dissolving the normal carbonate of an alkali metal or of ammonium in water, the salt may be conceived as yielding the ions $\overset{+}{M}_2$ and $\overset{-}{CO}_3$, where M is an atom of a monovalent metal. Under ordinary conditions of electrolysis such a solution gives hydrogen and the hydroxide of the metal at the cathode and a bicarbonate at the anode. The progress of ionisation of a normal carbonate can be followed in thought if it be considered that on the addition of water to the carbonate in the solid state, dissociation would be likely to occur in stages, the first of which might give the ions $\overset{+}{M}$ and $M\overset{-}{CO}_3$; complete dissociation, as shown above, into $\overset{+}{M}_2$ and $\overset{-}{CO}_3$ would occur only on the further addition of water. If this conception be just, it may be expected that by observing the proper experimental conditions, viz., great concentration of the electrolyte and a high-current density at the anode, there may be induced in the neighbourhood of the anode a union of the ions $M\overset{-}{CO}_3$ to form a new molecule $MCO_3 - MCO_3$. It is known that under similar conditions persulphates of the form $M'_2S_2O_8$ can be obtained by the electrolysis of normal sulphates.

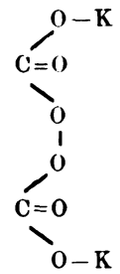
Working on the lines thus indicated, an attempt was made to produce percarbonates by the electrolysis of the normal carbonates of the alkali metals and of ammonium. It was soon found that it was necessary to carry out the process at a low temperature. Unfortunately, in the case of the sodium and ammonium salts this is incompatible with another essential requirement, viz., that the solution shall be concentrated, for at low temperatures the solubility of sodium carbonate and ammonium carbonate is greatly decreased. Using potassium carbonate, however, success was achieved. It is now the authors' hope that they, having prepared potassium percarbonate, will be able to obtain the percarbonates of other metals by ordinary substitution.

The actual process of preparing potassium percarbonate is described as follows:—On electrolysing a saturated solution of potassium carbonate while it is slowly cooled, one observes that the evolution of oxygen at the anode becomes continuously smaller, and at $-10°C$ ceases almost entirely. Instead of the crystalline precipitate of potassium bicarbonate which is formed while the evolution of oxygen continues, there appears a bluish amorphous powder, which is potassium percarbonate. In order to obtain a good yield it is necessary to keep the solution of potassium carbonate as nearly saturated as possible, because when the solution is dilute, the percarbonate, which may be conceived as forming, is ionised, and serves as the electrolyte. Electrolysis is performed in a tall beaker, standing in a freezing mixture and provided with platinum electrodes and a porous septum. As a source of current three to six accumulators are used, and widely-varying current density may be employed, *e.g.*, from 1 up to 300 amperes per square decimetre of anode surface. (This is in singular contradiction to the statement originally made that a high-current density is necessary.) With the higher current density the proportion of percarbonate in the product is generally larger. Although commonly a platinum wire has been used for the anode, and a large platinum plate as the cathode, yet the adoption of nickel electrodes (which are not likely to be attacked in alkaline solution) appears feasible. An indication as to whether a good yield of percarbonate may be looked for is afforded by the suppression of the evolution of oxygen at the anode. Although the favourable influence of a high-current density which was expected, was not observed, yet the other predicted condition, viz., lowness of temperature, has been verified, inasmuch as it is found that the temperature of the electrolyte should not exceed $-10°C$. and indeed is better below $-15°C$. Working in the manner described, a considerable quantity of a blue salt, suspended in the electrolyte, is obtained; it is easily decomposed by water, and must be collected with the utmost expedition and dried on porous plates over phosphoric anhydride without previous washing. During this process it loses its blue colour and becomes nearly white.

Proof of the reality of the assumption that this salt is potassium percarbonate $K_2C_2O_6$ is adduced by the statement of the analytical figures obtained for several independent preparations of the material. On account of the method of formation (viz., electrolysis in a concentrated solution of potassium carbonate) and the impossibility of washing the percarbonate free from foreign soluble salts, the analytical problem presented was the determination of the proportions of potassium percarbonate, carbonate and bicarbonate in a mixture of these bodies. Details as to the methods used would be out of place in *The Electrician*, and it is sufficient to say that a critical examination of the scheme adopted leads to the belief that it is adequate, and that a mistake for a new substance of something old and well-known, such as potassium peroxide, is not probable. At the same time it must be distinctly understood that *pure* potassium carbonate has not yet been prepared, although the mixture obtained in one experiment had a content as high as 77·91 per cent. of $K_2C_2O_6$.

Having entered this caveat we may proceed to the consideration of the constitution and properties of potassium percarbonate.

Given that potassium percarbonate is formed by the union of two anions $K\overset{-}{CO}_3$, the resulting salt may be written:



In the form in which it has been at present obtained potassium percarbonate is a bluish white, very hygroscopic amorphous powder, always contaminated (from the mode of its formation) with more or less potassium bicarbonate $KHCO_3$ and potassium carbonate $K_2CO_3$. On gentle heating decomposition occurs smoothly in accordance with the equation— $K_2C_2O_6 = K_2CO_3 + CO_2 + O$.

$K_2C_2O_6$ is soluble in ice-cold water almost without decomposition; in water at the ordinary temperature it evolves oxygen and forms bicarbonate according to the equation—

$$K_2C_2O_6 + H_2O = 2KHCO_3 + O.$$

It seems to be soluble in alcohol, for on washing the moist salt with absolute alcohol and evaporating the filtrate *in vacuo*, a solid residue is left which gives the characteristic reactions of percarbonate.

The salt behaves towards oxidisable substances as a vigorous oxidant. Thus, on adding the solid salt to a solution of potassium iodide containing starch, no blue coloration appears; but when the solution is acidulated a blue colour is obtained. Curiously enough, when the solution of potassium iodide and starch is cooled to about zero before the addition of the percarbonate, the blueing results without the use of an acid. No reason is advanced for this divergence, which is not altogether intelligible at first sight. Other substances which are readily oxidised by potassium percarbonate are lead sulphide and a solution of indigo, while cotton, silk and wool are bleached by its action. In common with certain peroxides, potassium percarbonate has the property of acting as a reducing agent towards particular classes of substances. Such substances are silver oxide and the peroxides of manganese and lead. The equation representing the reduction of lead peroxide is as follows:— $PbO_2 + K_2C_2O_6 = PbCO_3 + K_2CO_3 + O_2$.

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This characteristic behaviour causes potassium percarbonate to rank as the carbonate of potassium peroxide, and to come into the class of bodies which Traube has dubbed "holoxides." Similarly to the holoxides of the alkalies and the alkaline earths, potassium percarbonate yields hydrogen peroxide with acids, and comports itself not only as as an oxidising but also as a powerful reducing agent. When treated with a dilute solution of caustic potash, potassium percarbonate, even at as low a temperature as – 2°C., is split up into potassium carbonate and hydrogen peroxide, the latter in its turn being speedily converted into water and oxygen. At higher temperatures the evolution of oxygen is immediate. The greater stability of hydrogen peroxide in acid than in alkaline solutions accounts for the fact that when the decomposition of potassium percarbonate is effected by means of dilute sulphuric acid, a certain amount of the total available oxygen remains in the liquid as hydrogen peroxide, and, in the analysis of the various preparations made by the authors, had to be estimated separately from that portion which was evolved as gas and determined by volumetric methods. Seeing that potassium percarbonate is of the nature of an holoxide, the question arises as to whether it is possible that the authors have been deceived into accepting the substance as a true percarbonate, when it may really be nothing more noteworthy than a mixture or double compound of potassium bicarbonate and potassium peroxide or hydrogen peroxide. They themselves canvass this possibility, and dismiss it as improbable on grounds already briefly alluded to above, viz., that from the analytical figures it appears that in the preparations obtained in the various experiments there was never less than 41—42 per cent. of carbon dioxide and never more than 39·5 per cent. of potassium; the oxygen varied from 5 to 7 per cent. In the event of potassium peroxide being present, the content of carbon dioxide would be lower, and that of potassium would be higher, while the percentage of potassium and of carbon dioxide would be smaller were the oxidising properties of the body to be attributed to hydrogen peroxide.

In face of these candid and temperate statements it is fitting to acquiesce in the authors' deductions, and to conclude that we are enriched by the electrolytic acquisition of a highly remarkable new body. Rubidium percarbonate, a white very hygroscopic powder, has also been prepared by analogous methods. Further experiments on this substance are in progress.

## THE BRITISH ASSOCIATION SCREW GAUGE.*

### I.—The Past.

A uniform system of screw threads was first proposed by the late Sir Joseph Whitworth in 1842, and his thread, a compromise of the numerous threads then in use, has become of almost universal use for all large screws—that is, screws of over ¼in. diameter—in the United Kingdom. Mr. William Sellers in 1864 introduced another thread in the United States of America, which has come into very general use in that country, and this thread has recently been accepted by the French. In 1881 the British Association formed a committee to determine a gauge for the manufacture of the various small screws used in electrical apparatus, clockwork, and for other analogous purposes; and after three years of unremitting labour this Committee, in 1884, recommended a screw gauge which has come into very general use in this country. It was based on the metrical system, and, with one slight modification on the system, adopted in 1880 by the Swiss watchmakers.

The series of screws is given in the accompanying table.

The form of thread adopted was triangular, the sides forming an angle of 47½deg., with the top and bottom rounded off to $\frac{1}{10}$ths of the pitch. The diameter (D) is related to the pitch (P) by the formula $D = 6P^{\frac{9}{8}}$, all measurements being in millimetres, and P having successively the values :—

1 (or $0{\cdot}9^0$) mm.; $0{\cdot}9^1$mm.; $0{\cdot}9^2$mm.; $0{\cdot}9^3$mm.; . . . $0\ 9^n$mm. The index ($n$) thus becomes a convenient number designating the screw. The reasons supporting these recommendations were fully given in the Report submitted by the Committee at the Montreal meeting of 1884. Experience has justified the adoption of this gauge, which is almost universally used by the electrical trade, and is very considerably employed by the clock and instrument makers in the United Kingdom. It is not proposed to modify it, but there has been great difficulty in obtaining accurate gauges. No official system has yet been adopted by which manufacturers can compare their gauges with the standards, nor has a home been selected to deposit authorised standards for easy reference. British Association screws bought to-day from any screw manufacturer are not necessarily of the same dimensions as those supplied by the same maker a month ago. Screws supplied by different makers vary considerably from each other. Measuring gauges now existing, both male and female, differ largely from one another, and do not give correctly the true form of thread specified in the original report. The essential element of the value of screws made to a standard gauge—their interchangeability—has thus never been fully realised. The British Association, having had their attention called to these anomalies at their last meeting (Ipswich, 1895), appointed a Committee to consider the subject, which has now the pleasure to submit its first Report.

*British Association Screw Gauge.*

| Number. | Dimensions in millimetres. | | Dimensions in thousandths of an inch. | | Threads per inch. |
|---|---|---|---|---|---|
| | Diameter. | Pitch. | Diameter. | Pitch. | |
| I. | II. | III. | IV. | V. | VI. |
| 0 | 6·0 | 1·00 | 236 | 39·4 | 25·4 |
| 1 | 5·3 | 0·90 | 208 | 35·4 | 28·2 |
| 2 | 4·7 | 0·81 | 184? | 31·9 | 31·4 |
| 3 | 4·1 | 0·73 | 162? | 28·7 | 34·8 |
| 4 | 3·64 | 0·66 | 142 | 26·0 | 38·5 |
| 5 | 3·2 | 0·59 | 126 | 23·2 | 43·0 |
| 6 | 2·8 | 0·53 | 110 | 20·9 | 47·9 |
| 7 | 2·5 | 0·48 | 98 | 18·9 | 52·9 |
| 8 | 2·2 | 0·43 | 87 | 16·9 | 59·1 |
| 9 | 1·9 | 0·39 | 75 | 15·4 | 65·1 |
| 10 | 1·7 | 0·35 | 67 | 13·8 | 72·6 |
| 11 | 1·5 | 0·31 | 59 | 12·2 | 81·9 |
| 12 | 1·3 | 0·28 | 51 | 11·0 | 90·7 |
| 13 | 1·2 | 0·25 | 47 | 9·8 | 101·0 |
| 14 | 1·0 | 0·23 | 39 | 9·1 | 110·0 |
| 15 | 0·90 | 0·21 | 35 | 8·3 | 121·0 |
| 16 | 0·79 | 0·19 | 31 | 7·5 | 134·0 |
| 17 | 0 70 | 0·17 | 28? | 6·7 | 149·0 |
| 18 | 0·62 | 0·15 | 24 | 5·9 | 169·0 |
| 19 | 0·54 | 0·14 | 21 | 5·5 | 181·0 |
| 20 | ?0·47 | 0·12 | 19 | 4·7 | 212·0 |
| 21 | 0·42 | 0·11 | 17 | 4·3 | 231·0 |
| 22 | 0·37 | 0·098 | 15 | 3·9 | 259·0 |
| 23 | 0·33 | 0·089 | 13 | 3·5 | 285·0 |
| 24 | 0·29 | 0·080 | 11 | ?3·152 | 317·0 |
| 25 | 0·25 | 0·072 | 10 | 2·8 | 353·0 |

### II.—The Present.

The Committee was formed to "consider means by which better practical effect can be given to the introduction of the screw gauge proposed by the Association in 1884." It has held many meetings. It has added Col. Watkin, C.B., R.A., Mr. E. Rigg, and Mr. W. A. Price to its number. It has received great assistance from the Pratt and Whitney Company of Hartford (Connecticut, United States of America), who supplied each member of the Committee with a copy of their book on "Standards of Length and their Practical Application." Mr. Griffith, representing the Council, attended regularly, and took advantage of his presence in the United States of America to visit the Pratt and Whitney works. Evidence was taken by the Committee from large users of the screws. Mr. Willmot, of the Post Office Factory, stated that the Post Office had used some tens of millions of screws made to the British Association gauge, and he had never received a single complaint. Various apparatus for measuring screws and different methods of testing their accuracy were carefully considered and discussed. The Committee came to the conclusion that it was necessary to consider the subject from the three points of view of the Standards Office, the Works Manager, and the Workman.

1. *The Standards Office.*—This must include not only the custody of recognised and authenticated standards, but also a scientific mode of measuring the dimensions of commercial gauges and screws themselves, and of comparing their accuracy with the authorised standards. The peculiarity of the British Association gauge is this: that material standards are not imperatively necessary. The table of dimensions given above, together with the formula, enables any draughtsman to reproduce the form and pitch to any desired scale on paper. Colonel Watkin has shown to the Committee how

* Abstract of the Report of a British Association Committee, consisting of Mr. W. H. Preece (Chairman), Mr. Conrad W. Cooke (Secretary), Lord Kelvin, Sir F. J. Bramwell, Sir H. Trueman Wood, Major-Gen. Webber, Mr. R. E. Crompton, Mr. A. Stroh, Mr. A. Le Neve Foster, Mr. C. J. Hewitt, Mr. G. K. B. Elphinstone, Mr. T. Buckney, Col. Watkin, Mr. E. Rigg, and Mr. W. A. Price, appointed to consider means by which practical effect can be given to the introduction of the screw gauge proposed by the Association in 1884. (Drawn up by the Chairman.)



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to throw side by side for purposes of very accurate comparison a photographic image of—(*a*) The screw to be examined. (*b*) The standard with which it is to be compared. (*c*) A scale which may be divided to $\frac{1}{10000}$th of an inch, the images of these three objects being so close to one another that a comparison to a very high degree of accuracy can be made. The Appendix to this Report contains a description of Col. Watkin's method.

Mr. Price submitted to the Committee a microscopical method of measuring screws. The screw to be measured is attached to the stage of the microscope, the traversing slide of which is provided with a vernier and scale, while a vertical cross-hair in the eye-piece forms the index of the instrument. When the microscope has been adjusted for clear focus the screw is traversed across the field until the cross-hair intersects the thread of the screw at the desired point. The traversing screw of the slide is then turned until the corresponding point of the next thread is intersected by the cross-hair, and the reading of the vernier on the scale gives the measurement of the pitch with great accuracy. Mr. Buckney showed also how the angle of the thread could be accurately verified by this method by having suitable hairs.

2. *The Works Manager.*—The Committee, after considering various methods, came to the conclusion that male gauges for ordinary workshop use were best tested as regards pitch and form of thread by a template or "comb" for each number, the accuracy of which has been verified by the photographic method. The screw to be tested is placed against the teeth of the comb, and the correctness of its fit verified by the eye against a light background. The external dimensions of the screw can be obtained by any good micrometer gauge, and the internal diameter or core by a gauge such as that which is described in the Appendix by Mr. Stroh. The Committee have failed to discover any very reliable method of testing to any degree of accuracy a female standard gauge. No clearance was allowed in the original definition of the system between the male and female standards. Hence a mathematically accurate male gauge cannot be screwed into a mathematically accurate female gauge. But by allowing a certain margin—a maximum and minimum diameter—an internal compatibility of dimensions is allowed in the workshop gauges, which is of a sound, practical character. The female screw must always be a little larger than the standard male gauge, but this must never exceed what is known as a "good fit." A working margin is given in Appendix III., by a table, prepared by Mr. Le Neve Foster. Mr. Price, on behalf of the Committee, has made a series of measurements of certain sizes of B.A. screws which show the limits within which they are obtained in practice.

3. *The Workman.*—The measuring gauge, available to the workman as well as to the foreman, is one that need not possess the mathematical accuracy of the standard gauges, but nevertheless it must not be allowed to deteriorate or to maintain false belief in its accuracy. Those that are subject to pressure and friction must necessarily wear, become distorted, and, in time, inaccurate. Hence the Committee were anxious to obtain a mode of comparison which would be free from this source of error. The most important measurement, whose accuracy should be easily verified by the workman, is that of the pitch, and this is easily effected with the "half-nut gauge." The Committee are pleased to find that the result of their inquiry and discussion enables them to recommend for general use means of comparison which do not involve the wear and deterioration of the gauges. Deformation is confined to the taps and screw-plates, and as frequent verification of the manufactured screw is desirable, continued accuracy is ensured. With the introduction of simple methods of comparison and measurement, errors in the screws issued and want of interchangeability are rendered improbable in a well regulated shop, and unnecessary in any place. There remains now to determine a place where material standard gauges are available for immediate comparison, and where the photographic and microscopic methods can be readily applied to verify gauges and to obtain a record of those submitted for examination. This means work to be done, expenses to be incurred, and fees to be paid, as is now done at the Kew Observatory for chronometers, thermometers, &c.

## III.—The Future.

The opinions formed by the Committee, after full and exhaustive discussions, for furthering the objects to be attained, may be summarised as follows :—(*a*) This Committee recommend the construction and housing of the comb form of gauges or templates of the B.A. screw thread, by comparison with which master gauges or templates may be exactly and conveniently verified. (*b*) That, as no exact system of testing female threads has yet been devised, the Committee restrict themselves to recommending means for keeping male threads to gauge, and this they consider will be sufficient for the purpose of securing practical uniformity in female screws. (*c*) Male threads can best be measured by the comb, combined with suitably-arranged tests to give the correct diameters. (*d*) That for purposes of verification or standardisation the gauges to be deposited for reference should consist of a complete set of these comb-pieces, and a complete corresponding set of male screws, so that new combs can be compared with those deposited, or male screws can be compared with the standard combs with great accuracy by the photographic or the microscopic method, and that these two methods may be conveniently used to check and corroborate each other. (*e*) That in order to obtain interchangeability of these male screws for practical workshop use it is sufficient that they should satisfy the following tests :—(1) There should be no appreciable difference in the fit of the screw with a standard comb having not less than 12 teeth. (2) The diameter of the core must not exceed that laid down by the B.A. specification. (3) The diameter of the screw measured over the thread must not exceed that laid down by the B.A. specification. (4) The diameter of the screw measured over the thread must not fall short of that laid down by the B.A. specification by more than a certain amount, which amount depends on the class of work and purpose to which the screw is to be applied. The amount referred to in (4) must be settled by the persons in control of the work for which the screws are to be used. (*f*) They recommend for general use in the workshop the half-nut gauge, combined with inside and outside diameter gauges.

The Committee, in printing the tables, for which they have to thank Mr. Le Neve Foster and Mr. Price, do not take the responsibility of recommending any limits, but publish the information as an indication of the limits of accuracy to which these screws may be expected to be produced in practice. If the recommendations of the Committee be approved of, they further recommend that the Committee should be reappointed for the purpose of obtaining and verifying standard combs and male screws, and determining the future home of the gauges.

## Appendix I.—*Enlarged Shadow Photographs of Screws.**

The objects aimed at in producing enlarged photographs of screws are :—(*a*) To provide a means of verifying the accuracy of the shape of a thread. (*b*) To provide a means of accurately gauging the dimensions of screw threads. (*c*) To provide a record or certificate of a screw in a similar manner to the certificate of accuracy given by Kew Observatory.

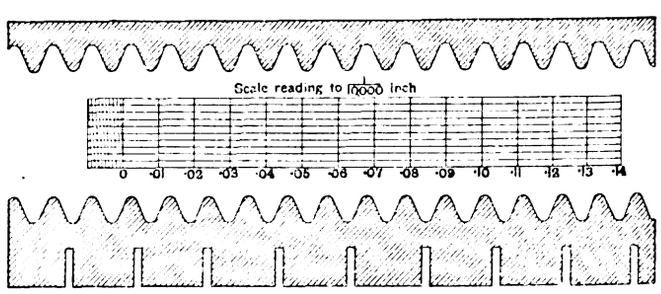


Fig. 1.—Standard Glass Scale, lines at intervals of ·02in. (Photograph of No. 12 B. A. Thread reduced from the original).

As in this process a standard scale is photographed at the same time as the screw, a direct reading to any desired accuracy can be obtained. There seems to be hardly any limit to the amount of enlargement, as the difficulties inherent to the enlargement of an ordinary negative do not apply to this process. The question arises, does the shadow photograph give accuracy as regards (1) dimensions ; (2) shape of thread ?

To test (1) a No. 2 B.A. thread was enlarged 37·18 times. The linear dimensions could, in this photo, be measured to at least $\frac{1}{5000}$th of an inch. The diameter, pitch, and angle of thread of this particular screw were gauged by a member of the Committee, and found to be :—

| | | |
|---|---|---|
| By an Elliott gauge ..... | 0·1818 | diameter. |
| By a Brown and Sharp gauge... | 0·1820 | diameter. |
| | 0·03184 | pitch. |
| | 54° 30′ | angle of thread. |

The photo gave the following :—0·1818 diameter, 0·03181 pitch, 54° 30′ angle of thread. Fig. 1 shows a reduced copy of an actual photograph and scale.

As regards (2) there has been considerable discussion as to whether the shadow photograph gave the true shape of the thread. There are two methods of obtaining a photograph of a screw thread : one in which the axis of the screw is at right angles to the beam of light ; the other in which the axis of the screw is inclined at an angle which differs from the right angle by the angle of the pitch of the screw. As regards the first method, a mathematical consideration worked out by Mr. Price seems to show that a slight correction of about ½deg. in the total angle of the screw thread would have to be made. I think, as regards the second method, no correction is required. In any case, the correction is so small that for practical purposes it might be neglected, as on a

* By Colonel Watkin, C.B., R.A., &c.

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No. 2 B.A. thread it only represents about $\frac{1}{700}$th of an inch, and proportionally less on the smaller sizes. However, to determine practically whether this was the case, I suggested filing away a part of the screw to be photographed to make it a comb. There could be no doubt that the photo of such a comb would give the true shape of the thread. Mr. Stroh kindly supplied such a screw. From the photos it would appear that there is no practical difference in the shape, and that therefore the photograph of a complete screw gives a true record of the shape as well as the dimensions.

The following gives the detail of the method employed in photographing the screws: On a plate, A, B, C, D, Fig. 2, is a block, E, to which is secured a glass scale, F, which has been carefully etched with lines $\frac{1}{50}$th of an inch apart. A piece of spring brass, H G, serves to hold the screw K K to be photographed, with its axis parallel to the plate A, B, C, D. The distance of the screw from the plate can be adjusted by mean of the screw I, so that when the scale is sharply focussed on the screen, the shadow of the screw may also be brought into focus. The frame A, B, C, D, Fig. 2, is adjusted in the same position as an ordinary microscopic slide in a magic lantern arranged for microscopic work; only I found it desirable to employ a photographic lens of modern design instead of the usual objective.

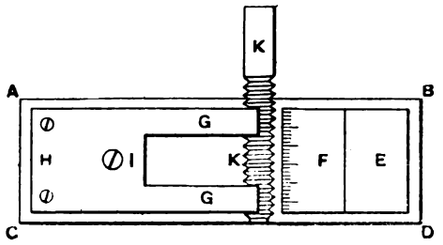


Fig. 2.

The arrangement is shown in the accompanying diagram, Fig. 3, where A represents the limelight, B the ordinary condenser, C alum trough to stop the heat rays, D small condensing lens, E screw, in its frame as described in Fig. 2, F photographic lens, G milled head screw for focussing the lens F.

Appendix II.—*Gauges for Verifying the Accuracy of Screws (for Workshop Use only).**

In the gauge represented in Fig. 4 the hole *a* is for the external diameter. It should be of exactly the diameter given in the table of sizes for B.A. screws. A screw should pass into this hole freely,

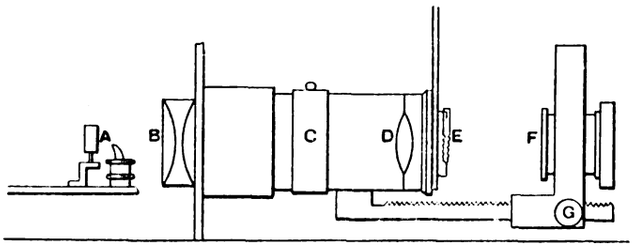


Fig. 3.

but without much shake. The hole *b* is the minimum gauge, and the screw should *not* pass into this hole. The difference of diameter between the holes *a* and *b* has not yet been determined by the Committee; in the present case it is 0·0015in. *c* is a threaded hole or female gauge in which a screw should just turn freely. The hole *d* is for the diameter of the core; but as it is impossible, without turning down some of the threads of a screw, to pass the core of it into this hole, the gauge *e* is provided for gauging the core, or, in other words, the depth of the thread. It consists of a fork, the inner edges of which are shaped so as to enter between the threads of a screw. The correctness of the pitch of a screw is ascertained by placing it in the comb *f* and against the back-rest *g*, and by holding the gauge against the light or a white paper.

It has been found by practice that there is considerable difficulty in making these combs with any degree of accuracy, and also that it would be almost impossible to carry out the above form of gauge for the smaller sizes. It is therefore suggested that the gauge represented in Fig. 5 has certain advantages over the comb-gauge. With this the half-nut *h* is employed for verifying the pitch of screws, instead of the comb. The half-nut can be carried out with greater certainty and ease, and is therefore less costly, and there is no difficulty in making it for the smaller sizes, as shown in Fig. 6. Gauges on the principle of Figs. 5 and 6 have also the advantage of being more compact and stronger for workshop use.

* By A. Stroh.

The process of making the half-nut gauges is the following:—Two have to be made at one time. When the two steel bars intended for the gauges are filed to shape they are placed together, as shown in Fig. 7 (*a* and *b*); a temporary rivet or bolt is put through the hole *c*, and the ends intended to receive the half-nut device are clamped together as shown. A hole of the diameter of the core is then drilled across the two bars at *d*, so that each bar receives one half of it. The clamp is then unscrewed, the bars are slightly separated, the tap is inserted

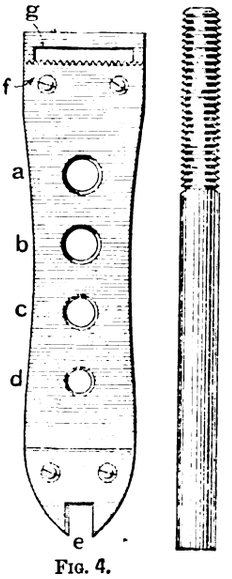


Fig. 4.

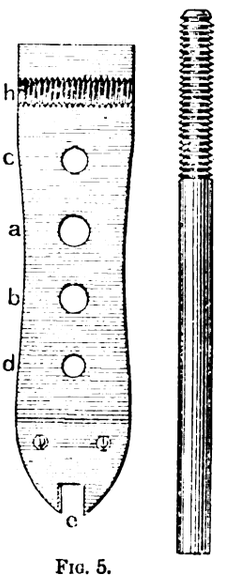


Fig. 5.

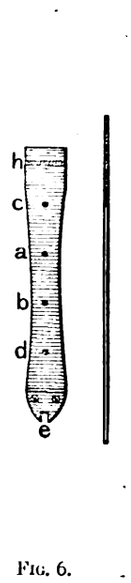


Fig. 6.

between them, and the clamp acrew tightened again gently. Of course now the two steel bars cannot meet, being prevented by the insertion of the tap. But the smooth end of the tap is now fixed in a chuck on a lathe, and is rotated forwards and backwards, while the clamp screw is tightened from time to time. This is carried on till the threads forming the half-nuts are complete. It is only

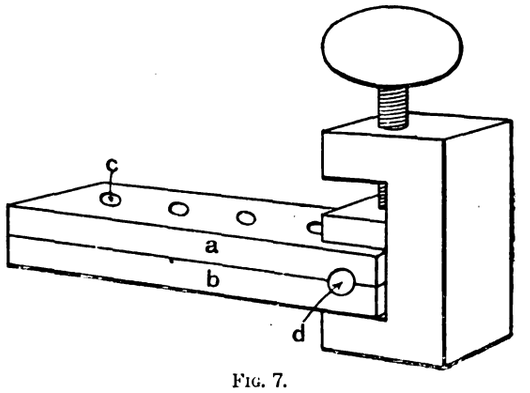


Fig. 7.

necessary towards the end of the operation to separate the bars once or twice for the purpose of removing the bur which is raised by the operation.

Appendix III.—*Working Dimensions in Millimetres and Thousandths of an Inch.*

| No. | External diameter. | | Diameter of core. | | Difference of diameter. | Pitch. | | Working margin. | |
|---|---|---|---|---|---|---|---|---|---|
| | Mm. | Inches | Mm. | Inches. | Mm. | Mm. | Threads per inch. | Mm. | Mils. |
| 0 | 6·0 | 0·236 | 4·8 | 0·189 | 1·2 | 1·0 | 25·4 | 0·05 | 0·002 |
| 1 | 5·3 | 0·209 | 4·22 | 0·166 | 1·08 | 0·9 | 28·2 | 0·05 | 0·002 |
| 2 | 4·7 | 0·185 | 3·72 | 0·147 | 0·972 | 0·81 | 31·4 | 0·04 | 0·0016 |
| 3 | 4·1 | 0·161 | 3·22 | 0·127 | 0·876 | 0·73 | 34·8 | 0·04 | 0·0016 |
| 4 | 3·6 | 0·142 | 2·8 | 0·110 | 0·792 | 0·66 | 38·5 | 0·04 | 0·0016 |
| 5 | 3·2 | 0·126 | 2·5 | 0·0984 | 0·708 | 0·59 | 43·0 | 0·03 | 0·0012 |
| 6 | 2·8 | 0·110 | 2·16 | 0·085 | 0·636 | 0·53 | 47·9 | 0·03 | 0·0012 |
| 7 | 2·5 | 0·098 | 1·92 | 0·076 | 0·575 | 0·48 | 52·9 | 0·03 | 0·0012 |
| 8 | 2·2 | 0·087 | 1·68 | 0·066 | 0·516 | 0·43 | 59·1 | 0·02 | 0·0008 |
| 9 | 1·9 | 0·075 | 1·43 | 0·565 | 0·468 | 0·39 | 65·1 | 0·02 | 0·0008 |
| 10 | 1·7 | 0·067 | 1·28 | 0·505 | 0·420 | 0·35 | 72·6 | 0·02 | 0·0008 |

Mr. Foster informed the Committee that in the experience of his firm these limits are found to be convenient for all screws connecting ordinary pieces of mechanism.



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## A CONFLICT OF AUTHORITIES.

On the occasion of the reading of his remarkable contribution on "Electrical Disturbances in Submarine Cables," at the recent meeting of the British Association in Liverpool, Mr. PREECE, whose Paper was postponed until the last day of the gathering, after lamenting the smallness of his audience, gave expression to the hope that there would be a thorough discussion in our columns as to the correctness or otherwise of his reasoning. So far this hope has not been exactly fulfilled. Seeing that, if Mr. PREECE's arguments are valid, we ought to be able to speak to great distances, and that the type of ocean cables must be revolutionised, this silence on the part of the author's natural critics cannot be due to the insignificance of the subject matter of his Paper. "Nothing is more useful than open and free criticism, and the truly earnest and disinterested student of science always welcomes it." Why the desired open and free criticism was not forthcoming at Liverpool we are at a loss to understand, unless it be a B. A. law that the discussions on Papers shall be inversely as their importance and directly as their informality. Mr. PREECE's Paper was publicly brought forward at a public scientific meeting; and in view of its somewhat puzzling train of reasoning leading up to a distinctly startling practical conclusion, involving, it may be, thousands of pounds of public money, it is to be regretted that the edifice of argumentation was not exposed to a destructive fire from the galaxy of mathematical talent then assembled at our premier port. However, as it was, Lord KELVIN, with his "matchless authority" in matters of this kind, publicly stated that the theory propounded led to proposals which he thought would not have the effects desired; and Mr. OLIVER HEAVISIDE, than whom there is no one in this country, or, indeed, in the world, more competent to express an opinion on the theory of submarine telegraphy and telephony, stated in a letter, which appeared in our issue of October 2nd, that the direction taken by Mr. PREECE "is the opposite one to that which I have so often advocated." Far be it from us to risk our valuable integuments by gratuitously thrusting them "between the pass and fell incensed points of mighty opposites." But

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since the point of scientific theory involved is fundamental, since the consequences of a practical mistake will be of great moment, and since discussion has been so frankly invited, we should fail in our duty to our readers, and in courtesy to the author of the Paper in question, unless we did what we could to draw attention to the important issue raised.

On page 413 of "Electromagnetic Theory" will be found summed up in two very simple equations all the law and the prophets on the subject of the transmission of telegraphic and telephonic signals. According to this view of the matter, the distortion $\sigma$ in transit depends upon the difference $R/2L - K/2S$, and the attenuation $\rho$ upon the sum $R/2L + K/2S$, where R is the resistance, L the inductance, K the "leakance," and S is the "permittance" or capacity of the circuit. From these equations follow several practical deductions. Firstly, the resistance of such a telephonic circuit as Mr. PREECE contemplates must at all costs be kept down; "the resistance of the guides is wholly prejudicial." Secondly, inductance is beneficial. Thirdly, low insulation resistance is seen to lessen the distortion of the signals transmitted—that is to say, to increase the maximum speed permissible, though *per contra* it results, of course, in leakage and consequent attenuation of the signalling current. Fourthly, large capacity means considerable distortion—a distortion which in practice is not found to be compensated by the lessening of $\rho$. For the arguments employed by Mr. HEAVISIDE, and leading up to these plain English conclusions, we must refer our readers to his well-known treatise, or to his "Electrical Papers." Mr. PREECE'S reasoning will be found on pages 690-692 of our issue of September 25th. We will not attempt to summarise it, but will content ourselves with describing the concrete result of his cogitations. The cult of self-induction is naturally somewhat of a stumbling-block to the majority of us; and even those who know or ought to know better are occasionally betrayed by momentary confusions of thought or inadvertent slips of facile pens into writing "mutual" in place of "self," imperilling by that fatal error their scientific salvation, and rendering completely nugatory the most imposing ratiocination. However, so far as we can understand his meaning, Mr. PREECE is anxious to reduce capacity and increase inductance, and thus would seem to have become a convert to the "distortionless circuit" theory. But, as will be seen by a glance at Fig. 6 on p. 691 of our issue of September 25th, in the four-circuit cable proposed, Mr. PREECE has reduced inductance to a minimum and increased capacity very nearly to a maximum. In this sketch it will be observed that the positive and negative wires are as close together as possible; in other words, the principle upon which inductionless resistances are made has been employed. Again, owing to the thinness of the dielectric between the two conductors and the peculiar shape given to these, the "permittance" must be enormously increased, notwithstanding the use made of a dielectric of low specific inductive capacity.

Here then we have two sets of eminent authorities in sharp disagreement—not now, as in days gone by, as to principles, but as to the correct method of embodying in a concrete cable certain mathematical abstractions or, as some would say, fictions. Under the circumstances, therefore, it would seem both fair and expedient that the mathematicians, whose views are at last finding acceptance at the hands of practical telegraph engineers, should have some voice in the construction of the cable which is to embody their ideas, and in the experiments which are to put them to the only test capable of allaying the healthy scepticism of the true "natural philosopher." Attention has recently been called to the way in which English chemical manufacturers have lost the advantage of being first in the field by reason of their aversion to and distrust of pure research. Our Government Departments ought to set a good example in this, as in other things. "In the multitude of counsellors there is wisdom;" and even if the counsellors perchance be Englishmen bearing the names of HEAVISIDE, FITZGERALD, and LODGE, the adage still holds good.

## REVIEWS.

**Practical Radiography.** By H. SNOWDEN WARD. (London: Published for The Photogram, Limited, by Dawbarn and Ward, Limited.)

There is a want of a small book on radiography which will give doctors and surgeons practical instructions and hints how to use Röntgen ray apparatus. This little volume before us only partly fills the want. The short chapter on the way to treat the photographic plate is clearly and concisely written, but the descriptions of the electrical apparatus and the instructions how to use it, leave much to be desired. Very few men who wish to make practical use of the X-rays would care to make an accumulator or induction coil according to the instructions given in the book, and if they did we fear that success would not crown their efforts. More might be said on the construction of primary batteries, and on the best method of connecting them. No proper instructions are given how to work an induction coil from the public supply mains; the reader is recommended to consult an electrician before making any such connection. He is, however, instructed how to charge an accumulator by connecting it to a ceiling rose through a water resistance. The current recommended to be taken in this way is from 8 to 12 amperes. "The little fuse wire in the ceiling rose will have to be altered under the advice of an electrician." It is a pity that the author did not consult one before recommending his readers to pass 8 to 12 amperes through wires and connections intended for 1 ampere. We wonder whether the author or the printer is to blame for twice calling a voltmeter a voltameter. Some forms of Crookes' tube are described, and the focus tube is recommended as the best. The Tesla coil is dismissed in four lines. Anyone who is not "well acquainted with electricity" is recommended to leave it alone. A brief description is given of some successful experiments with an influence machine used with a Crookes' tube, and the reader is instructed how to make a fluorescent screen. The author has coined the word "radioscopy" to denote "work with fluorescent screens." The illustrations consist chiefly of photographs of X-ray pictures, some good ones and others very indifferent. The book, although it only contains 80 pages, is very unsystematically arranged. It might easily be reduced to a 20-page pamphlet without any diminution of usefulness.

**Engineer Draughtsmen's Work.** By A PRACTICAL DRAUGHTSMAN. Illustrated. (London: Whittaker and Co.)

The object of this book is rather vague. According to the preface it is written for those who are desirous of entering a drawing office, but are perhaps in ignorance of the work carried on there; and it does not aim at imparting information to the practised draughtsman. Unfortunately, the author forgets this at the end of the first chapter. Whether the aspiring youth will be any nearer his object when he reads this book we very much doubt. Much of it will not help him, and a great deal of it he will not understand.

The book opens with a description of the instruments and appliances which a draughtsman requires, and stating that board and T-square are usually provided by the office, straightway proceeds to show how to make them. Some capital hints follow on the use and care of instruments. A chapter headed "Further Hints on Use of Instruments" is chiefly a treatise on screw-threads, toothed wheels and pinions, mitre and bevel wheels. Some notes on sketching are good, but all too short. An example is given to further elucidate the author's remarks. Levelling and surveying are hastily disposed of in an unsatisfactory manner, and in two pages is summed up the science of the indicator diagram.

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Chapters VI. and VII., on studies for draughtsmen, would bear largely expanding. The author rightly insists on a knowledge of theoretical and applied mechanics, and a fair amount of mathematics. To these subjects he adds, for electrical draughtsmen, steam, solids and fluids, magnetism and electricity, dynamo design and construction, electrical testing, sound, light and heat, machine drawing, solid geometry, and, if possible, building construction. He advises a good mechanical shop training and evening study, not only before but after entering the drawing office. The list of subjects is certainly a formidable one, but there are many draughtsmen well up in the majority, if not all of them, and these are the men who take leading places in big offices.

Why the next three chapters were written we really do not know. Chapter VIII. describes how paper should be stretched and drawings mounted; Chapter IX., the science and art of making "blue prints"; and Chapter X., the manner in which drawings and tracings should be stored and recorded. Perhaps they are to qualify the aspirant for the post of office-boy. The next chapter is useful, and explains the use of the planimeter. Not only is the instrument itself described, but its working is carefully shown by aid of diagrams and examples, the author computing one or two imaginary areas. In conclusion, the draughtsman is urged to be methodical in his work, to do all calculations in a book and to date and preserve them; to make note of any special formulæ, &c., that he comes across, and which are not, perhaps, in his ordinary books of reference; and to keep these notes well indexed for reference.

**The Slide Rule.** By CHARLES M. PICKWORTH. Second edition. (Manchester and London: Emmott and Co.)

We reviewed the first edition of this book two years ago, and we find no appreciable alteration in the second edition to cause us to alter the opinion of it we then formed. A student, after reading through the book with a slide-rule in his hand, would certainly obtain a good notion of the use of the instrument; but he would soon find that if he wished to use the latter as a time-saving machine, he must employ less clumsy conversion factors than those given in the book. The idea of employing double-conversion factors for converting inches to millimetres, or pounds to kilogrammes, &c., is not a good one.

**Alternating and Interrupted Electric Currents.** By Prof. G. FORBES, M.A., F.R.S., F.R.S.E. (London: Biggs and Co.)

A year ago Prof. Forbes gave three lectures on alternating currents at the Royal Institution. It will be remembered that these lectures were practically a succession of ingenious experiments, showing the mechanical analogies of various alternating-current phenomena. The book before us is a verbatim reproduction of the lectures, and as such it is not surprising that it fails to impress. For one who has seen the original experiments this book would perhaps be a pleasant memento, but any other will find it tiresome reading. The colloquial form of address has been retained, and we cannot help wondering how it was that its peculiarities were not more apparent in the lectures. We cannot remember whether the following passage was delivered with a wink of the eye or a touch of brogue, or whether Prof. Forbes stopped to adjust some of his apparatus in the middle of it. "Now it is all very well to talk about it in that kind of language, but it is not very intelligible, and for this reason that it is difficult to understand." This might have referred to the following sentence which occurs in the description of Clerk Maxwell's model illustrating mutual induction. "These wheels are connected, not by a rigid axis, but by means of three bevelled wheels in the centre—one keyed on each of the two horizontal shafts, and the third running loosely on a shaft, at right angles to the others, forming one of four cross arms, having heavy weights at their extremities, and therefore possessing considerable inertia, and so resisting any tendency to set them in motion round the horizontal shaft of the handwheel, to a sleeve running on which they are attached." Although we do not believe that such experiment-lectures (if we may coin such a word) can be adequately reproduced in black and white, a worse attempt than the one under review it would be hard to imagine.

**Computation Rules and Logarithms.** By SILAS W. HOLMAN. (London and New York: Macmillan and Co.) 1896.

The author of this useful work has treated mathematics, as it were, as an inexact science; or, to speak more plainly, he discusses the limitations imposed by probable error upon the value of calculations. In the first part of his book he explains a number of ingenious labour-saving "computation rules," whereby, say, a four-figure accuracy calculation may be carried out without the necessity of obtaining the result in 16 figures or more. Schoolboy mathematics is taught as an exact science, and the average schoolboy believes that 0·5 is identically the same thing as 0·5000, and each exactly equal to $\frac{1}{2}$. Practical acquaintance with calculations in physical science soon alter such ideas; and it is then realised that, with an uncertainty in the third figure of each factor, it is sheer waste of time to work out $34863 \times 79658$ by ordinary simple arithmetic or by seven-figure logarithms. The first fundamental principle adopted in these computation rules is to "retain everywhere enough places to correspond to two unreliable places in the final result; the direct effect of this is to keep the first place of unreliable figures in the final result substantially free from the accumulated rejection errors." This, for practical purposes, is a sound working principle. Whether the reader will care to adopt in detail these computation rules will largely depend on his taste; to some people such rules are more irksome than an untrammelled and conscious process of approximation throughout a calculation. But in any case there is a mass of useful information and valuable advice mingled with the explanatory notes on Mr. Holman's rules. The second part of the book contains a set of mathematical computation tables, conveniently arranged. The book is printed in stiff, heavy paper, suitable to its purpose; and it is well worth the modest dollar charged for it.

## APPLIED ELECTRO-CHEMISTRY.*

BY JAMES SWINBURNE.

*Electrolytic Caustic and Bleach.*

Inventors are still devoting their attention to curious vats and queer diaphragms. In some ways it seems as if too much attention has been given to electrolytic alkali. The alkali business is so enormous that it is a great temptation to inventors; but, on the other hand, the products are low priced, and therefore there is not so much margin. It does not seem to be quite well enough understood that electrolytic alkali is not waiting for some wonderful vat. The processes already in use are quite good enough to give enormous profits, if worked economically; but careful supervision is necessary, and great attention to detail. Unfortunately, such processes generally get into the hands of limited companies, and limited company management is seldom conducive to success in such cases. It must also be borne in mind that the cost of the electrolysis itself is a small portion of the cost of making electrolytic caustic and bleaching powder. So small a portion of the cost is it that a great improvement in the vats would make very little difference in the price of the finished material. Unfortunately, everyone wants to have a vat or system of his own invention. A manufacturer who started up with the determination to use no apparatus which was patented or called after anybody would have a much better chance of success, especially if he employed a few sharp young chemists to watch the vats, make tests, and find out the very best conditions for working. Generally the various inventions consist of varieties of porous diaphragm. Of course, an arrangement like that of using mercury as an anode and cathode in one is a different matter. This gives pure caustic, as there is no chlorine in the cathode chamber. If no hydrogen is given off at the surface of the mercury in the anode compartment the current efficiency must be unity. Having no salt in the caustic means considerable economy in finishing.

Some injustice has been done to this process by those who have raised the cry that the mercury is poisonous. There can be no danger whatever in such a case. I have had charge of lamp works where mercury is used in the exhausting rooms, where it seems to be ubiquitous. Yet all that is needed is to keep the mercury clean, so that it does not flour or powder. When a glass pump breaks, the mercury gets all over the linoleum-covered floor, and is merely swept up. In spite of this, I have, in several years, never had the slightest case of salivation. When the mercury is permanently

* Cantor Lecture.—IV.

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under liquid, as in the alkali process, it is quite absurd to suggest danger to the health of the workmen.

One of the difficulties in making bleach is that the anodes are attacked, and a proportion of carbon dioxide is given off with the chlorine. This converts some of the lime into chalk, and lowers the possible percentage of available chlorine. I have found—at least, on a small scale—that this difficulty can be overcome by letting the chlorine and carbon dioxide first pass over some bleaching powder, which takes up the dioxide, giving off chlorine instead. When it is converted into chalk it is thrown away. It would be useless to burn it into lime, as it contains chloride as well as carbonate. By this means good bleach can be made. It seemed possible that the carbon dioxide would evolve hypochlorous anhydride, which would be taken up by the lime, giving bleaching powder with a higher percentage of available chlorine than usual. It is doubtful ff such a reaction takes place, and still more doubtful if it could be worked on a large scale. Mr. Charles Waite was, however, before me in working out this scheme, and it has been in operation at the Rumford Falls Electro-Chemical Works for some time now.

Recently, Dr. Hurter has urged that it is impossible to get strong caustic in an ordinary vat at a high-current efficiency. I do not understand Dr. Hurter's reasoning, and so I may quite unintentionally misrepresent his views. At a discussion on Mr. Hargreave's Paper, at the Society of Chemical Industry, where I first heard Dr. Hurter's views, I suggested that he was confusing the carriage of the charges by the ions with the liberation of the final products at the electrodes. I have not seen the printed account of this meeting yet, so do not follow Dr. Hurter; but he kindly sent me a Paper, read by him at the Liverpool Physical Society in 1893. Unfortunately, I cannot follow this either; but as far as I can make out Dr. Hurter thinks that in a solution containing salt and caustic the current is carried partly by the hydroxyl ions and partly by the sodium and chlorine ions, with which I agree; and that the portion carried by the hydroxyl, or by the hydroxyl and some of the sodium ions, is useless because it does not make more caustic, with which I disagree entirely. As long as there is available chloride in the immediate neighbourhood of the anode, chlorine and not oxygen will be evolved. At the cathode again hydrogen must be evolved. This being the case either caustic and chlorine are made, or caustic gets at the anode and takes up the chlorine, making hypochlorite and perhaps chlorate.

Again, if hypochlorites or chlorate get to the cathode they will be reduced wastefully. But these are conditions that would not occur in a rationally conducted works. If you put salt into a vat and stir it round during the electrolysis the result will obviously be that very soon hypochlorite will be formed in large proportions at the anode to be reduced again at the cathode. But then nobody tries to make soda and chlorine that way. Suppose, however, that the liquid is still, and there is a porous partition. Start with all chloride. Chlorine comes off at the anode, and hydrogen at the cathode, and caustic appears at the cathode. We now have, in the anode compartment, chlorine moving towards the anode and sodium towards the cathode. In the immediate neighbourhood of the cathode we have both caustic and chloride. We thus have the current there borne by the sodium moving towards the cathode, and also by hydroxyl ions moving towards the anode, and chlorine ions moving towards the anode. Eventually the hydroxyl ions will reach the porous partition, and they will finally go on into the anode chamber, and we shall there have caustic which will take up chlorine and make hypochlorite. This, I take it, is Dr. Hurter's difficulty. If the current were borne entirely by the sodium and chlorine, all the chlorine would eventually move into the anode chamber, and all the sodium would move into the cathode compartment. In practice, however, we have to run brine into the vats continuously, and run off caustic solution. The ionisation of the caustic and salt depend on the strength of the solution with regard to both. I need not take actual figures, as it will serve my purpose to suppose for the moment that all the current is borne by the hydroxyl, the chlorine and both lots of sodium ions being idle and not migrating at all. Of course, in the anode chamber, where I assume no caustic for the moment, the current must be borne by the chlorine. Then we have a sort of army of hydroxyl ions marching from the cathode towards the anode at a certain rate. We admit the brine to the anode compartment, and we draw off caustic liquor from the cathode chamber. Then all we have to do is to feed the brine at such a rate that the whole of the liquid moves at the migration velocity of the hydroxyl. The hydroxyl then really stands still, and never gets to the anode. What is drawn off is really a mixture of salt and caustic. The vat has full efficiency, as hydrogen comes off at the cathode and chlorine at the anode. The current being borne by the hydroxyl makes no difference in the current efficiency of the vat, as the current borne by the hydroxyl is just as effective as that borne by the sodium or chlorine ions. The real difference is in the amount of salt it is necessary to draw off with the caustic. If the current were all borne by the chlorine, we could get pure caustic solution off. The relative ionisation of the salt and caustic affect the proportion of salt and caustic drawn off, and thus influence the cost of finishing; but they do not affect the current efficiency. I hope I have not misrepresented Dr. Hurter in any way.

In the case of making chlorate, all that is necessary is to feed the potassium chloride in at the cathode end and draw off the chlorate at the anode. The same vat gives either product, according to the direction of the fluid current. Of course, the chlorate vat must be hot, and as the anode liquid is not acid, platinum anodes are available. I tried small chlorate vats on this principle some years ago, but have made very few and imperfect experiments on caustic soda.

*Copper Refining.*

There is but little to be said about copper refining or the electrolytic extraction of the metal from its ores. A great deal has been published about refining, and still more about various schemes for extraction, and there would be little use in repeating such accounts here. At the same time there is a great deal—as Badt points out—that is not published. Copper refiners seem to think they are working a magic secret process, and that if they keep all the details to themselves no others will be able to compete with them. Such ideas are commonly to be found among workmen, but are seldom encountered among educated people; and the probability is that the various copper refiners are working their processes as badly as they can be worked, and understand very little about electrolytic work. The unfathomable secret guarded by copper refiners seems to be the use of anodes and cathodes of copper in a solution of copper sulphate. As regards details of management or of processes, such as the best temperature to work at, or the best method of circulating the liquid, there can be very little to learn. It would be much better, however, for electrolytic copper refiners to publish results and compare notes, as, if they are competing with one another, any knowledge, shared equally among them, makes no difference, but it puts them all in a better position as competitors in the race with refiners who use ordinary metallurgical methods. The same sort of thing went on in early days among incandescent lamp makers, and, in fact, it still goes on. Fortunately, workmen are migratory, and wandered from factory to factory, so that each factory knew what the others were doing, but thought its own processes were profound and valuable secrets. The more insignificant the works, and the more idiotic the process, the greater was the secrecy observed.

The main difference between two classes of copper refining processes consists in the series or parallel coupling of the plates. From a purely electrical point of view, this looks like a distinction without a difference; but there is more in it than appears at first sight. It makes little difference in the energy used per ton of copper refined, the only source of divergence being the numerous contacts in the parallel system. When a vat only takes a fraction of a volt, a large proportion of the power may be wasted on imperfect contacts.

The series arrangement, however, saves a good deal of money in the leads, and greatly simplifies the connections. It is often supposed to have some magic efficacy in giving a greater output of copper for a given power; but that is absurd. Its great advantage really lies in its needing less copper in the vats for a given output. This may seem a small matter; but if prices are worked out it may mean a very important saving. Take an example. Suppose copper is deposited at, say, five amperes per square foot; and suppose the anodes are cast say $\frac{3}{4}$in. thick, and are eaten off both sides. Roughly the anodes will take two months to be deposited on the cathodes. Take the case of a refinery dealing with 1,000 tons of copper per month. This means that 2,000 tons are in the vats. As a matter of fact there will be a little more, but we can take 2,000 tons as a good round figure. The value of this copper at £60 per ton is £120,000. Now the question is what value is capital to the owners of the refinery. They might perhaps be able to borrow money, partly on the security of the copper at a low interest; but it is more likely that money is worth 6 per cent. to them, or in other words that their works give 6 per cent. on the capital sunk, and would give at least that interest on any further money sunk safely in enlargement. The interest on the copper in the vats is thus £7,200 a year, or £600 a month. As the output is 1,000 tons a month this means that the price of refining copper is increased no less than 12s. a ton for interest on the metal in the vats. It is then of great importance to keep down the amount of copper going through the works, that is to say to make it go through quicker. A little can be done by removing the cathodes when they are $\frac{3}{8}$in. thick instead of $\frac{1}{2}$in., and putting new ones. This reduces the 12s., not to 6s., but to something above 9s., how much above 9s. depends on the cost of the initial cathodes. Many people may say there are such quantities of copper all about a copper refinery that it makes no real difference whether it is in the vats or in the stores. This argument is fallacious, for the copper in the vats is not available to fill orders, like the finished copper in the stores. The stock of crude copper is merely a kind of buffer or regulator to take up the variations in supply, and give a constant feed to the refinery: the stock of finished copper is to enable a slow and steady production to cope with sudden and irregular demands. The copper in the vats

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cannot act in either way, and is quite independent of the stocks held, and it cannot be drawn upon. It therefore represents capital lying idle. It is still an open question whether the series arrangement, as series arrangement, saves money. At the Bridgeport works in Connecticut, which are, I think, the largest electrolytic copper refining concern in the United States, the system worked out by Hayden is used. The anodes are rolled and are quite thin. I forget the dimensions just now, but think they were about $\frac{1}{4}$in. when I saw them. They were arranged in wooden vats taking something like 120 volts, connection being made to one at one end, and to a special cathode at the other. Each of the intermediate plates then becomes both cathode and anode, as one side of it is eaten away, while the other has copper deposited on it. As the plates are rolled they are eaten and deposited very evenly, and the process is carried on till very nearly the whole of the copper is transferred. As the deposited copper never sticks tight to the plates, the remains of the original anodes can be picked off the refined copper. There is, of course, a certain amount of scrap anode which has to be remelted and rolled again, but as no leads have to be connected to the anodes, and as they are finally supported by the deposited copper, they can be consumed much more completely than in the case of thick cast anodes. The saving is thus essentially in the use of the thinner plates, and in the cost of doing away with the necessity for making electrical connection to each plate with its attendant loss of power, due to inferior contacts. The saving in leads about the vat house is also considerable. The most important of these points is, undoubtedly, the thinness of the plates in the vats. There seems no reason, however, why equally thin plates should not be used in the parallel system. There is no reason why the parallel system should be tied down to cast anodes, which must be fairly thick to allow of casting. It might be possible to cast the anodes thinner by adding a little extra silver. I have heard that a very little silver allows copper to be cast well, but do not know if that is correct. The silver would practically all come out again in the refining. Whether a trace of aluminium would do is another matter. It would, of course, be lost, and would gradually accumulate in the bath. These are merely crude suggestions. The series arrangement has been worked out, no doubt independently, by Smith, Hayden, and Stalmann. Who invented it I do not know. It is described in a pamphlet by Hugon, dated 1885, but I do not know that any copy came into England or America until several years later. Hugon discusses the question of economy of capital sunk in copper going through the process; in fact, it is his main point, and he makes out that the series arrangement is cheaper, but it is difficult to see why, unless the series arrangement alone allows thin anodes and cathodes to be used. Hugon also discusses the use of cuprous chloride. Cuprous chloride gives twice as much copper as cupric sulphate with a given current; but that is not everything, and unless the resistance of the vat is so low that twice the pressure is not necessary, this does not pay. It might be said that a specially low current density might be used, but that means sunk capital again. I do not know at all how far the chloride would do, as it might carry over impurities that remain in the slimes in a sulphate solution. Copper nitrate gives good deposits of copper with enormous current densities, but it is probable that silver and, perhaps, gold are carried over. Swan has made numerous experiments on rapid deposition from the nitrate, but has, I think, published nothing as to its use in refining argentiferous copper. The presence of a very little chloride might prevent silver coming over, but it would hardly stop gold.

Stalmann, who was for some time manager, and who designed the Anaconda electrolytic copper refining works, uses a very ingenious series arrangement. Each plate has paper stuck to one side. A few copper rivets are put through, and the paper is blackleaded. This gives a paper cathode, which separates the deposited copper from the crude, and gives no trouble in separating the scrap anodes from the good deposited cathodes.

It is often supposed that everything electrolytic is pure. Unfortunately, this is not necessarily the case. Electrolytic copper is nearly pure, but it is generally, if not always, contaminated with antimony. It is probable this small trace of antimony does harm, as it most likely reduces the conductivity appreciably, and may alter the non-electrical physical properties of the metal. Antimony can be separated from copper by electrolytic analysis. What is wanted is a method which is possible on a commercial scale.

By the way, there is no space here for a discussion of electrochemical analysis; but there is just room for an urgent appeal to analysts not to measure electrical quantity in terms of bang-gas. Until quite lately, electroplaters and writers on electrolysis used the Smee cell as the unit of everything. When they told you they had passed the current of 57 Smee cells through anything, they thought they had given you information. The Smee cell, as a fundamental unit of everything, still lives in the somewhat muddled minds of many writers on electrolysis and electroplating of the old school. But in electro-chemical analysis—which is a new branch of science—surely we might expect chemists to work with volt and ampere meters, and to use the methods of other scientific men.

*Calcium Carbide.*

This compound has created an enormous sensation in the financial world, or at least in the speculative part of it, during the last year or so. As far as its discovery in America goes, it appears to have been a mere matter of chance, an invention in the literal meaning of the word. The formation of calcium carbide from carbon and lime seems to be a mere question of temperature, and to have nothing to do with electrolysis. It may be that lime and carbon do not react until the lime is fused or the carbon volatilised, and that the temperature of the electric furnace is needed to bring this result about. It is probable, however, that the very high temperature is necessary to bring about the reaction, apart altogether from getting the lime and carbon into contact. I have tried some experiments with an oxygen furnace, and have not succeeded in making calcium carbide, even when I used a solvent for the lime; so that there was no doubt that it came into contact with the carbon. These experiments were not tried thoroughly enough to be conclusive, but they tend to show that an exceedingly high temperature is needed. It is hardly necessary to say that an oxygen furnace, that is to say, an injector furnace fed with an oxygen and coal-gas blowpipe, gives a pretty high temperature.

The future of calcium carbide depends very largely on its cost of manufacture. It is, of course, very absurd to take the cost of coal, lime, and energy, and calling that the cost of the carbide, to compare the cost of a candle-power-hour with that of gas as charged to the consumer. The prime cost of gas delivered into the "hydraulic main" would be the right thing to compare in such a case, and would tell a very different story. On the other hand, the distribution of acetylene may well be much more simple in proportion than that of coal gas. If it is to be delivered by pipes its only advantage, as far as distribution is concerned, is that the pipes will be smaller. This would make but little difference in the total cost of distribution, as it only reduces the capital sunk in mains a little. The cost of laying them would not be very much reduced.

The first thing is to get some idea of the cost of calcium carbide. The estimates given vary enormously, as very little has been published as to actual cost of manufacture. It seems probable, however, that the cost of manufacture—that is to say, the cost of lime, coke, carbons, labour, and energy, taking energy at a farthing per kilowatt hour, will be a little over £6. If water is used, the price comes out a little lower; but, as already explained, water-power must not be reckoned upon too much, as rents will probably go up soon. It is best to be on the safe side, so we may perhaps take £10 a ton as the final price of electrically-made calcium carbide, capable of giving 5 cubic ft. of acetylene per pound, packed and delivered on rail, after paying manufacturers' profits and all charges. This seems a low price, and it may be said that the various aluminium works have all the plant ready, and know exactly the cost of manufacture, and have reduced the price as far as it will go already. The business has really hardly commenced, however, and there is little doubt that the processes will be cheapened. At present, it is the roughest and crudest method imaginable.

Let us assume the final price to be £10 a ton, and see exactly what its future may be at that figure. Allowing 5 cubic ft. of acetylene per pound, this gives, in round numbers, 18s. per 1,000 cubic ft. Calcium carbide is not acetylene, however. Suppose the treatment with water raises the acetylene to 20s., and that it gives 20 times as much light as coal gas, it would then correspond with gas at 1s. per 1,000 cubic ft. Now, let us look at the price of gas. A ton of coal at, say 10s., gives 10,000 cubic ft. of gas; so gas should be 1s. per 1,000 cubic ft. But the ton of coal gives 15cwt. or so of gas coke, which is worth something, and over 100lb. of tar, which is valuable, and 20 gallons or so of ammonia liquor. Some of the 15cwt. of coke is used to heat the retort benches, and labour, &c., has to be paid for; but still the actual value of gas at the hydraulic main is really only a few pence per 1,000 cubic ft., and acetylene has no chance in comparison. The common practice of taking the price—generally the prime cost—of carbide of calcium, reckoning from it the price of acetylene, and comparing it with the price of delivered coal gas is absurd. In addition, the great difference in lighting power comes in when the acetylene burner, though using little gas, is giving a very powerful light. Except in sitting-rooms people want small lights about their houses, and they want to be able to turn them down at will.

Acetylene may be used for enriching coal gas. Whether it will pay depends very much on the local conditions. Cannel coal is usually employed when enrichment is necessary. The prime cost of gas at any works depends on the price of coal and labour, and on the selling price of coke, tar, and ammonia. The cost of scrubbing and purifying would have to be incurred in making acetylene on the large scale, and the cost of distribution by pipes and collection would be about the same in both cases. It is impossible, however, to give any answer as to whether it would pay to enrich coal-gas, unless one knows the real cost price of gas in a given case. Thus to take a rough example, suppose crude gas costs 6d. a thousand cubic feet; so that acetylene costs 40 times as much. Adding 3 per cent. of acetylene would about double its lighting

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power, so that to replace 1,000 cubic ft. of gas we would have 500 cubic ft. costing 3d., and 15 of acetylene costing over 3½d. It is therefore clear that it will not pay to enrich with 3 per cent. of acetylene at these prices. I have not worked out figures to find the best enrichment for each relation of values of acetylene and coal-gas, for it seems clear that unless the cost of carbide is much less, or the cost of crude gas much greater than here assumed, there is no chance of its being utilised in that way. A public company does not make improvements if it can help it, and of all public companies gas companies, owing to their constitution and the sliding scale arrangement, are least likely to adopt such methods as enriching gas, even with the bye-products of electric lighting companies, who make carbide to get decent load factors.

In addition to this, gas is not used only for lighting. It is very largely used now for heating purposes, and the incandescent mantle has come to stay, and people with stoves and Welsbach burners would strongly object to having their gas bills doubled, and their gas contaminated with a body which necessitates their renewing all their gas fittings and removing all copper and brass taps and couplings.

It does not look, therefore, as if acetylene will compete with gas at present. It may be a different matter in other countries. In the United States, for instance, gas is generally very dear. I had charge of a works in Boston some years ago, and we paid 10s. per 1,000 for gas. One shudders to think what it must have cost in outlying districts. The enormous strides made by the electric light in America is not owing to the good electrical engineers, but to the bad gas producers. Perhaps the gas works are run by the urban authorities; this would account for anything. If sulphate of ammonia does not fetch good prices in America, and if tar distilling and the manufacture of dyes is not brought to the perfection they are in Europe, it is quite probable that acetylene has a much greater future there than over here, especially as in proportion to the inhabitants water power is much more plentiful, so that power prices may remain low for a very long time.

The next scheme is to deliver calcium carbide to houses, and let the consumers make their own acetylene. All that is needed is to add water. This sounds very simple. In the beginning of the century gas was to be made on the spot in the same sort of way. All you did was to put coal in a retort, and heat it, and off came the gas. Yet this was never practised, except in special cases, and gas never came into use generally until it was distributed by pipes ready for use. There are, of course, a few country houses and isolated establishments where they make a fluid they call illuminating gas. Exactly the same thing happened with the electric light. Each house was to have a gas engine and a dynamo, and generate its own power. Then the next idea was that the accumulators were to be left at the houses with the milk, and changed next day or week or month; but this never came into practice either. These two schemes correspond very fairly with those of distributing carbide for use in generators, and distributing liquid acetylene in bottles. The generators would always be troublesome in an ordinary house. No doubt the light would be much cheaper and better than that of gas, as commonly used, but that is by no means everything. People forget that the average households are controlled by women. Women may understand people, but they are completely wanting in the faculty of understanding things, and they have the unreasoning conservatism and conventionality belonging to the undeveloped mind as seen in boys and savages. A woman hates everything new, and would never understand how to work an acetylene generator until it had been in use for generations, and it was considered part of the duty of a good housekeeper to make good acetylene, as it used to be to make good beer. Of course, even then it would be done by rule of thumb. There is more than this. The first thing a woman asks when she sees anything new, be it a mousetrap or a telephone, is, "Will it explode?" Now no one can say on his honour that an acetylene generator won't explode. He does not think it will, in fact he feels sure it won't, and he sincerely hopes it won't; but an explosion might possibly occur. This settles the matter. The only thing to be done would be to utilise a woman's instinctive hero worship and belief in authority, and to arrange that acetylene generators should be recommended by her clergyman or doctor. I say her doctor advisedly, as she does not believe in other women's doctors.

The plan of distributing liquid acetylene in iron bottles sounds more promising, as very little goes a long way, and the bottles could be connected to the house service by the acetylene company without the women of the house having anything to do with the matter. Acetylene is given off on the addition of water to the carbide, at enough pressure to liquefy in a cold bottle at once, and it might be purified at the same time. It must be remembered, however, that the comparison must be made, as to cost, not with gas burned in the ordinary batswing burner, which is generally not even good of its kind, but with the incandescent mantle. If anyone is going to improve his lighting, he will not take up acetylene, as against the incandescent burner, unless it is better. Acetylene gives, for a cubic foot, about three times the light of the Auer burner, so that, at 20s. per 1,000 cubic ft., it corresponds to gas at 6s. 9d. Gas seldom costs 6s. 9d. per 1,000. Besides, it is easier to put in the Welsbach burners; but if a considerable alteration is to be made, the electric light may be preferred.

All the same, there is a very large opening for acetylene, apart from competition with coal gas. For country houses, and in carriages, omnibuses, trains, and on board ship, it ought to have its own way. One of the chief things wanted is a good burner, that will not give smuts under any conditions.

A good portable acetylene lamp is also much needed. If the lamp generates its own acetylene there is the difficulty of having it attended to properly, at least by maidservants. Even paraffin lamps are seldom in good order where there are no men servants, and the old colza oil lamps never were. There are other difficulties, however. The action of the carbide on the water is so energetic that each time they touch too much acetylene is given off, and some sort of gasholder is needed. I have tried mixing alcohol with the water to reduce the vigour of the action, and it works fairly well. I have lately found that this plan has been already fully worked out. Another difficulty is that the water gives off vapour which generates acetylene, so that when the lamp is out of use acetylene is being generated slowly. This means that the lamp will smell, and the smell of acetylene is not pleasant.

Small bottles of liquid acetylene for portable lamps should be no more difficult to deal with than mineral water siphons, and a small steel tube bottle would run a light and portable 10 c.p. lamp for a long time. The want of portability is the great drawback to gas. The electric light is a little better, but not much. The result is that candles are still used. Acetylene lamps would not ruin the carpets, or cement the piano keys together.

Too much has been generally said about the poisonous nature of acetylene. Experiments show that it is not at all a serious poison, and its smell is a great safeguard. It uses so little air in burning that, on the whole, it would be a very much more healthy illuminant than gas, oil, or candles, especially if it contains no sulphur. Healthy breathing is not generally sufficiently appreciated yet. Many people still sit in close rooms and sleep with their windows shut, and the smaller air consumption of acetylene would not really appeal to them very much. Besides, according to experiments recently made on polluted air, the evils of vitiated atmosphere have been greatly exaggerated. Though acetylene, like carbon disulphide, is an endothermic compound, it is not easily exploded. Fulminate of silver only fires it locally. The explosion does not spread. Carbon disulphide explodes under curious conditions. If some is put in a bulb, and an air-pump connected and used, it will go off. I do not know if acetylene has any analogous properties.

Calcium carbide may come to be used in the manufacture of alcohol, benzine, and other organic products; but it is too soon to prophesy its future in these directions. A great deal must depend on its price, and one of the chief items is the cost of electrical power. It is to be hoped that it will soon be made by non-electrical methods, and its price may then be reduced considerably.

## THE EXPLOSION ON BOARD THE "SCOTIA."

The "Scotia" (4,966 tons) left London for Vigo on the 6th inst., with a large crew and staff of engineers and electricians, amongst those on board being Messrs. F. R. Lucas, T. Clark, H. A. Taylor, A. Dearlove, and H. B. Forde. She had on board more than 600 knots of cable intended for the Borkum-Vigo line, and on her passage down Channel she met with very heavy weather and high seas. On Thursday, October 8th, about 4 p.m., before Ushant was sighted, in anticipation of still heavier weather in the Bay, the boatswain with two able seamen were going below to inspect and make fast any stores which required attention. They were about to descend into the fore peak, and before doing so an ordinary globe lantern was lowered into the hold. No sooner was this done than a tremendous explosion occurred, which shook the ship from stem to stern, and seriously injured the men. All hands rushed on deck, to find the bows enveloped in smoke. The first impression was that the ship had either struck wreckage, or that some machinery had come adrift. The hose was quickly brought along, but was quite unnecessary, as the enormous inrush of water at the bows into the forward compartments and hold immediately quenched any fire that may have been started.

The ship immediately began to settle down by the head, and it was soon seen that the damage done was serious. Capt. Cato gave orders to put her about, to lower the boats, and to make every preparation for what at this time appeared inevitable, viz., the abandonment of the vessel. If this had proved necessary, with such a high sea running, the lowering of and the taking to the boats would undoubtedly have been attended with considerable danger and loss of life—a point that was scarcely realised by those present.

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Great relief was felt when, notwithstanding the destruction of the collision bulkhead, it was found that the second bulkhead, more than 30ft. in the ship, and reaching up to the main deck, had resisted the heavy seas and inflow of water. This bulkhead was strengthened and shored up, and good hopes were then entertained that the vessel and all on board might be saved. Previous to this distress signals were hoisted, and rockets fired. These were responded to by the s.s. "Maristow," of Plymouth, sighted about five miles off. She came alongside, and was asked to "stand by," and accompany the "Scotia" to Plymouth, distant about 70 miles N.N.E. This she agreed to do, and the natural anxiety of those on board the damaged steamer was considerably allayed by this arrangement. Steaming slowly ahead at less than four knots, and with a following sea, the fore part of the ship and the bulkhead, upon the stability of which the safety of the "Scotia" depended, was subjected to the least possible strain, but was anxiously watched during the night.

On arrival at Plymouth a closer survey of the damage done more than confirmed the serious nature of the accident; the plates, frames, &c., on the port bow of the ship were entirely blown out, leaving a hole of some 300 sq. ft. of area open to the sea, and extending for some distance below the water line; whilst on the starboard bow a similar enormous gap was partly closed by a flapping sheet of plates, which hung as if hinged from the stem.

It is assumed that the cause of the explosion was due to an escape of vapour from two 1cwt. drums of anti-fouling paint; this vapour, when present in certain proportions with atmospheric air, forms a highly explosive mixture.

It is gratifying to be able to state that Capt. Cato's orders and those of his officers were carried out with promptitude and nerve; at the same time, those who were on board are to be congratulated that the "Scotia" had not, when the accident occurred, entered the Bay of Biscay, and that the bulkheads were of exceptionally strong construction.

We understand that, under the circumstances, the Admiralty have allowed the "Scotia" to be docked at the Government Dockyard at Devonport, where it is possible to carry out the necessary repairs without removing the cable from her tanks. The cable itself was absolutely uninjured. The work to be done will be completed in about a fortnight.

## ARTISTIC FITTINGS.

As in all other things connected with electricity, marked progress has been made, since their first introduction, in the design of electroliers and similar accessories possessing pretension to artistic merit. We cannot say that there has been any striking development of originality in any way commensurate with the novelty of the illuminant to be decoratively treated; but—and we must be

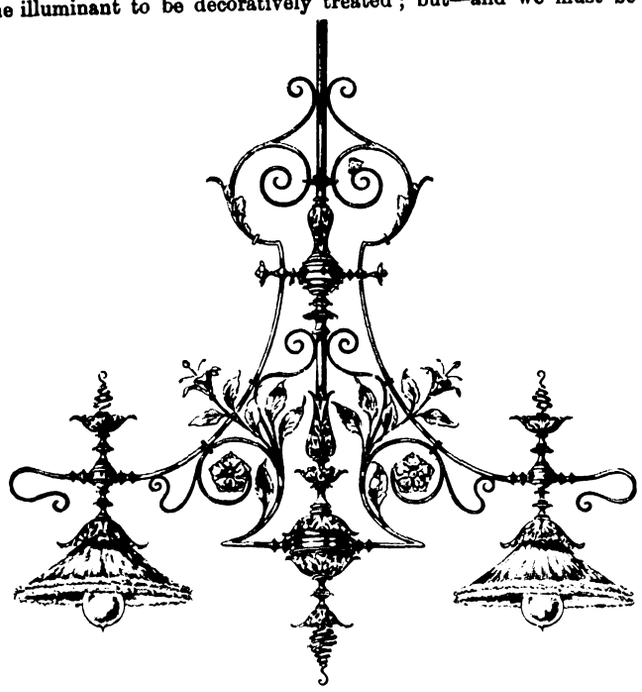

Fig. 1.

thankful for small mercies of the kind in this commercial age—there has been a distinct decrease in the visible supply of vulgarly elaborate fittings.

The sketches which we offer our readers to-day represent some designs to be seen in the showrooms of Messrs. Benham and Froud. Fig. 1 is a simple but effective two-light electrolier in "steel-bronze," suitable for a dining-room; the three-light fitting of the same type, of which it would be difficult to give a correct idea in a sketch, being, if anything, more effective than the one

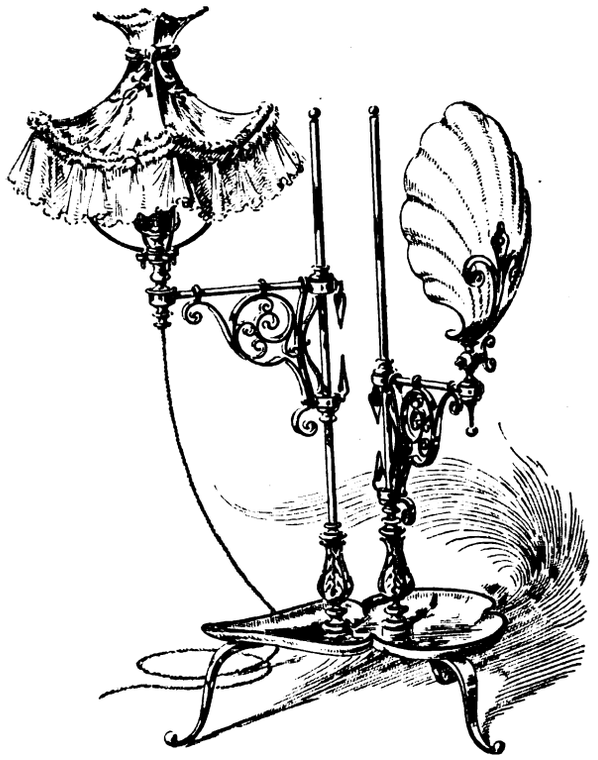

Fig. 2.

adopted for two burners only. Fig. 2 gives some idea of an extremely taking portable lamp in dead and polished brass, with silvered shell reflector and steel rods. The shade can be lifted off,

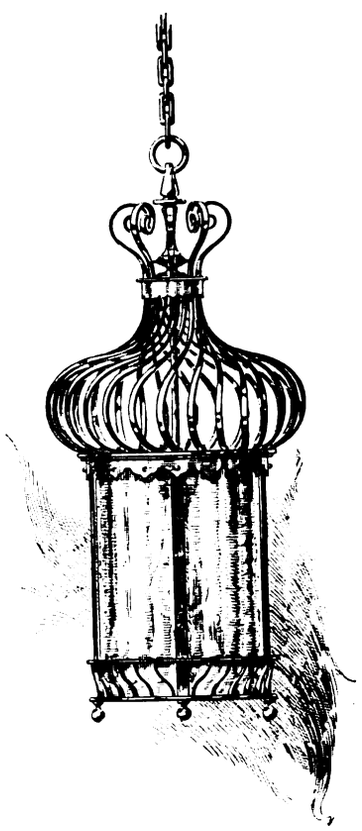

Fig. 3.

and the lamp swung round into the reflector, and the light can then be projected in any direction desired, the shell being capable of motion both around a vertical and around a horizontal axis. The brackets supporting the lamp and reflector can be moved up and down the rods as required, and by means of a stout spring can

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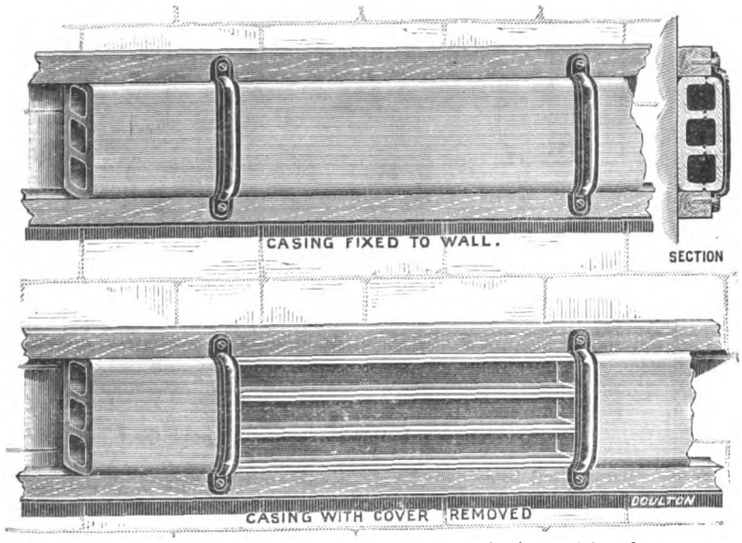
be made to rest in whatever position they are left, without any ado with screws. Fig. 3 shows a severe-looking lamp in "steel-bronze" of the type usually employed to light halls. We were also shown a moresque electrolier, of a pattern much used at "Constantinople in London." The openings in the pierced brass-work dome are filled in with ruby glass, and a lamp is hung right inside, whilst six lamps hang round the edge of the dome.

Messrs. Benham and Froud have, of course, a large variety of fittings, but limitations of space prevent our doing them full justice.

## STONEWARE CASING FOR INTERIOR WORK.

Messrs. Doulton, who have laid down so many miles of glazed stoneware casing for outdoor electrical purposes, have now devised a type of casing suitable for use *in* electric supply stations, or in other situations where electric cables of large capacity have to be carried inside buildings. The material being incombustible, impervious to moisture, and a non-conductor of electricity, is very much to be preferred to wood. The casing shown is of strong glazed stoneware, with three ducts, each 1in. by 1in. During manufacture a partial division of the substance is made longitudinally, leaving sufficient material to preserve strength. By means of a chisel the upper portion may be at any time detached. The two portions need not be separated until access is required to the cables. The illustrations show one method of fixing. The casing is placed




between two wood fillets, and the lengths are held in position by small cast-iron clips. Inspection of the cables can be made at any point by removing a clip and detaching the cover of one of the lengths. Buried in cement or concrete, this casing forms a permanent conduit in walls or ceilings.

## SOME ELECTRICAL FEATURES OF THE UNITED STATES BATTLESHIP "INDIANA."*

Of the several heavy-armoured battleships of the United States Navy, the "Indiana" is the most formidable, and in her design and equipment presents to the electrical as well as naval engineer the greatest interest.

On the mast we find installed two 24in. projectors or searchlights, one on the starboard, the other on the port side, each being furnished with an electrical control-stand, consisting of two small motors, one permitting of lateral train, the other of vertical. These motors are operated from a small platform above the bridge. The lights are rated at 20,000 c.p., and have horizontal carbons placed perpendicular to the Mangin or parabolic reflector according to which each is provided. The positive carbon, which is soft-cored and larger in diameter than the negative, has its crater towards the reflecting mirror. A small disc metal reflector perpendicular to and over the positive carbon also aids in reflecting scattered rays to the larger mirror. Two similar projectors are placed on the bridge deck aft and are operated from a platform under the bridge deck. Each projector is supplied with a Weston volt and ammeter as well as a rheostat, which are located in the dynamo room in a convenient position for the man in charge to handle. To the right of the bridge helm is the helm indicator, forming a part of the Fiske system of ship-telegraphs. It indicates the position of the helm at any instant, and is in principle merely a galvanometer, having its zero point in the central vertical position, and connected in parallel with a circuit such as shown in Fig. 1. Rigidly fastened to the rudder-post is a strip of resistance wire through which a current continually passes, produced by a drop across a resistance in the main lighting circuit. As the rudder moves a contact simultaneously slides over this resistance, which cuts in or out more or less of it, and therefore produces a corresponding change in the difference of potential at each indicator. These indicators are placed in various parts of the ship, and are illuminated each by a small incandescent lamp.

Directly in front of the bridge helm is the compass, of the navy ordnance pattern, and to the left of this (in Fig. 1) is the steering telegraph, the function of which is to telegraph to the steering

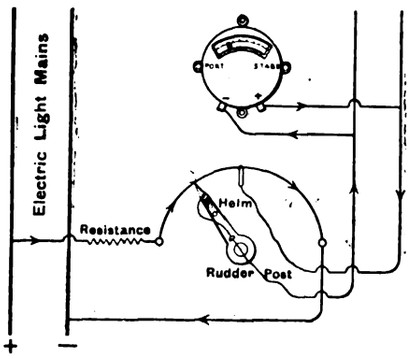



FIG. 1.—Connections for Helm Indicator.

wheels the position at which the officer in charge desires to have the helm placed. This transmitter, which is but one of several, is electrically connected to indicators secured in conspicuous positions near the steering wheels, and operated upon the same principle as the helm indicator just described. A diagram of the connections is shown in Fig. 2, where G represents the transmitters which are located on the bridge, directly under the bridge in the pilot house and directly under the pilot house and within the mast, called the conning tower. In fact, the entire management of the ship can be controlled from either of these positions, the latter, which is heavily

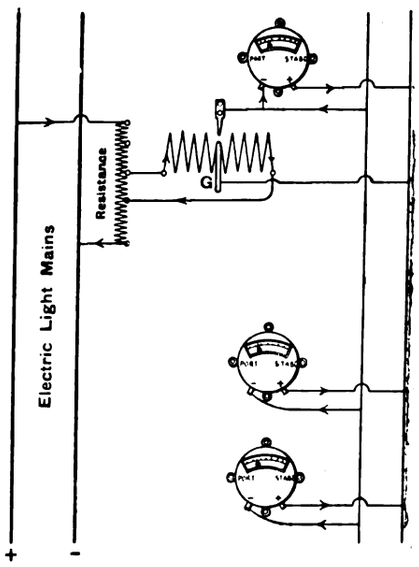



FIG. 2.—Connections for Steering Telegraph.

armoured, being used only in practice or an engagement. The movable contact of the transmitter G does not touch when in the central position, in which position it remains when not being used, so that any transmitter is independent of the others and may be used at any time. After the command has been given to set the helm at a certain position indicated by all of the steering indicators, the precision with which the man at the helm obeys is immediately recorded by a helm indicator placed near the former.

Fastened to the mast a few feet above the bridge is a speed and direction indicator, having a port and starboard needle, which are respectively operated by the port and starboard engine shafts. This indicator is for the purpose of telling in which direction the shafts are turning, and with the aid of a watch the number of revolutions

* From the *Electrical World* of New York, August 15th. Abstract.



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may be determined. In principle the indicator is exceedingly simple, being merely a polarised relay. It is operated by a toothed eccentric strap fastened to the shaft, and rolling on which is a small tooth roller (*see* Fig. 3). As the shaft turns the roller is shifted slightly, depending upon the direction of rotation, and at the same time raises at each turn a contact point which makes contact at either the right or left, thereby determining the direction of the current through the indicator at the bridge.

Another and far more important instrument to be found on the bridge is the Fiske engine telegraph. The function of this instrument is to signal to the engine room the desired speed and direction of the engines. Each engine has its transmitter and receiver, the transmitters being in one instrument and one receiver in each

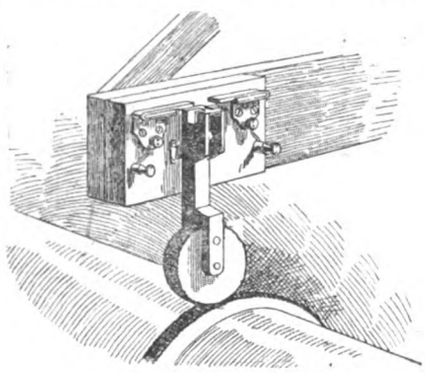

FIG. 3.—Shaft Contact Device.

engine room. The telegraph is operated on the Wheatstone bridge principle, as shown in Figs. 4 and 5. Both the transmitter and receiver have equal resistances arranged in an arc of a circle. The zero position of each instrument is vertical. It follows therefore that if the transmitter handle be moved over a given arc, it will be necessary, in order to balance the bridge, to move the receiver handle a corresponding amount. In series, with both the receiver and transmitter, are galvanometers, that on the former being a Weston instrument. After the transmitter handle has been thrown over, both galvanometers will deflect and will continue to do so until balanced at the receiver. Thus the officer giving the command knows immediately if his order has been received. The Weston

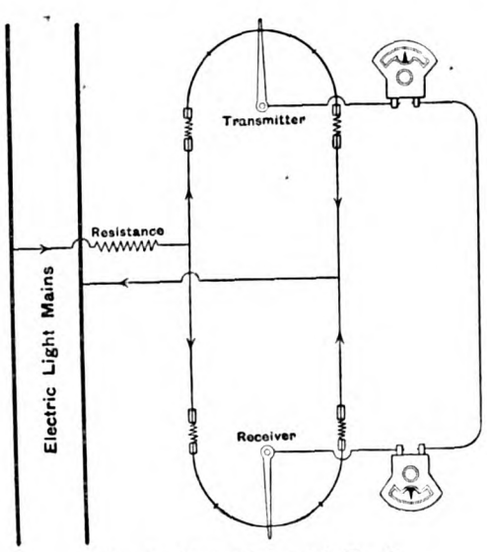


FIG. 4.—Engine Telegraph Circuit.

instrument, placed on the receiver, moves with the handle, and inasmuch as the needle is not balanced for all positions, it is necessary to have a second stationary galvanometer, shown at $g^1$, Fig. 6, to make more exact adjustments. This is done by shifting the handle and tapping the key K. Moving the arm of the transmitter over a very small arc automatically rings a 10in. gong located in the engine room, thereby attracting the engineer's attention. It will be seen in Fig. 5 that the engine telegraph has two handles. The two sides are duplicated, and transmit respective orders to the port and starboard engine rooms. Placed at each side is a small 1 c.p. lamp to illuminate the faces at night. The whole system is operated by taking a drop across the lighting mains. The graduations on both the receiver and transmitter correspond to revolutions per minute

There are two systems of night signalling used in conjunction with the electric lighting system. The truck light consists of a double lantern placed at the top of the mast, the upper half of the lantern being red, the lower white, in each half of which an incandescent lamp is placed. These lights are operated separately or together by means of a pulsating switch situated on the forward part of the mast on the top of the pilot house. This signal is for the admiral's use in squadron evolution.

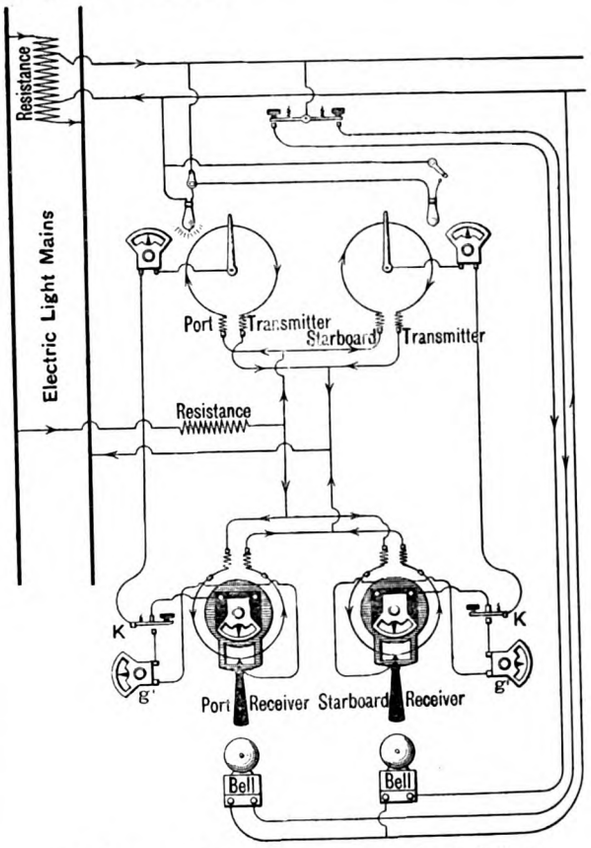


FIG. 5.—Complete Design of Engine Telegraph Circuits.

The second is called the Ardois signalling set, and is composed of four double lanterns, upper red, lower white, having Fresnel lenses. These lanterns are suspended by two wire jack-stays with connecting cross-arms, from the centre of which the lanterns hang, spaced 10ft. apart. The upper end of the jack-stays is secured aloft to a stay; and the lower end sets up with two turnbuckles, one on each leg. There is a cable containing a wire for

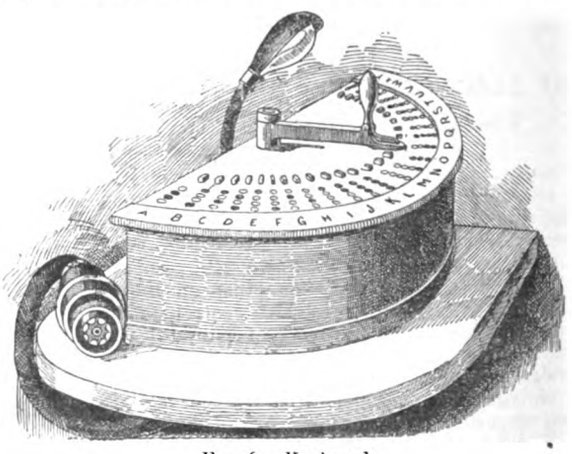

FIG. 6.—Keyboard.

each lamp with a common return, which is connected electrically to a keyboad (Fig. 6). The face of the board is divided into sections; each one of these sections is marked with the number and order in which the lanterns will burn when the key is moved to this section. These sections designate numerals, letters or sentences. By this system it is possible to form 64 combinations. The type of lantern used is shown in Fig. 7.

Passing from the bridge to the pilot house an addition to the instruments already described is one for automatically blowing the

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whistle at stated intervals. It is simply a clock arrangement operating an electric contact, completing a circuit, which in turn operates by means of a magnet a lever attached to the steam whistle. A telephone also runs from the pilot house to the "central station," where it is connected to the desired circuit.

The Fiske "Range Finder," one instrument of which is situated just above the bridge and the other on the bridge deck aft, 42⅔ yards apart, consists of two pedestals, on each of which is mounted a telescope with cross hairs, also an indicating instrument placed in the conning tower, consisting of a Deprez d'Arsonval type galvanometer, manufactured by the Weston Instrument Company. The graduations on the galvanometer are in yards. The observers at the two telescopes are connected by telephone with each other, and with the observer at the indicating instrument. The operation

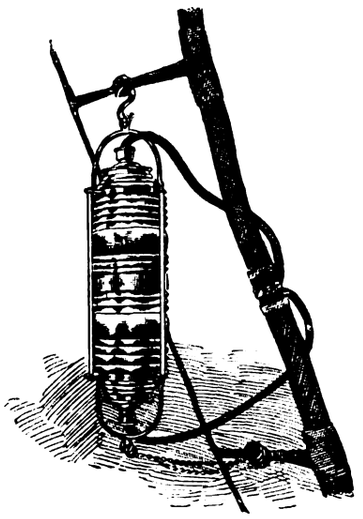

Fig. 7.—Ardois Lamp.

of these instruments is also based on the Wheatstone bridge principle; but instead of employing resistances in the form of arcs of circles, the resistance wire is wound upon cylinders, which, by means of proper gear, revolve simultaneously with the lateral movement of the telescopes. This method allows of correcting for inequalities in the resistance wires, which is done by moving the contact point perpendicular to the axis of the cylinder by means of a surface formed by elevating or lowering a series of pins the height of which is determined when testing the instrument. When the two telescopes are parallel, and the circuits are in correct adjustment, the reading instrument, located in the conning tower, points at infinity. An adjustable resistance is in series with the voltmeter, so that if the E.M.F. of the storage battery supplying the circuit changes, or the resistance of the indicator changes, due to temperature effects,

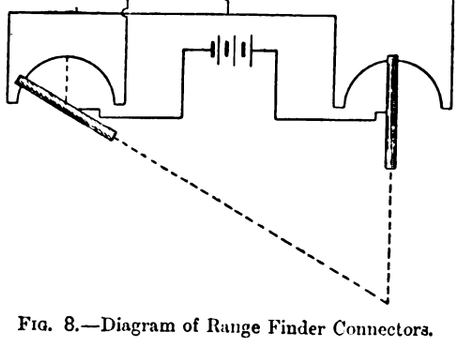

Fig. 8.—Diagram of Range Finder Connectors.

the same may be corrected. Upon pointing the two telescopes upon the same object the indicator needle is deflected and will indicate the distance in yards, the object is from a position on the base line half-way between the two instruments (*see* Fig. 8). Space will not permit of showing how the indicator is graduated, it being done, however, by a simple trigonometrical process. Similar range indicators are located at the various guns, the entire firing of which is directed from the conning tower.

The 8in. gun turrets have electrically operated hoists for lifting ammunition from the lower deck to the gun breech. These equipments were furnished by the General Electric Company. In the 13in. gun turrets two Lundell fan motors are used to blow the smoke out.

The dynamo and engine room contains three navy standard marine generating sets composed of three 24 kilowatt G. E. compound-wound dynamos, connected direct to three G. E. navy standard marine vertical double-cylinder engines. The units run at 400 revolutions per minute, and deliver each 300 amperes at 80 volts. The switchboard is designed for 22 circuits, 20 now being in use. There are two switches for the lighting circuits, four for search-lights and six for ammunition hoist motors. The switches are arranged so that each can be thrown on one of the three dynamos; the board is also provided with three parallel switches for throwing dynamos in parallel when necessary.

The ship is supplied with the necessary electrical testing instruments, consisting of one 20,000-ohm magneto, one Evershed testing set, comprising one portable hand generator and ohmeter. There is also supplied for testing one hand tachometer, one hand-speed indicator and three Tabor engine indicators.

There are 615 incandescent lights installed. The wire used for this work is of the navy standard, and was furnished by the Safety Insulated Wire and Cable Company, New York. Taking all the different sizes, there are about 7 miles of wire and about 3½ miles of wood moulding for the same. The wires are all in moulding and are very thoroughly insulated, being carried through rubber tubing at each beam, the beams being four feet apart and through water-tight stuffing tubes at each water-tight bulkhead or where the wires pass through decks.

There is a complete set of fire and water alarms throughout the ship. The electric thermostats consist of an iron thimble containing mercury and provided with a non-combustible fibre cork. Through the latter is a small screw passing down through a glass tube. By turning the screw the thermostat may be set for any desired temperature. Upon heat being applied to the thimble the mercury rises and makes contact, which indicates on an annunciator placed aft. The water alarm consists simply of a float which rises and completes an electrical circuit when the water in that particular department attains a certain height.

A telephone system, consisting of 24 Claymond telephones and a "central station," is one of the features. Speaking tubes with buttons and annunciators are run from all principal points to the central station and conning tower. The central station is located in the forward part of the protective deck inside of the armour belt.

The apparatus employed on the "Indiana," although at the time it was installed it was of the latest design, will be changed in several material particulars on Government vessels now under construction. From the foregoing description it will be seen that electricity now plays a most important *rôle* in modern naval engineering.

## ELECTRIC LOCOMOTIVE TRUCKS.*

The axles of an ordinary car truck are not driven, but the truck is hauled by a locomotive. Electric locomotive trucks have driving wheels, and therefore must be adapted to pull cars. This throws quite a different stress on the transoms, and necessitates a much stronger and more rigid construction. In order that the motors may be reversible and interchangeable, they must drive the axles at opposite sides of the truck; this produces a distorting stress tending to put the frame "out of square." In the trucks specially designed by the Baldwin Locomotive Works, of Philadelphia, to meet the demands of electric locomotive or motor car work, the transoms of the truck are provided with a substantial gusset to the side frame, and knees and brackets are introduced to hold the frame perfectly square and true, and enable it to withstand the distorting stress developed in the truck by the operation of the motors. Care is taken that the boxes and journals shall be of the proper form and size to adequate wearing surfaces, and that they shall be so fitted as to resist properly the shocks transmitted to them without being thrown out of line. The weight of the trucks and motors is supported on the journal boxes by means of suitable springs with limited range of motion. A swing bolster of improved design is introduced to carry the weight of the car; this is connected to the truck by suitable links, and provided with easy-riding double-elliptic springs.

For the purpose of gaining access to the parts of the truck, and for readily removing the wheels, axles and boxes, a swinging jaw may be arranged to form the outer pedestal leg. This is secured to the truck frame by a joint connection, and securely held in place by the pedestal-cap bolt. When desired, it can be lifted, and the released parts removed without taking the truck from under the car. The swing bolster and springs can be dropped down and taken out without disturbing any of the other details of the truck. The brakes are arranged without brake-beams, so as not to interfere with the removal of the swing bolsters or motors. The motor

* Abstract from the *Electrical Engineer* of New York.

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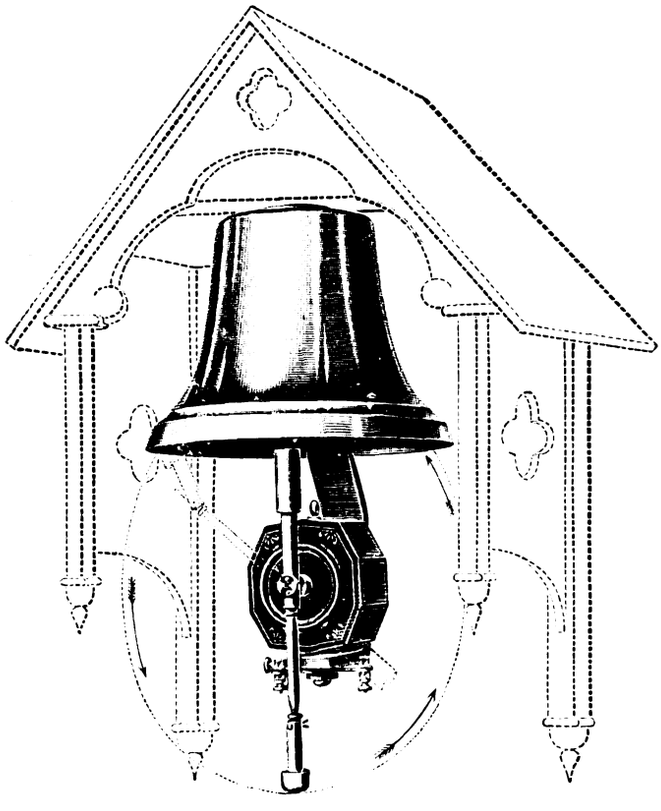
hangers are so placed that the motors can be dropped out of the trucks without brake-beams, so as not to interfere with the removal of the swing bolsters or motors. The motor hangers are so placed that the motors can be dropped out of the trucks without taking down the swing bolsters or the brakes, and without removing the wheels or axles. The workmanship in these trucks is equal to that in steam locomotive construction. All the bolts are turned taper to a driving fit in reamed holes, and all parts are well fitted with planed surfaces.

## GENERAL ELECTRIC "TURRET" MOTOR BELL.

The accompanying illustration represents the new "Turret" motor bell, made by the General Electric Company. The clapper of this bell moving in a complete circle each time the gong is struck, a great impetus is obtained, with the result that the blow is much heavier, and consequently a much louder ring is produced, besides which the time taken for the clapper to revolve gives the gong an opportunity of vibrating freely before it is again struck; so that a clear ring is produced instead of the discordant rattle so frequently heard from electric bells. The motor used is said to be absolutely reliable, and is quite enclosed in a cast-iron box with self-oiling bearings. The diameter of the gong is 10½in., and the



electromotive force required is 4½ volts and the current about 2 amperes. There is a form of "Turret" motor-bell suited to work with 60, 100, or 110 volts circuits. This should be very useful in country houses as burglar, fire, or other alarms; and is most convenient, as well as cheap, saving the cost and bother of batteries by working directly from the house mains.

## BOOKS RECEIVED.

"Lean's Royal Navy List." October, 1896. By Lieut.-Col. Francis Lean. (London: Witherby and Co.) Price 7s. 6d.

"Examples in Electrical Engineering." By Samuel Joyce. (London: Longmans, Green, and Co.) Price 5s.

"The Elements of Electro-Chemistry." By Max le Blanc. Translated by W. R. Whitney. (London: Macmillan and Co.) Price 6s.

"Annuaire de l'Association Suisse des Electriciens." By Dr. A. Dengler. (Zurich: Jacques Bollmann.)

"The Light Railways Act, 1896." By Evans Austin. (London: Reeves and Turner.) Price 5s.

"Professional Papers of the Corps of Royal Engineers." Paper III., Vol. I. By Capt. W. W. Baker, R.E. (Chatham: W. and J. Mackay and Co.) Price 4s. 6d.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October 2, 1896.*

**Dr. Louis Duncan's Presidential Address to the American Institute of Electrical Engineers.**—After a season of rest the American Institute of Electrical Engineers resumed its regular monthly meetings on the evening of September 23rd. Dr. Louis Duncan, the President, occupied the chair, and delivered his inaugural address, the subject of which was "The Present Status of the Transmission and Distribution of Electrical Energy." Dr. Duncan condemned the present practice of installing a number of stations for the distribution of energy for power and traction purposes, preferring a single centrally or favourably-located station, and the adoption of the "booster" system, to serve more distant territory. He also favoured the use of storage batteries, supplied by the "boosted" current, for centres of secondary supply in outlying districts. A radius of ten or twelve miles could be easily supplied by the "booster" system alone; but for suburban lines he thought that the "booster" and the storage battery combined would give better results. The use of high potential alternating currents for transmission, with rotary transformers at local points, with or without storage as an adjunct, was a method full of promise. Regarding the cost of copper for the transmission of energy he gave some comparative figures. Taking the cost of copper for direct currents as a basis and representing it by 100, the cost for a simple alternating current would be represented by 200, that of the two-phase current by 200, and the three-phase by 250. The direct current, he stated, had the advantage that no losses ensued by induction effects, but its voltage could not be changed by stationary transformers. For power purposes a simple alternating current was yet of little value, for the reason that no self-starting motor had yet been invented. The three-phase current was considered better for transmission purposes, and the two-phase for distribution. Regarding the long-distance transmission of power for railways, he had some doubts as to the outcome. To accomplish such a result it would be necessary to utilise high-potential alternating currents, feeding rotary transformers, located at frequent intervals along the line.

**Standardising Incandescent Lamp Bases.**—Mr. Frederic Nicholls, President of the National Electric Light Association, has arranged a meeting of manufacturers and central-station men to discuss the question of standardising incandescent lamp bases and sockets. The subject is one that is recognised as an important one in the trade, and it is hoped that this organised effort to bring about the reform so much desired will result in something tangible.

**The United States v. La Compagnie Française des Câbles Télégraphiques.**—On October 1st the United States District Attorney filed in the office of the Clerk of the United States Circuit Court a bill of complaint in a suit brought by the United States against La Compagnie Française des Câbles Télégraphiques, the United States and Hayti Telegraph and Cable Company, and the United States and Hayti Cable Company. The complaint alleges that the defendant companies are combining and conspiring together for the purpose of monopolising a part of the trade and commerce between the United States and the several States thereof and foreign nations, to the irreparable injury of the people and business interests of this country, An injunction is asked to prevent the defendants from carrying out their alleged unlawful agreement, and from establishing their connecting cables on the shores of the United States. The details of the case in brief are as follows:—The Compagnie Française des Câbles Télégraphiques is the successor in interest of companies heretofore known as the Compagnie Française du Télégraphe de Paris à New York, the Société Française des Télégraphes Sousmarins, and of other French companies, in the ownership of certain transatlantic cables, and of certain submarine cables in or between several islands of the West Indies, and of other lines of cables extending from these islands to several South American

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countries. The successor Company owns a system of submarine cables connecting Cuba with Hayti, San Domingo, and other of the West Indies, together with South American lines. These cables were laid under concessions from the various countries concerned, giving the Company exclusive right to land and operate them between those countries and the United States for periods of from 25 to 60 years from the dates of concessions, which were granted between 1888 and 1890. By reason of these concessions no American companies or citizens are permitted to land lines of submarine cable in those countries. The Compagnie Française des Câbles Télégraphiques, which was organised under French laws on July 2, 1895, entered into an agreement with the French Government in December of that year to operate within two years a cable connecting the West Indies cables. It also agreed to lay a new cable line from Brest to a point near Cape Cod, Mass. The cable company and its predecessors had been endeavouring for years to land a cable on the shores of the United States, but they could not obtain the permission of the United States government except on condition that the French Company should surrender its cable monopoly between the United States and the West India islands and South American countries. For the purpose of evading this obstacle, it is charged in the bill of complaint that the Compagnie Française des Câbles Télégraphiques entered into an unlawful agreement with the other defendant companies to secure direct communication between the United States and the West Indies and South American systems. The United States and Hayti Cable Company was organised in February, 1895, in West Virginia, its incorporators being John W. Mackay, George G. Ward, Albert B. Chandler, and others well known in the cable world. It is charged in the bill of complaint that this Company was organised in the interests of the French Company for the purpose of laying a few miles of cable from Coney Island out to sea which could be connected with the West Indies and South American cable systems. The purpose of this action, it is claimed, was to enable the French Company to escape the conditions and maintain its monopoly and exclusive concessions, at the same time fulfilling its contract with the French Government, and earning the subsidy which the French Government has agreed to pay the cable company. Ten miles of cable were laid from Coney Island July 9, 1895, and about that time the United States and Hayti Telegraph and Cable Company was organised under the New York State law, with practically the same incorporators as the Company above named. This latter Company had for its purpose the building of a telegraph line from New York City to Coney Island to connect with the Hayti cable, all of which, it is alleged, was to assist the French Company to achieve its unlawful object. In this connection it is interesting to note that on October 1st the cable steamer "Seine" arrived at Hampton Roads for coal, having on board 1,100 miles of cable, which will be laid between New York and Turks Island. This steamer is one of the two engaged by the French Company to lay the cable connecting the United States and the West Indies.

## CORRESPONDENCE.

### THE SEAT OF E.M.F. IN A CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Everyone with a liking for science has the greatest respect for Dr. Lodge. I go even farther; and when he tells us facts about objective ether and molecules and the movement of the thing energy with a cock-certainty about the unknowable that would do credit to an archbishop, I revere him. But I do not think the seat of the electromotive force comes under this head. It seems to me a matter of definition. If you define the seat of the electromotive force as the place where energy enters the electric circuit, then the place where energy enters the electric circuit is the seat of the electromotive force. It needs no pump analogies to make that clear. If Dr. Lodge supposes I mean that the energy given out as heat at a resistant part of the circuit is not paid for by chemical, heat, or mechanical energy, he has misunderstood me. Even if it has all decayed, except a definition skeleton, I don't want to exhume Dr. Lodge's seat of electromotive force from consecrated ground merely to rebury it at cross-purposes roads with a mistake through it.

I have some dim, and evidently only fancied recollection that at some discussion on Dr. Lodge's ubiquitous Paper, some twelve years ago, Prof. FitzGerald said it was a matter of definition. Whether he meant as to how the work done by a unit of electricity going from one substance to another is to be considered, or as to the seat of electromotive force being the sink of energy, does not matter, because he cannot really have breathed such a suggestion. All the same, I fear that some recalcitrant electrolytical curate may some day break away from pump analogies, and may want to trace the flow of energy through the medium to the place where the work comes out of the system, and that he may work from a circuital and cyclic standpoint. Such a proceeding would, I feel sure, shock Dr. Lodge very much, and I hope he will at once write him a nice gentle pastoral letter, giving the Cambridge undergraduate's explanation of the common pump as containing the whole philosophy of the matter.

Though it is a mere side issue, when Dr. Lodge was fixing the seat of the electromotive force I raised an objection to the air or oxygen theory of the Volta effect, that as air is not an electrolyte, incipient oxidation, by direct combination, cannot charge zinc. In modern language there are no charged atoms or ions to give up their charges. So far as I see, this is a good objection.

I do not know what text-books Dr. Lodge refers to. There appear to be some which grieve him. I have neither read nor written them. In short, it is quite open to any one to consider the cell circuit from the pump and pipe points of view, or to treat it as a case of cyclic potential, or to start up with a salt, and trace its change into charged atoms, and to examine the doings of the charged atoms, and to trace the energy across country to a resistant part of the circuit. He may even say that it goes in there and comes out at the same place, and that no work is done by a unit of electricity going through the resistance, that being only a coincident condition. All these have nothing to do with the phenomena of the case, and each view could be worked out perfectly consistently with the phenomena and itself. It would merely come down to a question of definition; but the advantage of different treatments is that they give different points of view, so that the phenomena may be finally more clearly seen.—Yours, &c.,

JAMES SWINBURNE.

### PROF. SILVANUS THOMPSON'S SUGGESTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Equally with yourself, I have "no wish to travel over old ground again" with regard to the history of the Institution of Electrical Engineers. Many things have happened since then; and cable engineers, at any rate, were under the pleasing impression that their agitation had justified itself by results.

Be this as it may, the mild protest which I entered against the proposal of Prof. Silvanus Thompson has the hearty support of all the telegraph people I have since met; and if there were no other objection to the "Bright proposal," it is sufficient to remember that only one of the three gentlemen whose names and memory it is desired specially to commemorate ever had any connection with the Institution, and the treatment he received at the hands of the Council is still fresh in the minds of the cable fraternity.—Yours, &c.,

W. T. ANSELL.

Winchester House, E.C., October 13, 1896.

### A TELEGRAPHIC JUBILEE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It has just occurred to me that it might possibly interest some of your readers to be reminded that in the year 1846—now just a jubilee 50 years ago—on the opening of Parliament, the "Queen's speech" was telegraphed for the first time to about a dozen towns in the Midlands and north of England, for the purpose of publication in local newspapers the same afternoon.

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In those days the telegraph north of London commenced at Rugby; and, therefore, the "speech" had to be conveyed to that station from Euston by "special" engine. On its arrival there it was at once telegraphed to Derby, where it was repeated on to Normanton, from whence it was despatched to York, to be again repeated to Newcastle and the North.

George Hudson—then Lord Mayor of York (and "railway king" besides)—took considerable interest in the matter, and, with several other notabilities of York, was present to witness the accomplishment of what at that time was thought to be little less than a miracle; and one present called it the "inauguration of the coming great telegraph era."

The arrangements for carrying out this event were completed by Mr. Culley for the southern portion of the system, and by myself for the northern lines telegraphed over. The "speech" arrived at York about 4 p.m., and a few minutes only elapsed after the last bit of "copy" was sent off, and it was cried in the streets by a host of boys as "extra speshul."

It is hardly to be expected that many persons will attach importance to the above incident; but for personal reasons, and just because the present date completes a recognised cycle of time—half a century—I thought it might be worth the telling to some of your younger readers; and even some older ones who know all about it, perhaps, would not be annoyed at being reminded of something that happened in their hey-day, fifty years ago.—Yours, &c., J. W. WILKINS.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]*

**SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d.; abroad 9s.**

**The New Edition for 1897 is in active preparation, and circulars and full information will shortly be forwarded. The Subscription price remains 5s., postage 9d.; abroad, 6s. 6d., post free.**

### NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A Fleming, M.A., D.Sc., F.R.S. *The New Edition is now ready.* Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

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"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d., post free.

TENDERS INVITED.—Particulars will be found in our advertisement columns of tenders required by the Town Council of Torquay for the supply and erection of plant, &c., at the electricity works which are about to be erected. Specifications, &c., can be obtained from Mr. W. H. Trentham, consulting engineer to the Council, 39, Victoria-street, London, S.W., or of Mr. Fredk. S. Hex, the Town Clerk, Town Hall, Torquay, to whom tenders have to be sent in not later than 3 p.m. on Tuesday, Nov. 3.

——— The borough electrical engineer of Bradford (Mr. Alfred H. Gibbings) invites tenders for 117 Aron, 86 Frager, 24 Edison and 21 Oulton-Edmondson electricity meters. Lists giving details and capacity of the meters may be obtained from the Electricity Office; and tenders should be sent in to Mr. Gibbings, Town Hall, Bradford. Further particulars appear in our advertisement columns.

——— The Directors of the Great Western Railway invite tenders for the supply of a quantity of stores, from Dec. 1 next to Nov. 30, 1897. The stores required include:—Telegraph instruments, telegraph apparatus, copper wire, G.P. wire, &c., telegraph iron-work and tools, telegraph drysalteries, carbons for electric light, india-rubber goods, telegraph poles and yellow pine, iron pipes, iron and steel tubes, &c., &c. Samples and patterns may be seen at Swindon from Oct. 12th to the 23rd, and specifications and forms of tender may be obtained at the Office of the Stores Superintendent at Swindon. Tenders must be sent in addressed to the Secretary, Mr. G. K. Mills, Paddington, London, not later than Monday, 26th inst.

——— By command of the Postmaster-General, tenders will be received until 10 a.m. on Monday Oct. 26th, for the supply of red fir poles and for creosoting the poles. Full particulars can be obtained of Mr. Chas. E. Stuart, Controller of Stores, General Post Office, London, E.C.

——— The Town Council of Monmouth invites tenders for the supply and erection of turbines, alternators, steam engines, boilers, electric motors, electric lighting mains, &c. Tenders by 12 noon on Nov. 2.

——— Tenders are invited for electric lighting, heating and cooking plant for the Victoria Hotel, Wolverhampton. Specification on application to the Secretary (Mr. Thomas J. Barnett), 25, Darlington-street, Wolverhampton.

——— The Spanish Minister of Marine invites tenders for the laying of a submarine telegraph cable between the islands of Luzon, Panay, Negros, and Cebu (Philippine Islands). Provisional deposit, £2,000; definite deposit, £4,000. All particulars from the Ministerio de Ultramar, Madrid. Tenders by Dec. 13.

——— Tenders are invited by the French Post and Telegraph authorities for the supply and laying of a 4-conductor submarine telephone cable between France and England. Tenders to the Sous-Secrétariat, d'Etat des Postes et des Télégraphes, 103, Rue de Grenelle, Paris, by 20th inst.

——— The Société Nationale des Chemins de Fer Vicinaux invites tenders for the electrical equipment of about 14 miles of suburban railway at Charleroi and elsewhere, on the overhead trolley system. Particulars from the Company, Rue de la Science, 26, Brussels. Tenders by Oct. 28.

——— The Belgian State Railway authorities invite tenders for the supply of 81,130 metres of arc lamp carbons. Tenders to be sent to La Bourse, Brussels, by 21st inst.

TENDERS ACCEPTED.—On the recommendation of the Works Committee the Mile End Guardians have accepted the tender of Mr. Fyfe for installing the electric light at the various establishments of the Guardians at £4,087. 10s.

——— The Cheltenham Town Council has accepted the tender of Messrs. Hardy and Padmore, of Worcester, for the supply of 20 arc lamp pillars, according to design, for the Promenade, at £12. 17s. 6d. each.

——— The Guardians of the Wandsworth and Clapham Union have accepted the tender of the Private Wire and Telephone Installation Company for a large telephone installation to be fitted in their new premises at Tooting. Magnetic ringing instruments are to be fitted throughout, with Hunning's transmitters. The wiring is to be on the "Intercommunication" system.

——— The Armagh Asylums Board has accepted the tender of Messrs. Cox Walkers for installing the electric light at the Asylum, for £1,070.

——— The County Antrim Asylum Board has accepted the tender of Messrs. Wm. Coates and Son, Belfast, for supplying electric lighting plant, and for wiring the County Asylum, at £3,210. The engines will be supplied by Messrs. Victor Coates and Co., of Belfast.

APPOINTMENT.—Out of 24 candidates for the position of canvasser to the Shoreditch electricity supply department, Mr. H. D. Crombie has been selected. The salary is £2 per week.

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APPOINTMENT.—Mr. G. D. Aspinall Parr has been appointed assistant lecturer and demonstrator of technical electricity at Yorkshire College, Leeds. Mr. Parr was formerly demonstrator and assistant lecturer at the Currie Technical College.

APPOINTMENTS VACANT.—The Council of Mason College, Birmingham, invite applications (which must be sent in by 24th inst.) for the appointment of demonstrator in engineering. Some further particulars appear in our advertisement columns.

——— There is a vacancy at the City and Guilds Central Technical College for an assistant with a good knowledge of mathematical and experimental physics. Salary £150 per annum. Applications to Prof. Ayrton, Central Technical College, Exhibition-road, London, S.W.

——— The Shoreditch Vestry requires a resident electrical engineer. Salary £250 per annum. Applications to be sent in by 9 a.m., Friday, 23rd inst., to the solicitor and clerk to the vestry, Town Hall, Old-street, London, E.C.

——— The Gas Committee of the Borough of Salford requires a switchboard attendant. Salary 35s. per week. Applications to the Gas Engineer, Gas Offices, Bloom-street, Salford, by 5 p.m. on Friday next.

DISSOLUTIONS OF PARTNERSHIP.—The partnership between Mr. William Emil Conze and Mr. Philip Fred. Wm. Simon, electrical engineers, 52, Queen Victoria-street, London, E.C., has been dissolved. Mr. Simon will carry on the business under the old style.

——— Messrs. George James Sheridan Lock, Harold Moultrie Lock, and Edward Charles Harold Tiffin, trading as electrical engineers and manufacturers of electrical fittings, at 17, Berners-street, London, W., under the style of Moultrie and Co., have dissolved partnership. Debts by Mr. G. J. S. Lock, who continues the business under the old title.

BUSINESS NOTICE.—Messrs. H. R. J. Burstall and E. W. Monkhouse have commenced business as consulting engineers at 14, Old Queen-street, Westminster, London, S.W. Mr. Monkhouse will be remembered as the energetic and successful resident electrical engineer to the Corporation of Edinburgh, and Mr. Burstall has acted for some time as principal assistant to Prof. A. B. W. Kennedy. The new firm, therefore, starts with every element of success.

REMOVALS.—The London offices of Messrs. Alex. Shanks and Son (Limited), steam engine makers, Dens Ironworks, Arbroath, N.B., have been removed from 110, Cannon-street, to Bush-lane House, Bush-lane, Cannon-street, E.C.

——— The Birmingham Installation Company have removed from 28 Broad-street to 18, Arcade-chambers, Corporation-street, Birmingham.

——— Messrs. Ernest Scott and Mountain (Limited) have removed their London office to 20, New Bridge-street, E.C.

BANKRUPTCY.—In the bankruptcy of F. L. Woillard-Rigg and H. E. Scarborough, trading as Woillard, Scarborough and Co., electrical and mechanical engineers, at Wade-street, Halifax, the trustee (Mr. Thomas England, official receiver, Town-hall Chambers, Halifax) has been released.

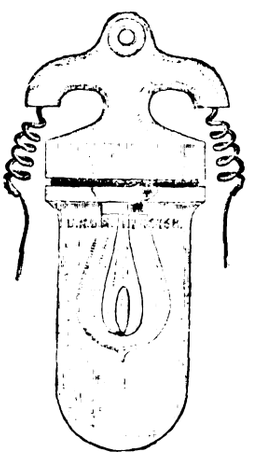
LIQUIDATION.—A general meeting of the members of the Val d'Aosta Electric Power Company (Limited) will be held at the offices of the Company, 32, Victoria-street, London, S.W., on Nov. 11th, to have an account laid before them of the winding up of the Company. Mr. A. L. Snowdon is liquidator.

IMPROVED GLOW LAMPS.—In our issue of May 17, 1895, we referred to the economy, illuminating power and durability of the patent incandescent lamps manufactured by Messrs. E. Goossens, Pope and Co., whose representatives were Messrs. Pope, Boddy and Co., of 26, Pall Mall, Liverpool. The success which has attended the sale of these lamps has necessitated some modifications of the arrangements at Liverpool; and it has been decided for the manufacturers to themselves conduct in future the lamp business at 26, Pall Mall, in order that consumers may be in direct touch with the manufacturers of the lamps. Clients are therefore requested to direct their orders and other communications to Messrs. E. Goossens, Pope and Co. Recent improvements in these lamps have special application to the caps. Where plaster was previously used there is now an air-space, which gives a perfect insulation. The lamps are by this means kept cooler when burning, the glass is saved from cracking at the leading-in wires, and the caps are quite damp-proof. This is claimed to lengthen the life of the lamps, and prevents the risk of short circuits or loss of current.

"JANDUS" ARC LAMPS.—There is now issued a useful catalogue of arc lamps by the Jandus Arc Lamp and Electric Company (Limited), for whom Messrs. Drake and Gorham act as sole agents. The list is neatly printed, and shows the "Jandus" lamp in actual use under differing conditions, including outside shop lighting, street lighting, &c.

RADIOGRAPHIC APPARATUS.—The General Electric Company have sent us a copy of their list of electrical apparatus for X-ray work. Prices and particulars are given of Ruhmkorff coils, primary and secondary batteries, focus-tubes (Jackson type), and stands for same, besides fluorescent screens, &c. On page 3 there is a useful detailed table, showing at a glance what form of battery is most suitable for any coil.

AIR- AND WATER-PROOF LAMPGUARDS.—We have received from Mr. F. W. Ostermann, of 27, Leadenhall street, E.C., a well-made and effective air- and water-proof lampguard for use in places where condensed water is present, in battery rooms, chemical works, mines, tunnels, and, in fact, wherever the fittings of an incandescent lamp require protection from surrounding influences. The illustration herewith gives a very good idea of the construction of



this device, which is extremely simple, and with a minimum of labour can be made to effect every purpose for which such a guard is required. For underground railway lighting and ship work quantities of these lampguards have been sold. The guard is supplied with screw holder or nipple for bayonet lamp holder.

POCKET MEMO. BOOK.—A very handy and useful little pocket companion of E.C.C. plant and apparatus is issued by the Electric Construction Company, of Dashwood House, New Broad-street, E.C., and Bushbury, Wolverhampton. The book contains particulars of the special features of E.C.C. plant, prices of accessories and other information in a form for ready reference. The particulars regarding switchboard arrangements for accumulator installations are illustrated. 50 pages of sectional paper, neatly indexed, occupy the centre of the book, followed by some useful everyday tables.

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AYR.—From the statement submitted at the last meeting of the Council the capital expenditure to date on the electric lighting undertaking amounted to £23,612. It was reported that the demand for current was so great that it would be necessary to at once put down additional plant. The Electric Lighting Committee was authorised to enter into the necessary contracts; and the Clerk was instructed to apply to the Secretary for Scotland for power to borrow an additional £5,000 for the purpose.

BLACKBURN.—A Local Government Board inquiry was held on Tuesday into the application of the Town Council to borrow a sum of £28,000 for electric lighting and £10,000 for electric traction purposes. The Town Clerk (Mr. R. E. Fox) appeared in support of the application, while technical details were given by the consulting engineer, Mr. E. M. Lacey. When the station was opened in Feb., 1895, there were 32 customers, representing an equivalent of 3,129 8-c.p. lamps, and at the end of the year the figures had increased to 121 customers and 5,915 lamps. This rate of increase had been kept up during the present year, and it had been estimated that by the end of 1897 they would have a demand for an equivalent of 20,000 lamps. Dealing with the question of electric traction the Town Clerk stated that this matter had been very carefully considered by the Corporation and the Tramways Company. The tramways had been laid by the Corporation, under the powers of the Blackburn Improvement Act (1882), and were leased in 1891 by the Corporation to the Company for 21 years. It was proposed to supersede the two horse sections only with electric traction, the overhead system having been selected. The Tramways Company had arranged to pay the Corporation a certain price per unit, whilst the basis of cost to the Company was 3d. per car mile for power only. There was no opposition.

BOOTLE.—Electric lighting matters have advanced a step in Bootle. Some time ago the Watch Committee, to whom the question was referred, consulted Mr. T. L. Miller, of Liverpool, with a view to formulating a scheme. Circulars were sent out to probable consumers of electric current, and as a result of the replies received, Mr. Miller recommended the putting down of plant for about 4,000 8 c.p. lamps alight at one time, or 6,500 lamps connected to the mains, with the usual spare plant. The entire cost

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of buildings, plant and mains was put at £21,000, and the first year's revenue at £1,156. In the event of street lighting being adopted it was recommended that a start be made by laying mains within the area lying eastward of Stanley-road between Balliol-road and Merton-road as far as Fernhill-road, and westward of Stanley-road between Balliol-road and Strand-road as far as the London and Yorkshire Railway. After examination of these proposals the Committe reconmended that the supply of electrical energy for lighting and motive power purposes should be kept in the hands of the Council and not delegated to a Company; that the Council should resolve to put in force its powers under the Bootle Provisional Order; that the Committee be authorised to select a site for a generating station, recommend the system of supply, fix the area within which the supply should be given, determine whether and to what extent electricity should be used for street lighting, obtain tenders for the plant required, ascertain the capital sum which the Council would have to borrow for the scheme, and that for these purposes the Committee be empowered to obtain such expert assistance and advice as may be required. At Wednesday's meeting a lengthy debate arose on the motion for the adoption of the report, Councillor Brewster stating that wherever electricity works had been established the development of electricity and gas went forward together, and were of mutual assistance to one another. Ultimately the report was adopted.

BRADFORD.—The Gas and Electricity Committee has now entered into possession of No. 204, Swan-arcade, where a stock of electrical appliances will be kept for exhibition purposes. This course has been adopted, it is urged, in order to encourage the use of electricity for lighting and motive power purposes within the borough. The Committee has also decided to lay an additional cable in Kirkgate at a cost of £1,400.

CHESTER.—It has been resolved to wire the Town Hall, Public Market and Annexe, and Free Library for the electric light. The tenders sent in for wiring the Town Hall ranged from £473 to £772.

COMBE DOWN (BATH).—Owing to the refusal of the gas company to lower their rates, an effort is being made to form a syndicate for the purpose of establishing an electricity generating station to supply current for public lighting.

CORK.—As stated in our last issue, the City Council has determined to transfer its Provisional Order to the local Electric Tramways Company. In reply to the recently-issued advertisements inviting offers for the Order, two proposals were received—one from the Cork Electric Tramways Company, and the other from the County of London and Brush Provincial Company. On the advice of the consulting engineers (Messrs. Kincaid, Waller and Manville), to whom these proposals were referred, the Council decided to accept the tender of the local company, as their proposals were considered to be more suitable than those of the County of London and Brush Provincial Company, while the capital to be expended was one-third greater. The terms of the agreement provide that the Company shall supply electric current for public lighting for 21 years at 2½d. per unit, including renewals of carbons and lamps. The Company also undertake to reduce the price of current for private lighting ¼d. per unit for every 1 per cent. over 7 per cent. dividend paid to the Company's shareholders, the minimum price to be 4d. per unit, and that the Company be entitled to set aside a sum not exceeding 10 per cent. of the profits for a reserve fund, and 1 per cent. on the amount of the capital for a sinking fund.

DARWEN.—The Electric Lighting Sub-Committee has just presented a report to the General Purposes Committee, advising that electric lighting powers be at once obtained. The Consulting Engineer (Mr. E. M. Lacey) puts the initial cost of an electric lighting installation at £15,645.

DUNBLANE (N.B.).—The present price of gas in this district is 5s. 10d. per 1,000, and a consulting engineer has been called in by the leading tradesmen to prepare a report upon electric lighting matters.

DUNDALK.—Mr. F. J. Warden-Stevens urges the Town Commissioners to keep the electric lighting powers in their own hands, to establish an electricity station for lighting and traction purposes, and to enter into an arrangement with the Tramways Syndicate to supply electric current. A Committee has the matter in hand.

ELECTRICITY IN MINING.—The Buffelsdoorn Estate and Gold Mining Company has recently received from its consulting engineer, Mr. G. W. Starr, a report concerning the engineering work done in connection with the mining operations at the Company's mines in South Africa. An extensive electrical installation is included in the work, and is approaching completion. It is to include generators and motors for transmitting power for the elevators, pumps, and other apparatus round the mine, together with a very efficient lighting plant, more than capable of supplying current to the 900 incandescents and 12 arcs already installed. The miners' quarters (married and single), staff quarters, managers' house, mine buildings, cyanide works, compound, &c., and the ground surrounding the principal buildings where night work will be required are to be lighted electrically, as well as the underground shafts and stations. The engineer affirms that this will prove one of the finest electric lighting installations erected in these gold fields.

ELECTRIC RAILWAYS IN AMERICA.—New York advices state that a corporation is being formed which will undertake the equipment of the Manhattan Elevated and Metropolitan Traction Railroads with electric motors, from which considerable savings are anticipated in operating expenses.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from October 7th to October 13th, with the ports of destination:—

*Australasia*—Auckland, £46; Fremantle, £153 (telegraph material); Melbourne, £62 (telegraph material); Nelson, £38; Perth, £720 (telegraph material); Sydney, £589; Wellington, £225. *Belgium*—Antwerp, £820 (including £670 electric fuses); Brussels, £362. *Brazil*—Porto Alegre, £30 (telegraph material). *Chili*—Boca, £64 (telegraph material). *China*—Macao, £32 (telegraph material); Shanghai, £23 (telephone stores); Tientsin, £453 (including £126 telegraph material). *Ceylon*—Colombo, £118. *Germany*—Hamburg £280 (including £270 telegraph material); Stettin, £80. *Holland*—Amsterdam, £160; Flushing, £21. *Hong Kong*, £309 (including £49 telegraph material). *India*—Bombay, £18; Calcutta, £326. *Kilindini*, £4,745 (telegraph material). *Portugal*—Bevia, £1,300 (telegraph material); Lisbon, £500. *South Africa*—Cape Town, £527; Durban, £232; East London, £2,059; Port Elizabeth, £108. *Spain*—Bilbao, £80; Vigo, £83,000 (telegraph cable). *Straits Settlements*—Singapore, £22 (telephone material). *Sweden*—Stockholm, £171. Total, £97,675.

*Foreign manufactured Electrical Apparatus and Material.*—Foreign made goods have been re-exported as follows:—

*Australasia*—Rockhampton, £80. *Sweden*—Stockholm, £27 (telephone apparatus). Total, £107.

EXHIBITION.—In the 1897 Stockholm Exhibitions section will be devoted to engineering, electricity, science, building industry, machinery implements, shipbuilding and navigation, education and instruction, and scientific appliances, &c. The machinery hall will be situate at Saltsjon, will be built of iron and glass, and have an area of 100,000 sq. feet. There will be three large halls for Sweden, Norway, and Denmark, and smaller buildings for other countries.

FIFE.—At a meeting at Cupar of sub-committees from the County Council, it was unanimously agreed to recommend that the county should establish an independent telephone system at an estimated cost of from £1,500 to £2,000.

GLASGOW.—The *Glasgow Herald* has recently placed before its readers some interesting particulars relating to tramway matters in the United States, with the object of educating Glasgow citizens as the best means of traction for their city—so far as the conditions prevailing in the States apply to Glasgow.

GREAT YARMOUTH.—The charge for current for motors and for cooking and heating purposes has been reduced to 4d. per unit The income of the electricity department for the past month was £314, and after payment of station expenses, &c., there was a balance of £141. 12s. 5d., to meet capital and sundry charges of £130 per month. At present there are 188 customers connected to the Corporation mains, representing an equivalent of 9,279 8 c.p. lamps.

HAMMERSMITH (LONDON).—At the next meeting of the Vestry it will be proposed that a deputation be appointed to wait upon the Metropolitan District Railway Company to urge upon them the desirability of extending the electric railway proposed to be constructed between the City and Earl's Court to Hammersmith.

HAMPSTEAD (LONDON).—The insurance society with whom the Vestry effects the insurance of the electricity supply works has notified that in accordance with the instructions from the Fire Offices Committee, the insurance rate for the building and contents, exclusive of dynamos, would be increased from 5s. to 10s. 6d. per cent., thus raising the total annual premium from £53. 10s. to £89. 5s. After some discussion it was agreed to effect the insurance of the station for the coming year at the increased rate; but the insurance society's letter was referred to the Finance Committee, with instructions to report on the whole question.

HARTLEPOOL.—The gas in this town is, to say the least, indifferent and an offer, submitted by the local Electric Tramway Company, to supply current for lighting the town, has been discussed by the Town Council. It has been decided to apply for a Provisional Order.

JAPAN.—In a report from the British Consul at Tokio, on the foreign trade at Japan for the first six months of 1896, he points out that amongst the various kinds of machinery imported into Japan dynamo-electric machines stand out with special prominence, the value reaching $427,666. This, in the Consul's opinion, indicates, together with the importation of spinning machinery, the direction of Japanese industrial activity at the present time. He further points out that Kyoto is already provided with electric

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tramways in working order, and that most large cities of Japan have electric traction schemes approaching realisation. A line from Kobe to Yuyama, near the hill resort Arima, is projected. Nagoya and Yokohama have each a plan or plans. In Tokio electric tramways are only to be permitted as a municipal concern, and progress has been retarded by a recent refusal of the City Council to allow the utilisation of the headwaters of the Tamagawa for the generation of motive power, on the plea that the town water supply might suffer contamination.

JOHANNESBURG.—A telegram from the French Bank of South Africa states that the application of the Johannesburg Tramway Company to the Government of the Transvaal to permit the use of electricity in the place of animal traction will be shortly granted.

LEEDS.—The City Council has decided to promote a Bill in the next Session of Parliament authorising the extension of the present tramway system in various parts of the city.

LLANDRINDOD (SOUTH WALES).—The District Council has entered into an agreement with a local electric lighting contractor for the lighting of the streets by means of incandescent electric lamps.

LONDON COUNTY COUNCIL.—At the meeting on Tuesday last Lieut.-Col Ford proposed that the Victoria Embankment and Westminster and Waterloo Bridges should without further delay be lighted by electricity, with a view to further relieving the congested state of the traffic in the Strand and Fleet-street. He pointed out that many of the principal thoroughfares of London were badly lighted, and that it would be advantageous to the public if electricity were more generally used in street lighting. The Council in 1892 obtained an Act of Parliament authorising them to light the Embankment and Waterloo and Westminster Bridges by electricity, and yet in 1896 it had not been acted upon. The Chairman of the Highways Committee said the matter was now under the consideration of the Committee, and a report would be submitted at a very early date. They had a lot of very valuable information, and, as Col. Ford was aware, plans had been brought up by the Committee, but the Council had referred them back. One point to be settled was the particular pattern of lamp that would be best suited for the purpose.

MAIDENHEAD.—The Town Council, being dissatified with the manner in which the town is illuminated by the gas company, seems disposed itself to undertake the public lighting. There is a strong feeling in favour of the establishment of electricity supply works.

MENDOZA (ARGENTINE REPUBLIC).—It is stated that the Mendoza Municipality has granted a 20 years' concession to an electric light company, with permission to erect overhead cables in the city.

NEWSPAPER OFFICE LIGHTING.—The offices of the *Irish Daily Independent* (Dublin) are now lighted electrically. Current is supplied by a "Taunton" dynamo, driven by a 22 H.P. Crossley gas engine.

OLDHAM.—Major-Gen. H. D. Crozier recently held an official inquiry into the application of the Corporation to borrow £10,000 for electric lighting purposes. The Town Clerk, Mr. A. Nicholson, who supported the application, said the demand for current was so great that considerable extensions had to be carried out last year, and the present application was made in order to provide for certain additional extensions which were urgently required in order to keep pace with the still increasing demand. The present proposals were to double the station buildings, and to provide an additional unit of generating plant. The consulting engineer, Prof. A. B. W. Kennedy, gave technical details, and said that the new unit would have a capacity of about 7,000 8 c.p. lamps. There was some opposition to the application, on the ground that the extensions would be unremunerative.

PAISLEY.—The Electric Lighting Committee is at present actively engaged in the selection of a site for an electricity station. The borough electrical engineer (Mr. F. Teague) has been instructed to prepare a report on the sites suggested in Blackhall and Seedhill-roads. The Committee is also considering the advisability of providing a battery of storage cells at a cost of £400 for the George A. Clark Town Hall installation.

PARTICK (GLASGOW).—The District Council has sanctioned various proposed extensions of the electric light mains by the Kelvinside Electricity Company.

SHIP LIGHTING.—Messrs. Claud Hamilton and Co. (Limited), of Glasgow, have fitted the new steamer "Inyati," built by Messrs. J. T. Rennie and Sons, of Aberdeen, for the London and Natal service, with a complete installation for the electric light, electric bells, &c.

SHOREDITCH (LONDON).—Owing to ill-health Mr. Russell F. Ferguson has resigned his position as resident electrical engineer at the Shoreditch electricity works. It has been decided to advertise for a successor, at a salary of £250 per annum.——The Vestry has decided to ask the London County Council to sanction the borrowing of a sum of £24,800 for engines and machinery for the electricity works.

SOUTHPORT.—An important report on the present position of the electricity supply works has been prepared by the borough electrical engineer, Mr. C. D. Taite, who estimates that by March 31st next the present available plant will be fully loaded, and additional plant will, therefore, be required for the following winter. To meet the anticipated demand a 300-unit alternator and engine would be required, thus bringing the total capacity of the station up to 675 units, and the working capacity to 375 units. The cost of the additional plant, with the necessary additions, is put at £12,000, bringing the total capital expenditure to £58,822.

STAFFORD.—The Town Council has decided to reduce the price of electric current from 8d. to 7d. per unit for any quantity up to an average maximum of 1½ hours per day during the two winter quarters, and three-quarters of an hour per day during the two summer quarters, 4d. per unit remaining as the charge for all current used above such maximum. Since the electric supply station was opened the number of customers had about doubled. The result of the working for the year ended March 30th shows a profit of £105, apart from the question of interest and sinking fund, which together amount to about £850.

STIRLING.—Once again the electric lighting question is revived, and the Police Commissioners have now decided to consult Prof. A. B. W. Kennedy as to the advisability of establishing electric supply works.

STOCKPORT.—The Town Council intends to apply for a Provisional Order.

TAUNTON.—Col. Luard, R.E., held a Local Government Board inquiry on Friday last into the application of the Town Council for sanction to borrow an additional sum of £3,000 for electric lighting purposes. Evidence was given of the progress made by the electricity department, and of the steady demand for electric current in the town. There was no opposition.

TELEGRAPH WIRE EXPORTS.—The value of the telegraph wire and apparatus exported from this country during the month of September last amounted to £76,273, compared with £65,176 in the preceding month, and £45,268 in September last year. During the nine months ended September the aggregate value of the exports was £537,851, against £383,437 and £1,304,594 in the corresponding periods of 1895 and 1894.

TELEGRAPH RATES TO THE EAST.—The Liverpool Chamber of Commerce has been in correspondence with the Postmaster-General and the Secretary for India on the subject of the rates for telegrams to India and the Far East. In reply to the memorial from the Chamber, Mr. C. G. Hall (for the Postmaster-General), states that the question of the reduction of rates to India was discussed at the recent Conference at Budapest, and it was found that the proposal could not be entertained, in view of the very considerable loss of revenue which the reduction would entail; but, although the rate to India remains the same as at present, the cable companies have made appreciable reductions in the charges for telegrams to the Far East, particulars of which will be duly announced. The rate to China, for instance, is to be reduced from 7s. to 5s. 6d. per word. Reductions are also to be made in the charges to Spain, Portugal, Gibraltar, the Canaries, the Azores, and Tangier. Mr. Hall further points out that the number of letters and figures per word allowed in extra-European telegrams will, from July 1st next, be raised from 10 to 15 and from 3 to 5 respectively for telegrams in plain language.

THORNABY.—A Committee has been appointed by the Town Council to consider the advisability of applying, in the forthcoming Session of Parliament, for powers to construct an electric tramway between Thornaby and Newport.

TORQUAY.—The Town Council has approved of the plans and specifications of the proposed electricity supply works, and advertisements are now being issued inviting tenders for the supply and erection of the necessary plant and machinery. This advertisement will be found on another page of the present issue.

TRAMWAYS IN LANARKSHIRE.—The Lanarkshire County Council has appointed a Committee to inquire into the advisability of applying to Parliament for powers to construct tramways propelled by electricity or other motive power throughout the populous districts of the county, and to report thereon.

WAKEFIELD.—The West Riding County Council proposes to light the new county offices electrically, and an arrangement has been arrived at with the City Council for supplying the necessary current. The maximum price of current has been fixed at 6d. per unit, with a rebate to 4d. to large consumers.

WELLS.—The Board of Trade has expressed its approval of the method proposed by the Council for carrying out its electric lighting scheme.

WINCHESTER.—The City Council has accepted the offer of Messrs. Edmundsons (Limited) for the transfer of the Winchester Provisional Order. The transferees agree to pay the cost of obtaining the Order; while the Council has liberty to purchase the electricity works proposed to be erected by Messrs. Edmundsons at twelve

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months' notice, on the following terms:—At any period within seven years, on payment of the capital expended, plus 15 per cent.; after seven and within 14 years, on payment of the capital expended, plus 10 per cent.; after 14 years, on payment of the capital expended, plus 5 per cent. The price to be charged for current to private consumers not to exceed 8d. per unit for the first year, and 7d. for the second year, with a sliding scale reducing to 6d. to large consumers; while the Council would be supplied at 4d. per unit.

WITHINGTON (LANCS.).—The District Council has formally resolved to apply to the Board of Trade for a Provisional Order.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

September 17, 1896.

20,539. R. BURN, A. C. BROWN and L. G. TATE. London. Improvements in electrical apparatus for signalling to or from a railway train or locomotive.

20,579. W. NICOL. London. Nicol's electric time-handicap starter. [Date applied for under Patents, &c., Act, 1883, Sec. 103, February 17, 1896, being date of application in New Zealand.]*

20,600. J. A. DEUTHER. London. Improvements in and relating to electrodes.*

20,601. J. A. DEUTHER. London. Improvements in and relating to electrical furnaces.*

20,604. W. M. MORDEY. London. Improvements in electrical resistances.

September 18, 1896.

20,707. J. GREENWOOD. London. Improvements in coating tubes by electro-deposition.

September 19, 1896.

20,745. R. P. STEVENSON. Portobello. An improved method of actuating switches or other controlling gear placed on or below the surface of the roadway in an enclosed conduit or other system of electric traction. (E. H. B. Tyler, South America.)

20,778. J. ALDWORTH and J. SHAW. Liverpool. Improvements in safety attachments or devices for preventing the falling of suspended wires or conductors used for the transmission of electricity.

20,796. H. H. LAKE. London. Improvements relating to electric railways. (R. Lundell, United States.)*

20,805. V. A. FYNN. London. Improvements in devices for protecting electric circuits and apparatus or instruments from injury by excessive electrical potential.

September 21, 1896.

64A. F. KRIZIK. London. Improvements in and relating to electric or other tramways. [Date claimed under Patents Rule 19, January 1, 1896.]*

64B. F. KRIZIK. London. Improvements in or relating to electric tramways or railways. [Date claimed under Patents Rule 19, January 1, 1896.]*

20,864. F. M. STAUNTON. London. Improvements in and connected with automatic and other electric meters.

20,881. V. G. MIDDLETON. London. Improved means for jointing and protecting electric conductors, specially applicable for use in the wiring of buildings.

20,902. P. R. JACKSON AND CO. (LIMITED) and L. C. H. MENSING. London. Improved mechanism for electric arc lamps.*

September 22, 1896.

20,961. J. T. LISTER and W. S. CHAMBERLAIN. London. Improvements in incandescent electric lamps.*

20,962. J. T. ROSSITER and THE BRITISH ELECTRIC TRACTION (PIONEER) COMPANY (LIMITED). London. Improvements in or connected with electric railways.

20,963. J. T. ROSSITER and THE BRITISH ELECTRIC TRACTION (PIONEER) COMPANY (LIMITED). London. Improvements in switches for use in connection with electric railways.

20,964. J. T. ROSSITER and THE BRITISH ELECTRIC TRACTION (PIONEER) COMPANY (LIMITED). London. Improvements in current collectors for electric railways.

20,966. F. W. DUNLOP and J. R. QUAIN. London. An attachment for electric incandescence lamps.

20,969. H. EDMUNDS. London. Improvements in the armourings or coverings of electric cables.

20,981. H. H. LAKE. London. Improvements relating to the production, regulation, and utilisation of electric currents of high frequency and to apparatus therefor. (N. Tesla, United States.)

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

18,673. DENAYROUZE. Automatic speed regulator for electromotors.

18,931. WEBBER. Prepayment apparatus for attachment to gas, electricity, or other fluid meters. (Date applied for under International Convention, 16th April, 1895.)

19,245. WOOD. Dynamo electric generators and motors.

19,734. DE DION and BOUTON. Means or apparatus for electrically igniting and governing petroleum and other like motors.

1896.

3,712. MOUTERDE, CHAVANT and GEORGE. Electric accumulators.*

5,274. SMITH, SMITH, SMITH, SMITH and DEAKIN. Apparatus for the electro-deposition of metals.

12,895. SMITH. Electric elevators.

12,813. COPE. Conduits for electric railways.

13,729. CEREBOTANI and BERNSTEIN. Multiple telegraphy.

13,889. OPPENHEIMER. Electrical distribution.

14,014. DYMOND (the Chemisch-Elektrische Fabrik "Prometheus" Gesellschaft mit beschrankter Haftung). Electric cooking, &c., apparatus.

# COMPANIES' MEETINGS AND REPORTS.

## Monte Video Telephone Company (Limited).

The Report of the Directors of this Company for the year ended July 31st last, to be presented at the meeting to be held at Winchester House, London, E.C., on Thursday next, at 12 o'clock, states that a net profit of £5,727. 7s. 6d. has been realised, after providing for all working expenses in Monte Video and London, and writing off bad debts, &c. This, added to £710. 17s. 1d. brought forward, leaves an available balance of £6,438. 4s. 7d. During the year a marked improvement has been made in the Company's service by the adoption of a new microphone. The whole outlay of this and other extensive additions to the plant has been charged to working expenses.

The number of subscribers is gradually increasing, and the general position of the Company is satisfactory. The Directors recommd the payment of a dividend of 4 per cent. on the Preference share capital (absorbing £5,600), leaving £838. 4s. 7d. to be carried forward. Mr. Frank W. Jones offers himself for re-election as Director, and Messrs. Gérard Van de Linde and Son as auditors.

# NEW COMPANIES, STATUTORY RETURNS, &c.

**BEACON ENGINEERING COMPANY (LIMITED).**—This Company was registered on Oct. 5 with a capital of £5,000, in £5 shares, to carry on the businesses of electrical and mechanical engineers, &c.

**COVENTRY MOTOR COMPANY (LIMITED)**—This Company was registered on Oct. 5, with a capital of £10,000, in £1 shares, to manufacture and deal in and with automotor cars, carriages, tramways, &c., and also to carry on business as electrical and general engineers, &c.

**ELECTRIC FREE WIRING SYNDICATE (LIMITED).**—This Company was registered on Oct. 6th, with a capital of £1,000, in £1 shares, to carry on at Liverpool or elsewhere the business of electricians, mechanical engineers, suppliers of electricity for light, heat, motive power or other purposes, and manufacturers of and dealers in all apparatus required for or capable of being used in connection with the generation, distribution, supply, accumulation and employment of electricity, and to construct, lay down, fix and carry out all necessary cables, wires, stations, lines, accumulators, dynamos, batteries, &c. The subscribers, with one share each, are:—J. B. Atherton, manufacturer; G. H. Nisbett, electrical engineer; F. J. Leslie; Arthur Ellis, electrical engineer; C. O. Grindrod, A. G. Haptie, and A. Ruckley.

**FLEETWOOD AND DISTRICT ELECTRIC LIGHT AND POWER COMPANY (LIMITED).**—This Company was registered on Oct. 9th, with a capital of £20,005, in £1 shares, to carry on at Fleetwood in the county of Lancaster, and elsewhere, the business of an electric light company in all its branches, to construct, lay down, establish, fix and carry out all necessary cables, wires, lines, accumulators, lamps and works, and to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity, and manufacturers of and dealers in electrical apparatus. The subscribers, with one share each, are S. E. Hubbard, Alfred Slatter, electrical engineer, Charles W. Sax, electrical engineer, A. G. Seaman, electrical engineer, T. E. Ingoldby, electrical engineer, E. A. M. Winter, and Jacob Atherton, electrical engineer.

**LAING, WHARTON AND DOWN (LIMITED).**—This Company was registered on Oct. 8th, with a nominal capital of £30,000, divided into 6,000 £5 per cent. cumulative Preference, and 24,000 Ordinary shares of £1 each, to acquire and take over as a going concern the business of electrical engineers and contractors carried on by Messrs. C. J. Wharton, Arthur F. Davies and Fred. J. Down, at 82a, New Bond-street, London, W., under the style of Laing, Wharton and Down, and to carry on the business of electricians, electrical engineers and contractors, suppliers of electricity for the purposes of light, heat and motive power, and manufacturers of and dealers in all kinds of electrical apparatus. The subscribers, with one share each, are: Arthur F. Davies, electrical engineer; C. J. Wharton, engineer; H. King Smith,

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engineer; F. J. Down, engineer; W. Howard, A. W. Lipsham, and G. Cruikshank. The first Directors are Frederick J. Down, Arthur F. Davies, and Justus Eck.

**MEYRICK AND HOLT (LIMITED).**—This Company was registered on Oct. 10th, with a capital of £3,000, in £5 shares, to acquire the business carried on at Rochdale under the style of Meyrick and Holt, and to carry on the business of electricians, machinists, motor, cart manufacturers, &c.

**SIEMENS BROTHERS AND COMPANY (LIMITED).**—The annual return to August 7th has been filed. The nominal capital is £500,000, in £100 shares. All of these have been taken up, and £85 per share has been called and paid.

**SINGLE WIRE MULTIPLE TELEPHONE SIGNAL COMPANY (LIMITED).**—The annual return to June 22nd has just been filed. 324 shares have been subscribed for out of a capital of £5,000, in £10 shares, and the full amount has been called and paid.

**SOUTH AFRICAN LIGHTING ASSOCIATION (LIMITED).**—The annual return to May 28th has just been filed. The nominal capital is £50,000. in £10 shares, and 4,100 have been taken up. 105 shares have been issued as fully paid, and the full amount has been called and paid on the remainder.

**SPANISH TELEPHONE COMPANY (LIMITED).**—The annual return to June 24th has just been filed. The nominal capital is £16,000, in £10 shares, all of which have been issued as fully paid.

**SUNBEAM LAMP COMPANY (LIMITED).**—The annual return to Aug. 21st has been filed. 1,732 shares have been taken up out of a capital of £25,000, in £10 shares, and of these, 857 have been issued as fully paid. The full amount has been called on the remaining 875.

**TELESCRIPTOR SYNDICATE (LIMITED).**—The annual return to Aug. 20th has been filed. 20,757 shares have been taken up out of a capital of £40,000, in £1 shares, and 20,750 of these have been issued as fully paid. The full amount has been called on the remaining seven, but nothing has yet been paid.

**THOMAS PARKER (LIMITED).**—The annual return to July 10th has just been filed. The capital is £75,000, in £10 shares, and 6,352 have been taken up. 1,750 shares have been issued as fully paid, and £8 per share has been called on the others, resulting in the receipt of £35,896, and leaving £920 in arrears.

**UNITED ELECTRIC WIRE AND TELEGRAPH WORKS (LIMITED).**—The statutory return to Aug. 6th has been filed. 3,032 shares have been taken up out of a capital of £6,000, in £1 shares, and 2,993 have been issued as fully paid. £1 per share has been called and paid on the remaining 39 shares.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 3 per cent. (Sept. 24, 1896). Price of silver 29¾d. per oz. (Oct. 15th). Consols (2¾ per cent.) 108⅞—108⅞ for money 108⅞—108¾ for account; 2½ per cent. 105—105½ (Oct. 15th). Stock Exchange Settling Days: Consols, Nov. 5th; Stocks and Shares Continuation Day, Oct. 27th; Ticket Day, Oct. 28th; Pay Day, Oct. 29th; Mining Share Carry-over Day, Oct. 26th.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).**—The accounts of this Company, subject to audit, show a profit sufficient to enable the Directors to recommend a final dividend of 3s. per share, making, with previous distributions, a total dividend of 6 per cent. for the year ended June 30, and also the payment of a bonus of 2s. per share, both free of income tax, which together amount to £32,500, leaving a balance of £31,060, of which amount £20,000 has been placed to the reserve fund, and £11,060 carried forward. The dividend and bonus are payable on the 29th inst., and the register of transfers will be closed from the 20th to the 28th inst. inclusive.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended Oct. 11th were £965, against £916 in the corresponding week of 1895, an increase of £49. The total receipts for the half-year amount to £13,681, against £12,774 for the corresponding period of 1895, an increase of £907.

**CITY OF BIRMINGHAM TRAMWAYS COMPANY (LIMITED).**—A prospectus inviting subscriptions for £220,000 Four per Cent. First Mortgage Debentures of £100 each (issue price £102) and 24,000 cumulative Five per Cent. Preference shares of £5 each (issue price £5. 4s.) has been published this week. The capital of the Company is £1,000,000—£400,000 in Five per Cent. Preference, and £600,000 in Ordinary, and there is in addition £500,000 First Mortgage Debentures. 60,000 Ordinary shares have already been applied for and allotted at par. The Company acquires the whole of the tramways in the City of Birmingham and neighbourhood. Particulars concerning this scheme have previously appeared in *The Electrician*. Mr. Henry Buckley, Chairman of the Birmingham Electric Supply Company, and Mr. William Neale, Chairman of the Birmingham Central Tramways, are on the Directorate, as are also the President of the Toronto Railway Company, and the Vice-President and Managing Director of the Montreal State Railway Company. The Secretary is Mr. W. Holmden, and the offices are 119, Colmore-row, Birmingham. The prospectus states that the Birmingham tramways have hitherto been worked by four different systems of traction—horse, steam, cable, and electric storage batteries, all of which, with the exception of cable, have proved unsatisfactory. It has, therefore, been decided to substitute an improved method of traction, and to develop the tramway system by connecting the existing tramway within the city, extending the lines to outlying districts, and constructing such additional lines as public accommodation may require. Messrs. Mackenzie and Ross, two of the Directors, have successfully applied their system of traction to Canadian undertakings; and the prospectus sets out the results of their efforts in this direction. The list of applications closes on Monday next.

**DIRECT UNITED STATES CABLE COMPANY (LIMITED).**—The Directors of this Company have resolved upon the payment of an interim dividend of 2s. 6d. per share, free of income-tax, being at the rate of 2½ per cent. per annum, for the quarter ended Sept. 30, payable on and after the 24th inst.

**ELECTRIC LIGHTING EXTENSION SYNDICATE LIMITED (PARENT COMPANY).**—With a capital of £5,000, all in shares of £1, a syndicate has been formed with the above title, the object being to acquire the sole rights for the United Kingdom of Bastian and Hodges inventions relating to prepayment electricity and other meters, to manufacture and supply the meters, and for other purposes connected with the extension of electric lighting; and also to promote a company or companies to deal with the whole or any part of the property of the syndicate. The penny-in-the-slot meter which the Company is placing before the public can, the prospectus states, be seen working at Messrs. Hodges and Todd's works, 30, Hampstead-road, London, N.W. For the present, subscriptions are invited for 2,500 shares, 10s. being payable on application, and the balance on allotment. The purchase price of the patents is £3,000, £500 in cash, the balance in fully-paid shares. The list closes on Monday next at noon

**ELECTRIC WELDING COMPANY (LIMITED).**—A private meeting of the shareholders of this Company was held on Tuesday last.

**ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED) (IN LIQUIDATION).**—A meeting of the security-holders in this undertaking was held on Monday at Winchester House, London, E.C. Mr. J. H. Duncan, the receiver and liquidator, presided, and explained that he had called the meeting to consult on an important point before closing up his accounts and terminating his office. Under the reconstruction scheme certain bonds were issued. These bonds were debentures in the English Company, which was the holder of all the Founders' shares of the French Company. The Founders' shares were not yet in receipt of dividend. Therefore, as far as they were concerned, the English Company was an absolutely non-dividend paying company. There would be a few other assets to transfer from himself as receiver to that Company; but they would not amount to any large sum. The principal income would always be what was received from the Founders' shares of the Paris Company. The bonds referred to were up to the present in default. The first payment of interest on them was due on June 30, 1894. He had not hastened matters to a conclusion before; but now the Board of Trade wanted to know why he did not close his liquidation. He had now no valid excuse to offer, except that he wished to protect the bondholders' interests against proceedings being taken against the Company; and to effect this purpose delay in closing up the affairs of the Company was essential. It was for them, however, to express their wish on the point. As to the business in France, on which they were really dependent, he said that it had been taken in hand by French capitalists in a manner they could not have done on this side; and, in spite of competition, the Company had paid two dividends in addition to 6 per cent. on their bond issue and all other charges. That did not afford them any great comfort as holders of Founders' shares, because they did not participate in the profits until 10 per cent. had been paid on the French capital. But the very fact that 5 per cent. had been earned, besides satisfying the debenture interest, seemed to him to contain the germ of a considerable amount of hope for them in the future. A new factory had just been erected for the purpose of enabling the Company to turn out other manufactures than copper tubes; and looking at all the circumstances, there appeared to be a reasonable prospect of the Founders' shares coming within sight of a dividend. When that happened they would take the first of the surplus profit. That being the case, he thought they should protect themselves by having a buffer between them and a wrecking policy which might be put into force by any individual holder of the bonds, if he were not in a position to protect them. If the Board of Trade sanctioned a proposal for his continuance as liquidator, it would not involve any additional cost to the bondholders. After a short discussion Mr. Shurmer proposed that Mr. Duncan should continue his duties as receiver and liquidator, and this was carried.

**GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).**—The Directors of this Company announce interim dividends of 1s. 6d. per share on the Ordinary shares and 3s. per share on the Preference shares.

**INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).**—The Board of Directors of this Company have declared an interim dividend for the half-year ended June 30th last at the rate of 5 per cent. per annum, free of income-tax, payable on and after 1st Nov. The transfer books will be closed from the 26th to the 31st inst.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 11th inst. amounted to £1,076. The amount for the corresponding week last year was £1,118. Decrease, £42.

**ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).**—The sale of electricity by this Company for the quarter ended Sept. 29, representing the supply at 6d. per unit, amounted to £10,084, against £7,402 at the same rate for the corresponding period of 1895.

**STOCK EXCHANGE NOTICE.**—An application to allow a further issue of 3,504 shares in Evered and Co. (Limited) to appear in the Official List has been made to the Stock Exchange Committee.

**SUBMARINE CABLES TRUST.**—In the announcement which appeared in our last issue it was incorrectly stated that the sum of £2. 7s. 6d., payable on and after Oct. 15, was the *balance* of the coupon, instead of being *on account* of the coupon.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—This Company's traffic receipts for the week ended Oct. 9th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,895.

**WESTERN UNION TELEGRAPH COMPANY (LIMITED).**—At the annual meeting held on Wednesday, Messrs. Rolston and Perkins were elected as Directors to fill the vacancies at the board.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price October 7. | Price Wednesday, October 14. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Oct. 10. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American | 50 53 | 50 53 | 4 14 4 | Jan., Apr., July, Oct. | 53⅜ | 50 |
| £2,993,560 | Stock | 24/0 | Do. Preferred | 96 97 | 96 97 | 5 3 1 | " " | 97⅞ | 96½ |
| £2,993,560 | Stock | 5/0 | Do. Deferred | 9 9½ | 8⅞ 9½ | .. .. | .. .. | 9⅝ | 9⅜ |
| £173,400 | 100 | 4⅞ | *African Direct Teleg. 4% Deb. (Reg. & Bearer) | 100 104 | 100 104 | 3 17 8 | January and July | 102½ | 101⅜ |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) | 8½ 9½ | 8½ 9½ | .. .. | .. .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 14⅜ 15⅜ | 14⅜ 15⅜ | 4 11 10 | Mar., June, Oct., Dec. | 15⅜ | 15⅛ |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) | 112 116 | 112 116 | 4 7 4 | June and December | 115½ | 114½ |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock | 145 150 | 145 150 | 4 13 8 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 12 13 | 11½ 12½ | 6 8 0 | February and August | 12½ | 12 |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. | 17½ 20½ | 18½ 19½ | 5 2 7 | | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) | 3⅜ 4⅜ | 3⅜ 4⅜ | 4 8 11 | April and October | — | — |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each | 107% 110% | 107% 110% | 4 2 9 | | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 | 9½ 10 | 9½ 10 | 4 10 0 | Jan., Apr., July, Oct. | .. | .. |
| 400,000 | 10 | 5/6 | Eastern | 17⅜ 18½ | 17⅜ 18½ | 3 11 3 | " " | 18⅛ | 18 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 1 6 | " " | .. | .. |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 131 134 | 131 134 | 3 0 7 | May and November | 132½ | 131½ |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899 | 104 107 | 104 107 | 4 14 4 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 17⅜ 18½ | 17⅜ 18 | 3 17 9 | Jan., Apr., July, Oct. | 18⅛ | 17⅞ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock | 130 133 | 130 133 | 3 0 6 | February & August | 133 | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900 | 100 104 | 100 104 | 4 17 7 | January and July | 102 | — |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 | 101 105 | 101 105 | 4 16 7 | " " | .. | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) | 106 109 | 106 109 | 3 13 11 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.) | 111% 114% | 110% 113% | 3 12 1 | May and November | 111½ | 111 |
| 180,227 | 10 | 3/9 | Globe Telegraph and Trust | 10⅜ 11⅛ | 10⅜ 11⅛ | 3 13 7 | Jan., Apr., July, Oct. | 11⅛ | 10⅞ |
| 180,042 | 10 | 6% | Do 6 per Cent. Preference | 17⅞ 18⅞ | 17⅞ 18 | 3 6 8 | " " | 18⅛ | 17⅞ |
| 150,000 | 10 | 5/0 | Great Northern | 23½ 24½ | 24 25 | 4 0 0 | Jan., April, and July | 24⅜ | ... |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue | 104 107 | 104 107 | 4 13 11 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 52 55 | 52 55 | 4 10 11 | May and November | 54½ | 53 |
| 37,548 | 10 | .. | London Platino-Brazilian | .. .. | .. .. | .. .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures | 109 112 | 109 112 | 5 7 10 | March & September | — | — |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 | 108 111 | 108 111 | 3 12 9 | — | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's | 7 8 | 7 8 | 5 0 0 | April and October | 7⅞ | 7½ |
| 3,381 | £100 Cert. | £1 | *Submarine Cables Trust 6 per Cent. | 138 143 | 138 143 | 4 3 11 | " " | 142 | 139½ |
| 15,609 | 10 | 6/0 | West African Telegraph | 5 6 | 5 6 | 5 0 0 | January and July | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.) | 102 105 | 102 105 | 4 15 8 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America | ½ 1½ | ½ 1½ | .. .. | January and July | .. | .. |
| £160,000 | 100 | 8% | * Do. 8 per Cent. Debentures, 1902 | 98 103 | 98 103 | 7 18 5 | June and December | 100 | 98 |
| 83,321 | 10 | 0/6 | West India and Panama | 1½ 1½ | 1½ 1⅝ | .. .. | — | 1⅝ | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference | 11½ 12 | 11½ 12 | 5 0 0 | May and November | 11⅝ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £80,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) | 108 111 | 108 111 | 4 11 4 | June and December | .. | — |
| 64,251 | 15 | 5/3 | Western and Brazilian | 8½ 9 | 8½ 8⅞ | 5 2 7 | May and November | 8⅞ | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred | 6½ 7 | 6½ 7 | 5 1 0 | — | 6⅞ | 6¼ |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary | 2½ 2⅞ | 2½ 2⅞ | .. .. | — | .. | .. |
| £158,100 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 | 103 107 | 103 107 | 5 13 2 | February & August | .. | .. |
| £197,600 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 | 103 107 | 103 107 | 5 13 2 | " " | — | .. |
| $1,177,000 | $1,000 | 7% | * Western Union 7% 1st Mort. (Building) Bonds | 110 115 | 110 115 | 6 5 7 | May and November | — | — |
| £164,300 | £100 | 6% | * Do. 6 per Cent. Sterling Bonds (red.) | 100 105 | 100 105 | 5 15 5 | March & September | — | — |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chill Telephone (fully paid) | 3½ 3¾ | 3½ 3¾ | 5 6 8 | — | — | — |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing | 1/16 3/16 | 1/16 3/16 | .. .. | — | — | — |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) | 1⅛ 1⅜ | 1⅛ 1⅜ | .. .. | — | .. | .. |
| 484,597 | 5 | 2/6 | National | 1⅜ 1⅝ | 1⅜ 1⅝ | 6 3 1 | Yearly | .. | .. |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. | 7⅜ 7⅝ | 7½ 7⅝ | 3 13 4 | June and December | 7 1/16 | 7 |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid) | 17 19 | 17 19 | 3 3 2 | " " | 18 | 17½ |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. | 17 19 | 17 19 | 3 8 7 | " " | .. | — |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) | 6⅞ 7⅛ | 6⅞ 7 | 3 11 5 | — | 6⅞ | .. |
| 58,000 | 5 | 4/0 | United River Plate | 103 109 | 106 109 | 3 4 9 | January and July | 103 | 107½ |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) | 3½ 4 | 3½ 4 | 5 0 0 | July | .. | .. |
| | | | | 101 103 | 101 103 | 4 15 8 | January and July | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| .. | 5 | .. | Birmingham Electric Supply (fully paid) | 9¼ 9⅞ | 9 9½ | .. .. | .. | .. | .. |
| .. | 5 | .. | Do. (£4 paid) | 7 | 7½ | .. .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) | 16 17 | 16 17 | 2 18 10 | February & August | 17 | 16⅝ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) | 17½ 18½ | 17½ 18½ | 3 4 10 | January and July | .. | .. |
| £100,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) | 131 135 | 131 135 | 3 14 11 | June and December | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain | .. .. | .. .. | .. .. | — | .. | — |
| £30,000 | £5 | 2/6 | Charing Cross & Strand Electricity Supply Corp. | 9½ 10 | 9½ 10 | 2 15 0 | — | 9⅝ | 9⅜ |
| £57,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 | .. .. | .. .. | .. .. | — | .. | — |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid) | 8½ 9½ | 8½ 9½ | .. .. | — | 8⅝ | .. |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) | 13¾ 14½ | 13¾ 14½ | 4 4 3 | — | 14 | .. |
| 8,322 | £5 | — | House-to-House Electric | .. .. | — — | .. .. | — | — | — |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid) | — — | — — | .. .. | — | — | — |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid) | — — | — — | .. .. | — | — | — |
| 111,000 | 5 | .. | London Electric Supply | — — | — — | .. .. | January and July | — | — |
| 49,900 | £10 | 5/0 | Metropolitan Electric Supply (fully paid) | 1 1½ | .. .. | .. .. | — | — | — |
| £1 0,000 | Stock | 4½% | * Do. 4½% Debs. | 12½ 13½ | 12½ 13½ | 2 19 3 | — | 13½ | 13 |
| 6,452 | £10 | 4/0 | Notting Hill Electric | 121 124 | 121 124 | 3 13 0 | June and December | 123 | .. |
| .. | .. | .. | Raud Electric | 1⅛ 1⅜ | 11⅛ 12⅛ | .. .. | — | — | — |
| 19,980 | £5 | 2/6 | St. James and Pall Mall | 1⅜ 1⅝ | 1 7/16 1 9/16 | .. .. | — | .. | — |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference | 11⅜ 12⅜ | 11⅜ 12⅜ | 3 2 0 | — | 12½ | .. |
| 59,900 | 5 | 3/0 | Westminster Electric Supply (fully paid) | 10 11 | 10 11 | 3 6 8 | — | 10⅞ | .. |
| | | | | 10½ 11½ | 10½ 11½ | 3 8 2 | — | 11 1/16 | 10⅝ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering | ⅞ 1⅛ | ⅞ 1⅛ | .. .. | — | 1⅛ | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative | 1⅛ 1⅜ | 1⅛ 1⅜ | .. .. | — | 1⅜ | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures | 110 113 | 110 113 | 4 0 9 | March & September | .. | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. .. | January and July | 2⅜ | .. |
| 84,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) | 1⅞ 2⅛ | 1⅞ 2⅛ | 6 13 4 | February & August | .. | .. |
| £1 0,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 103 106 | 103 106 | 4 6 2 | January and July | 103 | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) | — — | .. .. | .. .. | — | — | — |
| 110,000 | 2 | 1/0 | Electric Construction | 1½ 1⅝ | 1½ 1⅝ | 2 17 2 | — | 1⅝ | — |
| 12,845 | 2 | 2/0 | Do. 7 per Cent. Cumulative Pref. | 2½ 3 | 2⅛ 3 | 4 13 4 | — | — | — |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing | ½ ¾ | ½ ¾ | .. .. | September | 2 1/16 | 2⅛ |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) | .. .. | .. .. | .. .. | — | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works | 22 23 | 22 23 | 4 6 11 | — | .. | .. |
| £20,000 | 100 | 4% | * Do. 4 per Cent. Debentures | 105 108 | 105 108 | 3 14 1 | February & August | 22 | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) | ¾ ⅞ | ¾ ⅞ | .. .. | March & September | .. | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 40 43 | 39 42 | 4 5 9 | .. | .. | .. |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds | 104 107 | 104 107 | 4 14 9 | March and July | 41 | 40⅜ |
| £100,000 | 10 | 6/0 | W. T. Henley's Telegraph Works Ordinary | 18 19 | 17½ 18½ | 4 6 6 | January and July | .. | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference | 18½ 19½ | 18½ 19½ | 3 11 10 | March & September | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock | 110 115 | 110 115 | 3 18 9 | " " | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1⅝% | City and South London Railway Con. Ordy. | 48 50 | 50 52 | 2 17 6 | February & August | 114 | 112½ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference | 14⅞ 15⅛ | 14⅞ 15⅛ | 3 5 7 | January and July | 50½ | 48½ |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture | 136 138 | 136 138 | 2 18 0 | " " | — | .. |
| 37,500 | £10 | 2½ | Liverpool Overhead Railway | 13 1/16 13 3/16 | 13 1/16 13 3/16 | 2 4 6 | May and November | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference | 16¼ 17⅜ | 16⅞ 17⅜ | 2 17 9 | — | .. | .. |
| 125,000 | Stock | 4% | Do. 4% Debenture | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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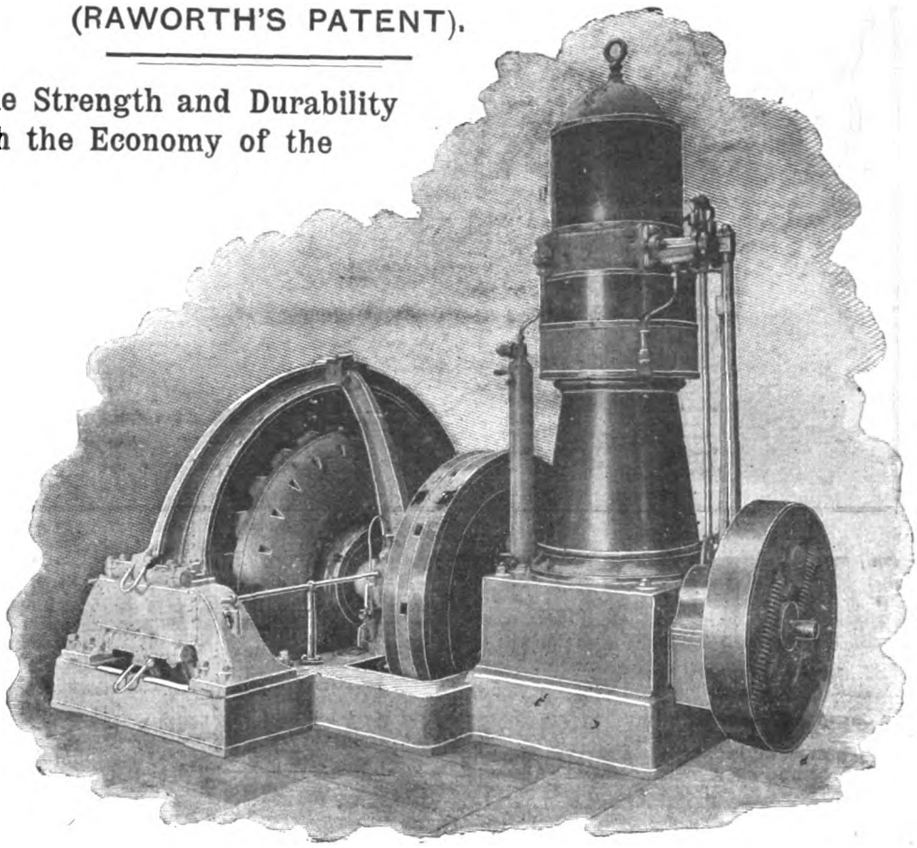

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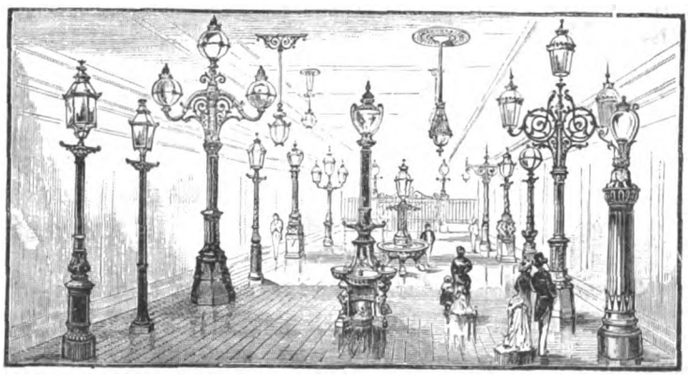

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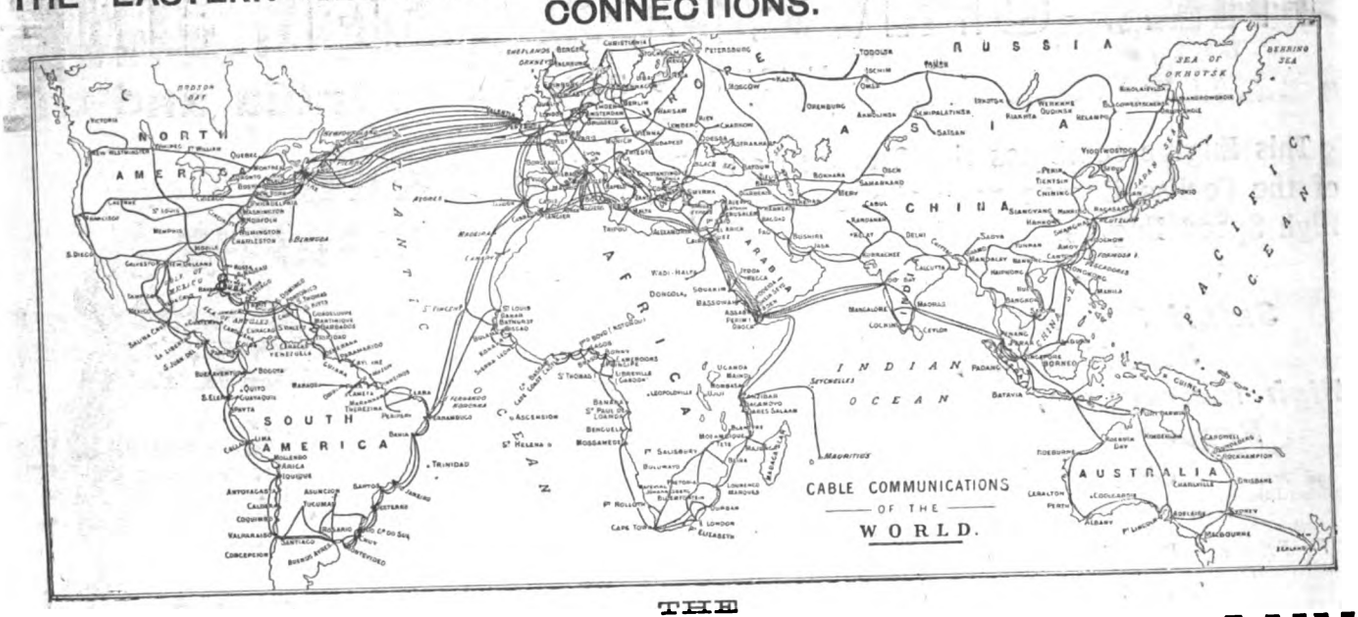


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At One o'clock precisely, Without Reserve, by order of Mr. L. C. H. Mensing, whose lease of the premises has expired, the remaining

**VALUABLE ELECTRICAL PLANT,**

10 Valuable Lathes by the best makers; Superior Dynamo, Drilling and Shaping Machines, 6 Parallel Sudden Grip and other Vices, 10 2in. Pedestal and Wall Boxes, a Quantity of Leather Belting of the best quality; 9 Overhead Gears and Slides, with Levers and Pulleys; 2 Grinding Machines for Power and Foot, Weighing Machine, Portable Forge and Anvil, 72ft. of 2in. Bright Turned Shafting and Couplings; Punching, Shearing, and Wire Cropping Machine; 2 Machine Vices and Angle Plate, a 3-h.p. Spiel Oil Engine, Band Saw for Foot Power, Tools, Fittings, and materials; various well-made Work Benches, and other effects. Also the useful Office Furniture, comprising a 5ft. Double Pedestal Mahogany Writing Desk, Leather-Covered Chairs, Copying Press, Deal Tables, &c.; also Two 22-rung Ladders and Several Pairs of Steps.

On View day previous and morning of Sale. Catalogues had on the premises, and of the Auctioneers, 67 and 68, Cheapside, London, E.C., and High-road, Leytonstone.

TO ELECTRICAL ENGINEERS, ELECTRICIANS, AND OTHERS.

Re Paterson and Cooper.—In Bankruptcy.

FOR SALE BY PRIVATE TREATY.

The Trustee of the above Estate is prepared to receive TENDERS for the PURCHASE of the following:—

1. The GOODWILL, FIXTURES, FITTINGS and FURNITURE as a going concern of the old-established and profitable Electrical Contracting Business, hitherto carried on by Messrs. Paterson and Cooper, at No. 3, Princes Mansions, Victoria-street, Westminster. The average turnover for the past six years is stated to have exceeded £10,000 per annum, with a very satisfactory gross profit.

A purchaser would be required to take to stock-in-trade suitable for the business (estimated at about £3,000) at a valuation.

The premises, No. 3, Princes Mansions, Westminster, consisting of three front rooms on the ground-floor east, and one back-room in the basement, are held on a yearly tenancy at a rental of £200, including rates and taxes.

2. The Goodwill, Furniture, Trade Fixtures and Fittings, as a going concern of the contracting business carried on by Messrs. Paterson and Cooper, at 137, West Regent-street, Glasgow.

The business has shown an increasing turnover, amounting last year to nearly £7,000, showing a satisfactory gross profit.

The purchaser would have the option of taking to stock-in-trade suitable for this business to an extent of about £1,000 at a valuation.

The premises are held on lease at a yearly rental of £34, for a term expiring Whit-Sunday, 1898.

3. The Goodwill of the Measuring Instrument Department of Messrs. Paterson and Cooper's Business, with their connection and the right to make and sell their instruments, which are well-known and widely used in the trade.

The turnover in this department is stated to have averaged about £1,700 per annum during the three years ending 31st December, 1895, with considerable gross profit.

The purchaser would be required to take to the Stock of this department, including instruments in process of construction tools, plant, and accessories, at a valuation in the usual way. The purchaser would have the option likewise of taking at valuation the stock of Arc Lamps, Switchboards, and Electric Light and Telegraph Appliances (which can be worked with the Instrument Department), together with the business connection in these goods.

4. The Goodwill of the Dynamo Department, including drawings, patterns, windings, &c., with Messrs. Paterson and Cooper's wide connection both in new dynamos and repairs.

The turnover (including repairs) is stated to have averaged about £3,700 per annum during the three years ending 31st December, 1895.

The purchaser would be required to take to the Stock, complete and incomplete, and materials, &c., of the department (estimated at about £2,000) at a valuation.

The figures given above have been supplied by Messrs. Paterson and Cooper. The Trustee cannot, of course, accept responsibility for them, but permission may be obtained by a proposed purchaser to inspect such books, contracts, and documents as he may require.

Further particulars relating to the businesses may be inspected and permission to view obtained at the Offices of the Trustee as below.

Tenders will be received by the Trustee up to and inclusive of November 20th, 1896.

The Trustee does not bind himself to accept the highest or any Tender.

EDWARD CECIL MOORE, Trustee, Chartered Accountant, 3, Crosby-square, London, E.C.

COUNTY BOROUGH OF BRADFORD.

The Borough Electrical Engineer is prepared to receive TENDERS for the following METERS, viz.:—

117 ARON METERS.
86 FRAGER METERS.
24 EDISON METERS.
21 OULTON and EDMONDSON METERS

A List giving details and capacity of the above Meters can be had on application to the Electricity Office, Town Hall, Bradford.

Tenders to be endorsed "Tender for Meters," and to be addressed to the Borough Electrical Engineer, Town Hall, Bradford.

All Meters are guaranteed to be in good condition and working order.

ALFRED H. GIBBINGS,
Borough Electrical Engineer.

Town Hall, Bradford,
5th October, 1896.

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TENDERS INVITED.

BOROUGH OF TORQUAY.

The TOWN COUNCIL of the BOROUGH of TORQUAY are prepared to receive TENDERS for the SUPPLY and ERECTION of the following PLANT, &c.:—

Section A.—BOILER-HOUSE PLANT: Boilers and Fittings, Forced Draught Apparatus, Feed Storage, &c.
Section B.—ENGINE-HOUSE PLANT: Steam Alternators, Condensers, Pumps, Steam and Exhaust Pipes, &c.
Section C.—SWITCHBOARD, &c.
Section D.—UNDERGROUND MAINS, LAMP POSTS, &c.
Section E.—TRANSFORMERS, &c.
Section F.—METERS.
Section G.—ACCUMULATORS, &c.
Section H.—CRANE, &c.
Section I.—BUILDER.

Tenderers are at liberty to tender for any Section or Sections, but not for part of a Section.

Specification, with Terms and Conditions of Tender and Contract, may be obtained of Mr. W. H. Trentham, the Consulting Engineer to the Council, at 89, Victoria-street, Westminster, S.W., or of the undersigned, on payment of £3. 3s., which sum will be returned on receipt of a bona fide Tender.

Tenders must be addressed to me, sealed and marked "Tender for Electricity Works," at the Town Hall, Torquay, and delivered at or before 3 p.m. on TUESDAY the 3rd November, 1896.

The Council do not bind themselves to accept the lowest or any Tender.

FREDK. S. HEX, Town Clerk.

Town Hall, Torquay, October 15th, 1896.

COUNTY BOROUGH OF WEST HAM.

TO ELECTRICAL ENGINEERS AND OTHERS.

The COUNCIL hereby invite TENDERS for:—

FOUR STEAM ALTERNATORS AND EXCITERS.
SURFACE CONDENSER AND PUMPS.
STATION SWITCHBOARD, &c.
HIGH AND LOW TENSION MAINS, &c.
TRANSFORMERS, SUB-STATIONS, &c.
INSTRUMENTS.
ARC LAMPS, POSTS, &c.
CRANE.

Plans of the suggested arrangements, Specification, form of Tender, and further particulars may be obtained at the Office of Mr. John J. Steinitz, Borough Electrical Engineer, Town Hall, Stratford, E., on the deposit of a £5 Bank of England note, which will be returned on receipt of a bona-fide Tender.

Tenders endorsed "Tender for Machinery, &c.," to be sent to my Office not later than Four o'clock on TUESDAY, 24th November, 1896.

The Council does not bind itself to accept the lowest or any Tender. The Contractor will be required to enter into a bond, with two sureties, for the due performance of the Contract, and no work will be ordered under the Contract until such bond has been duly executed.

The Contracter whose Tender is accepted, and with whom a Contract is entered into, will be required to pay the whole of his workmen such rate of wages, and observe such hours of labour, as are recognised by the workmen's trades unions and in force at the time of signing the Contract. In the event of any breach of such agreement the Council will enforce the penalty clause in its entirety.

By order of the Council,
FRED. E. HILLEARY, Town Clerk.

Town Hall, West Ham, E.,
22nd October, 1896.

TO ELECTRICIANS AND MANUFACTURERS.

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The Electricity Committee are prepared to receive APPLICATIONS for the post of "Electrician-in-Charge" at the Electricity Works. The duties consist of taking charge of the running plant and switchboard during an eight hours' shift each day, and such other work as the City Electrical Engineer may direct. Applicants must have held a similar position in a high-tension alternating-current station. Salary £90 per annum.

Applications, stating age, experience, and accompanied by copies of three recent testimonials, must be sent to me not later than 31st October, 1896, endorsed "Electrician-in-Charge."

E. T. RUTHVEN MURRAY, City Electrical Engineer.

Guildhall, Worcester, October 20th, 1896.

---

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MAINS SUPERINTENDENT.

The Corporation require the services of a thoroughly capable and experienced Electrician to act as MAINS SUPERINTENDENT. Salary, £2 10s. per week. Applications, stating full previous experience, age, &c., and enclosing three recent testimonials, to be sent to the undersigned not later than the 2nd November, 1896, and endorsed "M. S."

ROBT. C. QUIN, Borough Electrical Engineer.

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NOTICE is Hereby Given that the FORTY-SIXTH HALF-YEARLY ORDINARY GENERAL MEETING of this Company will be held on WEDNESDAY, the 28th day of October, 1896, at 2:30 o'clock in the afternoon, at WINCHESTER HOUSE, 50, Old Broad-street, London, when the Report and Accounts for the half-year ended 30th June, 1896, will be submitted, and the ordinary business of the Company transacted.

Dated this 19th day of October, 1896.

By order of the Board,

F. E. HESSE, Manager and Secretary.

Winchester House, 50, Old Broad-street, London, E.C.

---

## BRAZILIAN SUBMARINE TELEGRAPH COMPANY (Limited).

NOTICE is Hereby Given, that the FORTY-SIXTH ORDINARY GENERAL MEETING of the Shareholders of the Brazilian Submarine Telegraph Company (Limited) will be held in Room 174, WINCHESTER HOUSE, Old Broad-street, London, E.C., on WEDNESDAY, the 28th day of October, 1896, at Twelve o'clock noon, when the Report of the Directors and the Accounts to 30th June, 1896, will be presented, a Dividend declared, and the ordinary business of the Company transacted.

Notice is also Given that the REGISTER of TRANSFERS will be CLOSED from the 20th to the 28th October, both days inclusive.

By order,

RICHARD COLLETT, Secretary.

Winchester House, Old Broad-street, London, E.C., 20th October, 1896.

---

## SUBMARINE CABLES TRUST.

NOTICE is Hereby Given that an EXTRAORDINARY GENERAL MEETING of the Certificate Holders in the Submarine Cables Trust will be held at the Offices of the Trust, WINCHESTER HOUSE, 50, Old Broad-street, in the City of London, on FRIDAY, the 30th day of October, 1896, at 12:30 p.m., for the purpose of electing a new Trustee to supply a vacancy in that body.

A Trust Certificate must be produced by each person attending the meeting.

By order, A. BRODRICK, Secretary.

Winchester House, 50, Old Broad-street, London, E.C., 22nd October, 1896.

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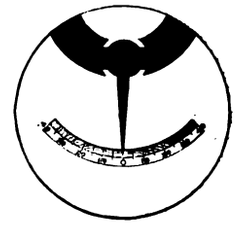

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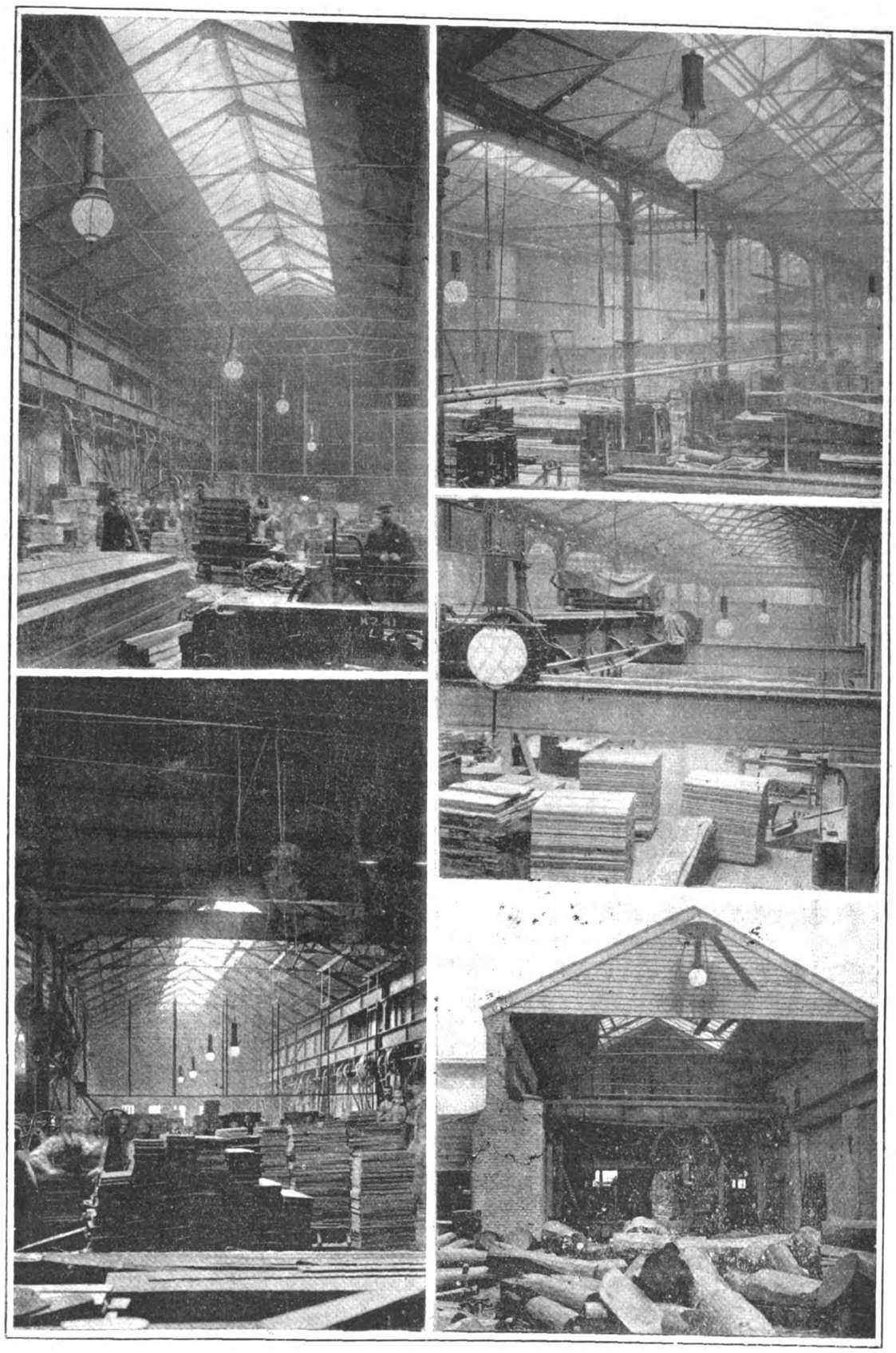

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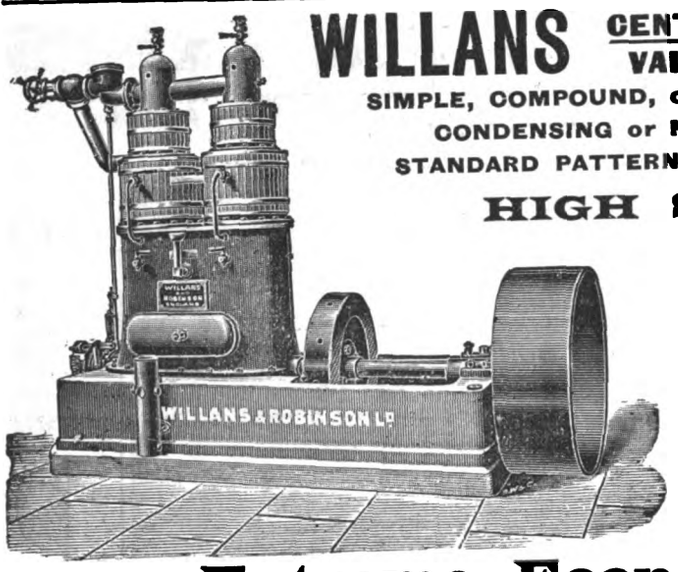


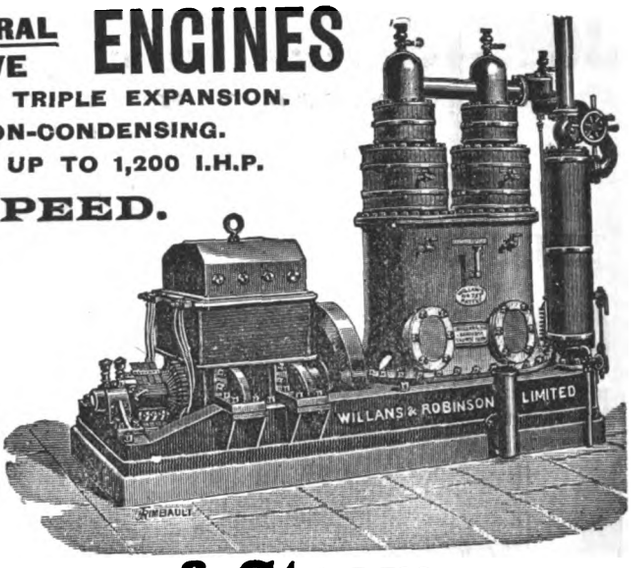


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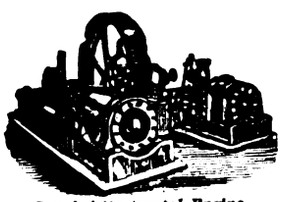

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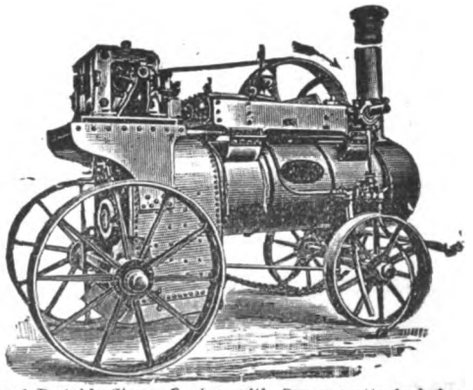

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# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

ESTABLISHED 1861–1878.

No. 962. [Vol. No. 26. XXXVII.] FRIDAY, OCTOBER 23, 1896. PRICE SIXPENCE.


## NOTES.

THE Gas and Electricity Committee of the Bradford Corporation decided last week to supply consumers with lamps free of cost. In days gone by, when there was but one quality of lamp in the market—the best—and when the low-pressure central-station manager did not hanker after the forbidden pleasures of high-voltage, the businesslike acumen of such a decision would have been open to question, since a reduction in the price of the Board of Trade unit would most certainly have been better appreciated by the consumer than new lamps for nothing and the old tariff for ever. To-day, however, the question is how to convert consumers to the 200-volt lamp faith, and how to protect them against the vendors of the cheap and nasty lamps. To take the supply—and, we presume, the testing—of lamps into his own hands at one stroke solves these questions for the central-station engineer, though it will, of course, add greatly to the work, and probably not a little to the worry, of the electrical staff, It has also been decided at Bradford to let out small motors (½ H.P. to 6 H.P.) on hire. This also is a commendable step, from the strictly business point of view, and so is the exhibition of electrical appliances. We only want municipal free wiring to complete the cycle.

THE results, engineering and financial, of the traction experiment now in progress on a short branch of the Third Avenue Elevated Railway in New York will be awaited with considerable curiosity by electrical engineers all over the world, and it is to be hoped that the experience gained will not be tightly bottled up until it is ancient history. The sudden severe fluctuations of the load upon an electric railway generator are no doubt a sore trial to everyone and everything concerned, but the New York remedy may well prove worse than the disease. To cart 256 heavy storage cells about on a 250 H.P. locomotive will doubtless tend to equalise the load upon the generators, but it must also tend to appreciably increase the normal load, and it would be interesting to learn why our American friends prefer this ambulatory accumulator station to the fixed type which finds favour over here.

THE telegraphists of Brussels have just been celebrating the jubilee of the introduction of Electric Telegraphy into Belgium in a manner highly appropriate to the occasion, and with commendable trouble to themselves. Every instrument that had been in use, ancient as well as modern, since the year 1846 was rehabilitated and put on exhibition in full working order, the operators, some of them no doubt much older than the apparatus, furbishing up their almost-forgotten methods of signalling for the purpose of illustrating by actual use the various stages through which the perfect systems of these days have been developed. The task reminds us of an ancient Swiss couple, a guide and his wife, who the other day, at the ages of 71 and 70 respectively, celebrated their golden wedding jubilee by climbing the Wetterhorn! A labour of love no doubt it was in both cases, whether at Brussels or Grindelwald. Apart from its inherent interest, the account we publish this week of the affair in the Belgian capital will be read with pride by Englishmen, to whose compatriots, COOKE and WHEATSTONE, the Belgians owe the inception of electric signalling in 1846, simultaneously with the formation of the Electric Telegraph Company in England.

ON page 822 will be found a brief description of a pretty and practical application to the construction of a new form of vacuum gauge of the discharging property of X-rays. The MCLEOD gauge, every lamp-maker agrees, is of little use to him; he prefers to test the vacua of his lamps by inspection of the mercury coming down the fall tubes, and later on by sparking. We trust, however, that the ingenuity of Messrs. BARR and PHILLIPS will do something to satisfy even the lamp-maker's requirements; at any rate, it would seem likely to give the vacuum-tube experimentalist a reliable criterion of the degree of exhaustion.

THERE is plenty of room for improvement in motors for electric traction. At present there is too great a liability on the part of the armatures to burn out; and the all-round efficiency is even now, notwithstanding the latest refinements in controller design, a quantity which might well be increased, and the increase of which seems within the bounds of practical possibility.

IN an article on "The Efficiency of Railway Motors," an abstract of which we publish this week, Mr. W. BAXTER criticises some items of practice in the construction of traction motors. Probably his most important point is that this class of motor should be designed to give a maximum efficiency at a low velocity—*i.e.*, at a lower percentage of the full speed than at present. The high figures obtained for the efficiency

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of these motors in shop tests, when run at full speed, are indeed, as Mr. BAXTER observes, no indication that they will have as high an efficiency on the track. A well-designed motor might be constructed to give a maximum efficiency of quite 90 per cent. in the shop test. The maximum efficiency of the motors on the Liverpool Overhead Railway, as measured at the car wheels, is about 87 per cent. The direct-coupled motors on the City and South London Railway have a maximum efficiency of about 88 per cent. Yet on this latter line it was estimated by Dr. EDWARD HOPKINSON that the average efficiency of the motors was not more than 70 per cent. The use of resistance gear instead of the series-parallel controller on the London line lowers the average efficiency of these motors to below that of motors controlled in the more modern way; so that Mr. BAXTER is probably within the mark in estimating an all-round efficiency of 75 per cent. between the trolley and the wheels of a series-parallel controlled car.

WHETHER it is sound advice which Mr. BAXTER gives, to abandon single-reduction gear, raises once more an old question. We ourselves are inclined to believe there is no general solution of the motor gear problem. Apparently, however, Mr. BAXTER wishes to see a return to double-reduction gear, which, we gather, he believes to give a higher efficiency. We doubt if this anticipation would be realised in actual practice, as, in all probability, the gain in the motor efficiency would be wholly lost in increased gear friction. To obtain, say, 50 H.P. by direct coupling, would entail a motor speed at which an efficiency of 88 per cent. might be realised. If a higher motor speed were adopted, with 3:1 single-reduction gear, a motor efficiency of 96 per cent. might possibly be obtained; but the gear itself would require to have an efficiency of not less than 92 per cent. in order that the total efficiency might be as high as before. The use of double reduction would nearly double the gear friction, without giving any very large available increase in the motor efficiency; and we doubt if even clean tramway gears ever have as high an efficiency as 92 per cent.

IT may be contended, however, that the purpose is not so much to augment the maximum efficiency as to ensure that the low-speed efficiency shall be raised. The use of a high-reduction gear would undoubtedly permit of a more solid construction of field-magnet, in proportion to the armature, without unduly raising the gross weight and cost of the motor. This would have the beneficial effect of reducing armature reaction, a result which would enable the motor more promptly to develop its full starting torque. It would also diminish the risk of sparking, and would enable the car to be run for a greater length of time continuously on the highest notch of the controller, with the field coils shunted, without injury to the commutator. Again, in virtue of the relatively greater mass of iron in the field-magnets, the saturation of the field would take place with a current corresponding to considerably less than the normal maximum speed. In other words, the motor would possess the quality advocated by Mr. BAXTER, of having its maximum commercial efficiency at less than full speed. But it has yet to be proved that this maximum commercial efficiency would be as high as the efficiency now obtained in common practice at the same fraction of the maximum speed. We suspect it would not be so high.

THERE is no doubt that we lag behind Germany in many electrical matters, notably in the applications of polyphase currents and in the construction of electric tram-lines. The reason for this is not that the English electrical engineer is a less efficient machine than his Teutonic rival; neither can our engineers be charged with undue conservatism. Polyphase currents are chiefly employed for long distance power transmission, and we have but little of Nature's "waste power" to transmit. The progress of electric tramway undertakings is, or was until quite lately, impeded by the lack of capital, the conservatism of the public, and still more by a natural detestation of any permanent disfigurement of the streets, rather than by any lack of enterprise on the part of electrical engineers. In the matter of central-lighting station practice we are, however, ahead of Germany. The German practice is to put the whole job into the hands of one big firm, and the independent consulting engineer is quite unknown. When a station is completed, it is a frequent practice to place a commercial manager at the head of the concern, with an engine-driver to look after the engines, &c. This is perhaps the reason that the correctness of the old method of charging has been little questioned in Germany. The firm who erect the station have no interest in endeavouring to produce a high-plant efficiency; and although the commercial manager ought to understand the economics of load curves, it is doubtful whether he often does.

OUR German contemporary, the *Elektrotechnische Zeitschrift*, publishes this week a long leader on the subject of charges for electrical energy. It mentions the usual form of load curve, and criticises the remedial efficacy of separate tariffs for light and power. The unfortunate owner of a dark shop who uses 10 kilowatts all day is compared with his neighbour who uses a 10 H.P. motor intermittently, and yet pays less per unit. It is stated that "The Oberschlesien Electricity Works have introduced an improvement in this direction, which brings us a step nearer to the ideal of a uniform and very cheap charge for current, and therefore deserves the notice of customers as well as managers of electric lighting works." Then follows a description of a method of charging which is practically the same as the Wright system. On the Oberschlesien plan 6d. per unit is to be paid for a number of units corresponding to the use of all the lamps and motors installed for 400 hours per year, after that only ¼d. per unit is to be charged. It is somewhat surprising that our Berlin contemporary should herald the introduction of a tariff system of this kind as a novelty. The only novelty we can see about this one is the surprisingly low charge of ¼d. per unit. This would seem ruinously low, except, perhaps, for a water-power station.

WE have been appealed to, to give our opinion as to whether or no, in the event of a tramway traffic manager being a non-technical man, the chief engineer and staff at the power-house

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should be placed under his jurisdiction. We make no pretensions to be tramway experts, and therefore do not propose to lay down the law on such a delicate point. Indeed, in such matters the laying down of general laws, and the disregarding of the particular circumstances of individual cases, is omniscience and oracularity run mad, since so much depends upon the engineers, who object to be subordinates, and the traffic manager, who wishes to be captain of the ship. Doubtless in these early days of electric traction in this country traffic managers will be inclined to treat the engineering staff in much the same cavalier manner as they treated the old stable hands. Doubtless, also, the different status and greater importance of the engineering staff will become better recognised as time goes on.

**The Electro-Harmonic Society.**—The second concert of the season will be given on Friday next, the 30th inst.

**Submarine Telegraph Memorial.**—The first meeting of the Executive Committee will probably be held on Friday next, the 30th inst.

| **Cable Interruptions.**— | Date of Interruption. |
|---|---|
| Puerto Plata—Martinique | Dec. 19, 1895. |
| Monte Alegre—Santarem | May 5, 1896. |
| Para—Maranham | Oct. 8, 1896. |

**Prof. J. J. Thomson.**—Prof. J. J. Thomson is now in America taking part in the sesquicentennial celebrations at Princeton, and he has arranged to deliver a special series of lectures on the Electric Discharge in Gases.

**Homage to an Inventor.**—On September 27th the monument erected at Saint-Hilaire-le-Bonis, to Archereau, the first French inventor of the arc lamp, was unveiled. M. Grimaud made a speech in which he gave an account of Archereau's life and his disinterested devotion to science. After this ceremony a bronze medallion, on the house in which the inventor was born, was also unveiled.

**Obituary.**—We regret to record the death, on Wednesday last, of Mr. J. H. Greathead, well known to our readers in connection with the ingenious tunnel-driving system employed in the construction of the City and South London, Waterloo and City, and Central London Railways. Mr. Greathead was, in conjunction with Sir Douglas Fox, engineer to the Liverpool Overhead Railway.

**Automatic Switches.**—In reference to a Note in our issue of October 9th, mentioning an automatic time switch, Mr. Ballance writes us that we are wrong in supposing that there would be sparking on the clock-face. Contact is *made* on the clock-face, but so soon as the switch moves the clock-face circuit is broken, so that, on the hand leaving the contact piece, there is no spark, and it is also immaterial how long the trailer on the hour hand is in contact with its pin.

**Prof. Silvanus Thompson's Suggestion.**—In Mr. W. T. Ansell's letter which appeared on p. 807 of our last issue under the above heading, there occurred an inexcusable printer's error. Mr. Ansell is made to talk of the "Bright proposal;" he wrote "*bright* proposal," quoting, somewhat inaccurately, an expression used in our leading article of October 9th. The proposal in question was voiced by Prof. Silvanus Thompson, and not by Mr. Charles Bright, who was good enough to call our attention to the misprint.

**Physical Society.**—There will be a special general meeting of this Society in the rooms of the Chemical Society at 5 p.m. on Friday, October 30th, after which there will be an ordinary meeting, of which the following is the programme:—"A Satisfactory Method of measuring Electrolytic Conductivity by means of Continuous Currents," by Prof. W. Stroud and Mr. J. B. Henderson; "A Telemetrical Spherometer and Focometer," by Prof. W. Stroud; "An Experimental Exhibition," by R. Appleyard. There will be a Council Meeting at 4 p.m.

**Battersea Polytechnic.**—Particulars will be found in our advertisement columns of the evening classes in electrical engineering at the Battersea Polytechnic, which are under the immediate supervision of Mr. A. E. Briscoe, B.Sc. Testing forms a feature of the laboratory work, and the Institute possesses electrical and physical laboratories and a dynamo testing room. There are trade classes in which electric wiring, and house fitting and electric workshop practice are taken. These classes are in charge of Messrs. Sillar, Walton and Brew.

**The Pacific Cable Conference.**—A *Times* telegram, dated Ottawa, October 21st, states that at a meeting of the Canadian Cabinet a formal order was passed appointing Sir Donald Smith, Mr. Sandford Fleming, and Mr. A. G. Jones, of Halifax, Nova Scotia, as Canadian Commissioners to the Pacific Cable Conference to be held in London on November 9th. Other telegrams state that the Canadian Government has asked that the re-assembling of the Conference may be postponed until the second week in December.

**"The Automotor and Horseless Vehicle Journal."**—No. 1, Vol. I., of this last addition to the sixpenny monthlies lies before us. The matter is varied, the tone sanguine, the style breathless. We note amongst other items a useful *précis* of the Locomotives on Highways Act (1896), which comes into force, by the way, on November 14th next, and a biography of Sir David Salomons, illustrated by a portrait. The leader is devoted to "Ourselves," whose object in life, we are told, will be to chronicle items of autocar interest, to describe and criticise novel productions, and to "expose abuses which are calculated to injure the Industry of which we aim to be the worthy and efficient representative."

**Teredo-Proof Paint.**—"The Commission appointed by the Secretary of the Navy to test a teredo-proof paint invented by Thomas J. Childerson, a painter at the Pensacola navy yard, has," says the *Railway Review* of Chicago, "concluded its labours. On March 16th four pieces of solid heart pine wood were sunk at the navy yard. One piece was unpainted, and the others had one, two and three coats of the teredo-proof paint respectively. At noon on September 15th the three members of the Commission assembled, and had the four pieces of wood raised. The piece that was not painted was literally honeycombed by the teredo, and fell to pieces. The other three pieces were not touched by the insects, and were perfectly dry on the interior." The Commission considers the invention a success.

**Franklin Institute.**—We have received from this well-known Institution a copy of the "program" of lectures for the ensuing session. Amongst these lectures the following will be of interest to our readers:—Friday, October 30th, Prof. E. J. Houston, "X-Rays;" Friday, December 11th, Mr. Francis A. Fitzgerald, "Manufacture and Development of Carborundum at Niagara Falls;" Friday, December 18th, Mr. H. M. Chance, "Applications of Electricity in Gold Mining;" Monday, January 4th, Lieut. Bradley A. Fiske, U.S.N., "Electricity in Warfare;" Friday, March 12th, Prof. D. S. Jacobus, "Artificial Light: Modern Methods Compared—Electric-Incandescent, Welsbach, Acetylene;" Friday, March 26, Mr. Alfred E. Hunt (President Pittsburg Reduction Company), "The Development of the Use of Aluminium in the Arts."

**The Proposed Sub-District Electric Railway.**—*The Times* of Tuesday contained an excellent summary of the *pros* and *cons*, from a financial point of view, of the proposed electric railway from Earl's Court to the Mansion House. "The conclusion of the whole matter would then seem to be that here, as in every other case of recent years, it is exceedingly difficult to see how a commercial profit can be made out of supplying the undoubtedly crying needs of the London public in the matter of railway transport. In this case the thing may possibly be done by economy and good management. There is certainly, however, no margin for financiers' profits; and it is difficult to see the justification for a 40 per cent. rise in the market quotation of Metropolitan District Railway Stock."

**A New German Insulating Material.**—The German technical press sings the praises of a new insulating material, called "Ambroin," compounded of copal-resin and a silicate. The specific resistance of the material is stated to be "more than

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a milliard of ohms," or, in plain English, $10^9$ ohms. Although this sounds very big, it may be mentioned that ebonite has a specific resistance of $28 \times 10^{15}$ ohms per cubic cm., and a slab of "ambroin," 50cm. square and 2cm. thick, would have an insulation resistance of less than a megohm, if its specific resistance were $10^9$ ohms per cubic cm. We also read that a piece of the material 0·34mm. thick withstood 5,000 volts without being pierced. On referring to a Paper read by Mr. Alexander Siemens in 1892 before the Institution of Electrical Engineers, it will be found that experiments on vulcanised india-rubber and celluloid gave a much smaller sparking distance at 5,000 volts, and the resistance of ebonite and vulcanite to sparking is doubtless still greater than that of india-rubber or celluloid. Insulation resistance, however, is not the sole desideratum in an insulating material, and it is claimed that "ambroin" is less inflammable than celluloid, vulcanite or ebonite, and withstands the action of all acids but acetic acid fairly well, though alkalies attack it.

**The Institution of Junior Engineers.**—The annual general meeting of this Institution was held at the Westminster Palace Hotel on the 16th inst., the retiring Chairman, Mr. H. J. Young, presiding. There was a large attendance of members. The Council's annual report, which was read by the Secretary, Mr. Walter T. Dunn, showed that the total membership was now 454, an increase of 36 on the past year. Mr. A. R. Binnie, M.Inst.C.E., was the President for the ensuing sixteenth session. Seven meetings had been held for the reading and discussion of papers, and eleven visits to works had been made, at which the average attendance had been nearly 90. The summer meeting in Scotland had been highly successful. The report also contained a copy of the address of congratulation presented to Lord Kelvin, one of the Institution's Vice-Presidents, on his professional jubilee. Appreciative reference was made to the work carried on by Mr. H. Kempster as Hon. Librarian, and to the special course of lectures on marine engine design, by Mr. H. M. Rounthwaite. The Institution's first conversazione, the appointment of delegates to the Sanitary Congress, and the office fund, were other matters noticed in the report. A vote of thanks was passed to the retiring officers for their past services. The scrutineers reported the election to have resulted as follows:—Chairman, Mr. H. B. Varley; Vice-Chairman, Mr. Basil Joy; Hon. Librarian, Mr. H. Kempster; Hon. Auditors, Messrs. W. H. De Ritter and P. Marshall; Members of Council, Messrs. Adam Hunter, E. Berry, K. Gray, Bertram Joy, A. Anstruther Thomson, G. F. Burtt, E. King, and Walter J. Hunter. On Saturday, October 31st, at 3 p.m., the members of this Institution will visit the Hotel Cecil, to inspect its electric lighting, hydraulic, warming and other engineering features.

**The Niagara Electro-Chemical Company's Plant.**—What is really one of the largest and most substantial plants yet erected on the lands of the Niagara Falls Power Company at Niagara Falls is, says our Niagara Falls correspondent, that of the Niagara Electro-Chemical Company. The site of the land leased adjoins the Acetylene Light, Heat and Power Company's site on the west, a street passing between the two plants. The power is supplied by the Niagara Falls Power Company, and comes to the factory over cables laid above ground and covered with a box. At present about 500 H.P. is taken. This is passed through rotary transformers before being used. The Niagara Electro-Chemical Company was founded in 1895, with a capital stock of $100,000, for the purpose of manufacturing sodium from caustic soda and peroxide of sodium from sodium under the Castner electrolytic process. The principal stockholders of the Niagara Electro-Chemical Company are the Aluminium Company (Limited), London and Oldbury; the Deutsche Gold und Silber Scheideanstalt vorm. Roessler, of Frankfort; and the Roessler and Hasslacher Chemical Company, of New York. The officers of the Company are Mr. Franz Roessler, President and Treasurer; Mr. Hamilton Young Castner, Vice-President; Mr. Jacob Hasslacher, Secretary and Manager; while, in addition to the above-named, Mr. William A. Hamann is a Director of the Company. The main office of the Company is in New York City. Mr. W. B. Reilly is in charge of the Niagara Falls office of the Company, while Mr. George F. Brindley, formerly of the Aluminium Company (Limited), of Oldbury, is Manager of the Niagara works. At the time of writing the Niagara plant is not in full operation, but it is expected to be so before very long.

**Inductor Alternators.**—Last year the Maschinenfabrik Oerlikon applied, through Mr. W. Lloyd Wise, for a patent (No. 13,164 of 1895) for an alternator of the inductor type. The claim was for "an alternating-current dynamo of the type herein referred to, wherein the number and arrangement of the grooves or holes in each armature-ring is such as to form polar teeth or projections equal to double the number of the pairs of poles multiplied by the simple or half-number of the phases of the system; and there is employed in combination with such armature rings a rotary magnet, which, without carrying any current conductor, consists of magnetic cast-steel or iron bow-shaped pieces, which are magnetically independent of one another, are equal in number to that of the pairs of poles, and carry on each leg a sheet-iron pole-shoe, substantially as described." On the application of Mr. Mordey, this patent was not granted until the specification was modified by the insertion of the following sentence before the claim:—"Having now particularly described and ascertained the nature of the said invention, and in what manner the same is to be performed, I wish it to be understood that I am aware of the specification of Letters Patent No. 8,262 of A.D. 1887, granted to William Morris Mordey, and I do not claim anything described and claimed therein; but I declare that what I claim is:— . . . ." The patent of Mr. Mordey's which is referred to is that which protects his well-known type of alternator. In it he describes, among others, two forms of inductor alternator, to one of which the machine described in the Oerlikon patent is very similar. On studying Mr. Mordey's patent it would seem that, unless he has been anticipated, he holds the master patent in this country for alternators of the inductor type.

**Action of Metals and Salts and on Röntgen and Ordinary Rays.**—In Section B of the British Association at Liverpool, a Paper on "The Action of Metals and their Salts on the Ordinary and Röntgen Rays: a Contrast," was read by Dr. J. H. Gladstone, F.R.S., and W. Hibbert. The authors, having worked at the action of metals and metallic salts on ordinary light, extended the investigation so as to compare that action with the corresponding transparencies or absorptions for Röntgen rays. The work was principally carried on in the laboratory of the Polytechnic, Regent-street, and photographs of the results were exhibited. The metals experimented on include some with which it is difficult to work, such as lithium, sodium, and potassium. In regard to the rays of ordinary light, solid metals absorb them completely, and are therefore opaque. If, however, the metals combine with an electro-negative radicle, they lose their power of absorbing light, except a few which show the phenomena of selective absorption. Solutions of salts resemble the crystallised solid in their action on light. With regard to the Röntgen rays, on the contrary, metals exhibit every degree of opacity or transparency, from lithium, which is practically non-absorptive, to such metals as gold and platinum, which are practically opaque, as shown by Barrett and others. The salts of the metal are not transparent; but the metal in them seems to have the same effect on Röntgen rays as in the uncombined condition. This seems to be equally true when the salts are dissolved in water. The order of absorption follows that of atomic weight, not that of density or combining proportion. The absorption of the Röntgen rays by a salt in solution appeared to be that of both its constituents added together, plus that of the solvent.

**Electricity in Shipbuilding.**—The engineering gold medal of the North-East Coast Institution of Engineers and Shipbuilders has been awarded to Mr. Henry Foster, for his Paper on "The Application of the Electric Arc to Machinery and Boiler Repairs." During the past session a great number of papers of interest to electrical engineers have been read. Among them we may mention the following:—"The Surface Condensing Plant at the Newcastle and District Company's Electric Light Works," by Mr. William Cross; "An Investigation into the Forces tending to produce Vibration in High Speed Engines,"

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by Mr. J. M. Allan; "The Determination of the Forces which produce Vibration with Three-Crank Engines at High Speeds," by Mr. R. M. Ferrier; "Balancing High Speed Engines," by Mr. A. E. Doxford. During Colonel Henry F. Swan's presidential address at the opening of the new session, he made the following remarks on the applications of electricity in shipbuilding:—

"There is no question that electricity is destined to play a very important part in connection with shipbuilding in the future, both as regards portable appliances, and also the general driving of the shop machines. It of course involves a certain amount of courage, not to speak of a large expenditure of capital, to abolish existing steam engines, boilers, &c., and replace them entirely by electric power; some establishments are therefore dealing with the matter tentatively, whilst at Hartlepool one of the chief yards has been laid out for electric driving entirely, thus abolishing several isolated boilers and steam engines, and dispensing with the necessary attendants; and, in addition, obtaining the facility of being able to use only such individual machines as are actually required from time to time, instead of having, as at present, all machines going, whether wanted or not, which, with the loss of power by transmission through long lines of main shafting, counter-shafting, pulleys, belts, &c., involves a total loss of the power transmitted varying from 30 per cent. to as much as 70 per cent. I am deeply impressed with the fact that there is a great future for this mode of applying power, and in which I am fully convinced that great developments will yet be shown, and I hope that members of the Institute will turn their attention in this direction. Although electricity has been efficiently used as a motive power in small launches, it may, in the future, be not impossible to utilise this mode of propulsion for larger vessels. The application of electricity, whether to vessels, locomotives, tramcars, or even to motor-cars—with an invasion of which we are threatened—furnishes great possibilities for the student who takes an interest in this important subject, and who is prepared to work hard with the view of producing some new development which may bring advantage to himself and also be a benefit to others."

**An Electric Branch of the Canadian Pacific Railway.**—The latest development in Canadian electric railway work is, says the *Electrical Engineer* of New York, the equipping of the Aylmer branch of the Canadian Pacific Railway with electric service. This line extends from Hull, a suburb of Ottawa, to Aylmer, where it connects with the Pontiac Pacific Junction Railway. The section from Hull to Aylmer has been leased by the Hull Electric Company for a term of 35 years, the understanding being that, besides passenger and mail traffic, they are to handle all through and local freight delivered to them by either the Canadian Pacific Railway or the Pontiac Pacific Junction Railway. As they are the only connecting link with the Pontiac Pacific Junction road, it can readily be understood that the quantity of freight is considerable. At the Aylmer end of the line the Company owns 60 acres situated on Deschesne Lake, a sheet of water 3 miles wide by 27 miles long. The traffic has been far beyond expectations, and the train service has increased until there are now running 36 regular trains each way per day, besides special excursion trains. Power is obtained from Deschesne Rapids, where the lake of the same name empties itself into the Ottawa River, at a point midway between the termini of the road. The turbine wheels are of the "New American" type, and operate under a head of 9ft. Four 60in. wheels are now installed, and space is provided for two more. By means of "Barbour" water-wheel regulators, the current output of the generators is automatically kept constant by cutting in or out dead resistance as the load varies on the line. By this means the speed of the machines is kept constant and the variation in voltage is held within a very close limit. All the cars are mounted on double trucks, and are each equipped with two G. E. 1,200 motors with K. 21 controllers. A locomotive, the first of the kind operated in Canada, is used for the through freight service. It weighs something over 20 tons, and is provided with double trucks, each axle being equipped with a motor. As all the wheels are driven, full traction advantage is obtained from the total weight, and a drawbar pull of 10,000lb. can therefore be exerted, equivalent to the power of the average 35 or 40-ton steam locomotive. This was designed and built by the Canadian General Electric Company.

**The London County Council and the Tramways.**—The Highways Committee of the London County Council are apparently not yet weary of well doing; once again, at next week's meeting of the Council, they will present a report on the London tramway question, and once again, no doubt, the report will be referred back. In this report the Council will be asked to consider a proposal for the immediate purchase of the whole of the undertakings within the County of London of the North Metropolitan and the London Street Tramways Companies, and for a subsequent lease to the first-named Company of the lines of the two Companies. The arrangement made, subject to the approval of the Council, is that the Companies shall sell their tramways to the Council at £10,000 per mile for double, and £5,000 per mile for single lines, and at this rate the purchase-money would amount to £437,000. Including the money paid for lines already purchased, but excluding the sums (to be settled by arbitration) to be paid for *buildings*, &c., the total capital expenditure on tramways will be about £540,000. The Committee point out that the proposed arrangement is such as in their opinion the Council should accept. They consider that the amount of rent under the proposed agreement (£45,000 a year, together with 5 per cent. of the increase of the gross receipts from the existing lines of the two Companies, both within and without the county, over the gross receipts for the year 1895) very fair. At the expiration of the lease in 1910 the Council will have received by way of fixed rent and percentage of receipts a total sum estimated at £903,630, of which £463,907 will go in relief of rates. The Committee further state that they have considered the question of the advisability of the adoption of some system of electric or other mechanical traction, and have arranged with the Company that if at any time during the continuance of the lease the Council should consider it desirable that some form of mechanical traction should be adopted, the leasing Company will be prepared either to carry out the necessary works on terms to be arranged with the Council, or, should the Council itself execute the works, to pay a fixed rent and a share of the extra profits which may be derived from the use of such traction. In the opinion of the engineer the conditions are so different in London, and in different parts of London, from those which obtain in any other city where electric traction is in use, that it is impossible to estimate, with any approach to reliability, what may be the results of its adoption. The only really satisfactory course appeared to the Committee to be that they should institute an exhaustive inquiry into the several systems; and, when convinced that any one possesses merits sufficient to justify the belief that it would be more economical as well as more convenient than the present horse system, to make a practical trial of it for a sufficient period over a typical portion of the London streets.

**Contemporary Electrical Science.**—In the *Physical Review* for July and August A. Wilmer Duff describes some delicate experiments made for the purpose of determining whether liquid dielectrics show any change of viscosity when subjected to electrostatic stress. The experiments, after several failures, answered the question distinctly in the affirmative. Castor oil gave the most definite results. When subjected to a potential gradient of 27,000 volts per centimetre, its viscosity, as determined by the fall of drops of mercury or small shot through it, increased by about one-half per cent. The small shot experiments are subject to a source of error which should not be overlooked. The electric force may turn them into a direction with their largest diameter parallel to the lines of force, and thus make them sink more slowly. But the percentage retardation being the same as in the mercury drops, this is improbable. Moreover, spheres of non-conducting material of nearly the same specific inductive capacity as castor oil, such as artificial pearls of hard wax, give nearly the same result as the shot. Glycerine also gives indications of an increase of viscosity, but heavy paraffin oil shows a slight decrease.—— W. S. Franklin, in the same number, describes a new electrolytic generator for hydrogen and oxygen. The generator consists of a series of chambers of an alloy of lead and bismuth. The various sections are divided by plates of rubber inser ed in the top and bottom of each chamber. The gases in ascending are caught in a kind of comb work of glass plates slightly inclined from the sides towards the centre of each chamber, and are collected in pairs of tubes provided with traps. Thus the difficulty of keeping the gases from mixing is overcome to a great extent, and the purity attained varies from 85 to 95 per cent. The efficiency of this generator is claimed to be 38 per cent. This is very high, and is ascribed mainly to its low resistance.

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## AUTOMATIC CURB TRANSMISSION.

The following particulars relating to the Muirhead form of automatic curb apparatus (Figs. 1 and 2) is extracted from a copyrighted work on the subject which has been prepared for the use of the staffs of some of the principal cable companies. The extracts are published by permission :—

The object of automatic curb sending on submarine cables is to diminish the retardation due to inductive effects, and this is usually accomplished by sending two or more currents, opposite in sign, into the cable for the production of each signal, instead of one current only. In the instrument here described two currents are employed, this method being known as "single curb," in contradistinction to "double curb," when more than two currents are used. The difficulty in reading on long cables is caused by the current (gradually diminishing in strength) continuing to flow out at the distant end of the cable after the battery contact has been broken at the sending end, and it is the object of the "reverse" or "curbing" current to check this continuous flow or discharge, and to quicken the return of the "arrival curve" to the zero line. This has the effect of sharpening the "curves of arrival," or received signals, and, by increasiug their legibility, enables an

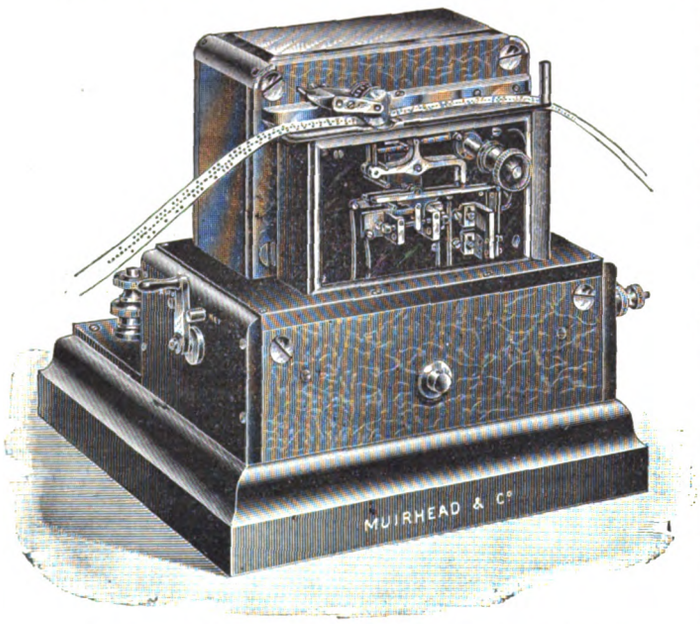


FIG. 1.—Muirhead Curb Sender. Front View of Apparatus.

increased speed of signalling to be obtained. The use of condensers attains this object to a certain extent, as by their means an impulse is communicated to the cable instead of a continuous current, and as it soon reaches a maximum and falls quickly back to zero, a curbing effect is produced. But even with condensers there is still a noticeable "lag" in the signals at high speeds, and, therefore, further curbing is advisable. As curbing, however, reduces the size of the signals, it is necessary either to use more battery power or more sending condensers with the automatic curb sender than when hand-keying is employed, and especially so when it is desired to increase the speed of signalling. The success of any automatic curb sender depends upon the promptness and regularity of the curbing and signalling contacts.

The following diagrammatic sketch (Fig. 3) explains the general principle of the Muirhead instrument :—

$L_2$, $L_2$ are two levers connected respectively to "line" and "earth," resting normally on the contacts $y$, $y$, which are joined together in the same manner as in an ordinary cable signalling key, and connected to the upright lever $L_3$, which, by the action of the revolving cam C upon the pawl $G_3$, makes connection alternately with the upright and fixed contacts $K_1$ and $K_2$, to which are joined the opposite poles of the batteries $B_1$ and $B_2$; $x$, $x$, are the two other contacts joined together in the same manner as the lower contacts of an ordinary cable signalling key, and connected to the junction of $B_1$ and $B_2$, the "signalling" and "curbing" batteries respectively.

The message to be transmitted is punched on a slip of paper in right and left holes, corresponding to the dash and dot of the Morse telegraphic alphabet. A line of central holes is also punched to facilitate the drawing along of the paper. The punched slip is put into the transmitter and carried along at a uniform rate by means of a motor. When either a right or a left hole passes above one of two needles attached to the two levers, $L_1$, the corresponding needle passes upwards through the hole, and in doing so allows the further end of the lever to which it is attached to descend, and to carry down with it one of the levers $L_2$ to the contact $x$ (Fig. 4). During the period of this contact, that is to say, during the time occupied by the passage of one space in the perforated paper, the cam C revolves once, and by means of the pawl $G_3$ causes the upright lever $L_3$ to make contact alternately at $K_1$ and $K_2$, thus sending opposite currents to line from the batteries $B_1$ and $B_2$. For example, should the needle which is attached to the upper lever corresponding to the lower "earth" lever pass through a hole in the perforated slip the "earth" lever is knocked over to the stop $x$, and a zinc current from battery $B_1$ is sent to line through $K_1$ and $L_3$, followed

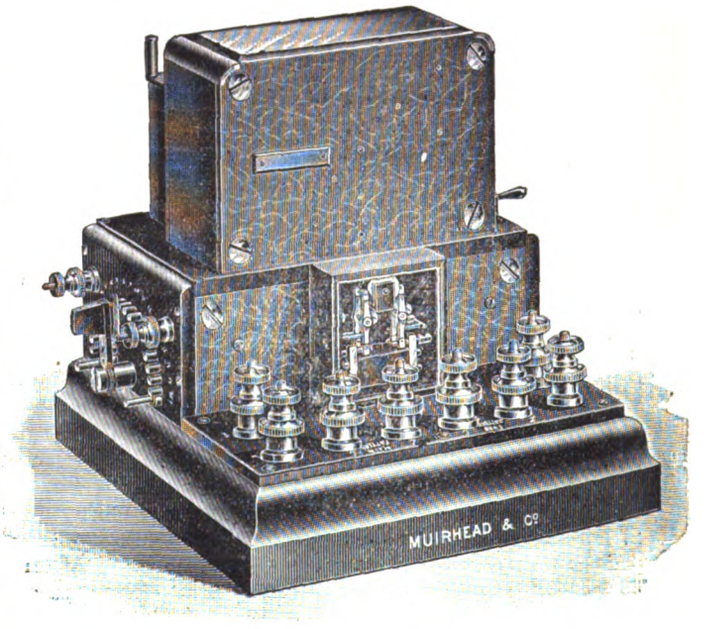


FIG. 2.—Muirhead Curb Sender. Back View of Apparatus.

by a copper current from battery $B_2$, viâ $K_2$ and $L_3$, as soon as the pawl $G_3$, actuated by the cam C, causes the lever $L_3$ to pass over from contact $K_1$ to $K_2$. On the other hand, should the needle which is attached to the upper lever corresponding to the lower line lever pass through a hole in the paper, the sequence of currents is opposite to that just given. Thus an operation of reversal of currents takes place during the passage of every space in the paper; but whether the signal current is to be "copper" and the curb current "zinc," or *vice versâ*, is determined by whether the needle has risen up through a hole on the left side of the perforated slips or on the right.

Motion is imparted to the transmitter by means of a motor constructed on an extension of the principle of the well-known "mousemill" of the Kelvin recorder.

The revolution of the machinery of the transmitter accomplishes two objects. It moves the paper along by means of a toothed roller or spur wheel, D (Fig. 4), working into a central row of holes in the punched slip, and it causes the cams which are fixed to the rotating axle to effect certain electrical contacts, through the agency of various pawls and levers, the action of which is governed by the motions of the cams. The toothed roller which engages in the central holes of the paper ribbon has 10 teeth, and it revolves once for every 10 revolutions of the axle to which the cams are fixed. Hence the cams make one complete revolution for every space in the

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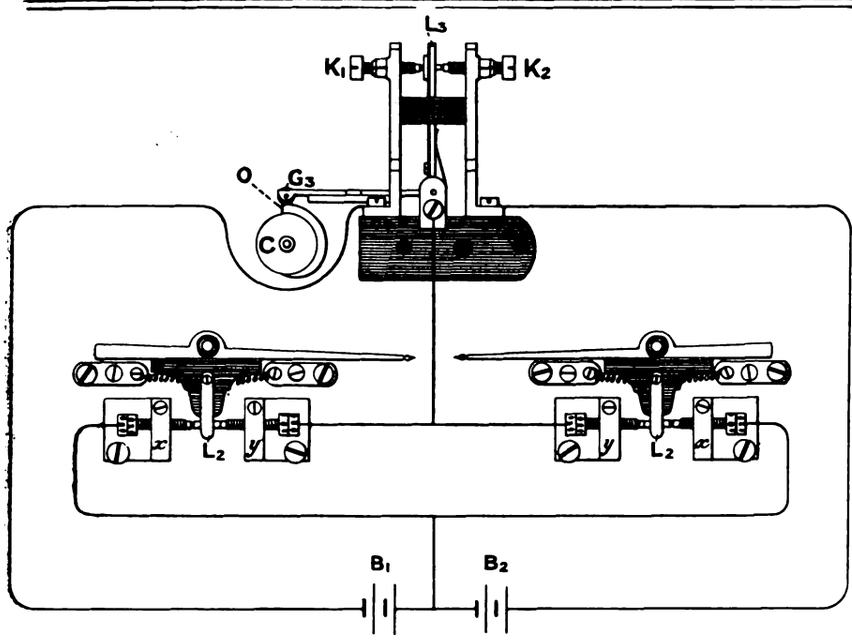


FIG. 3.

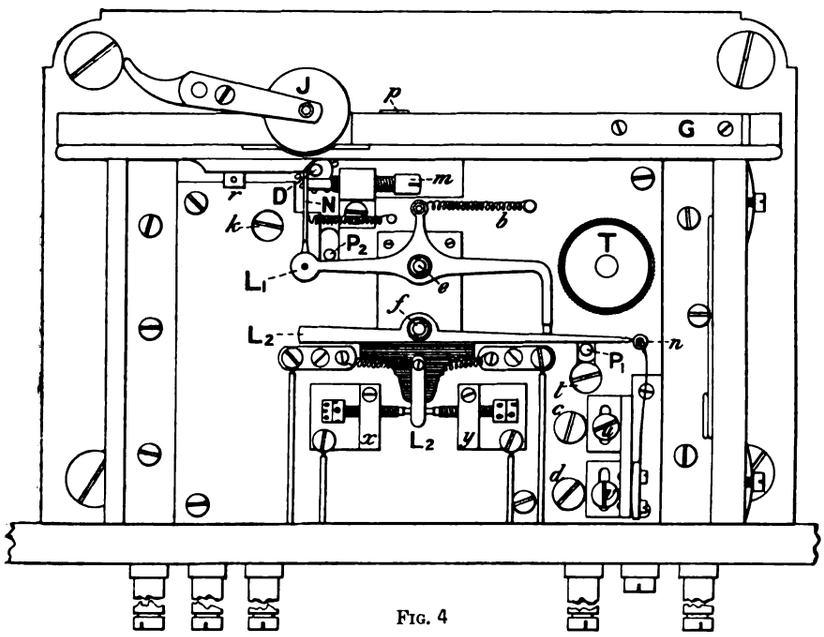


FIG. 4

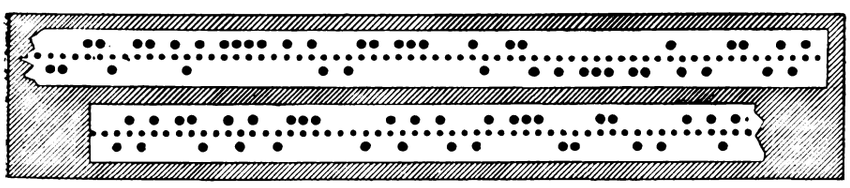

FIG. 5.

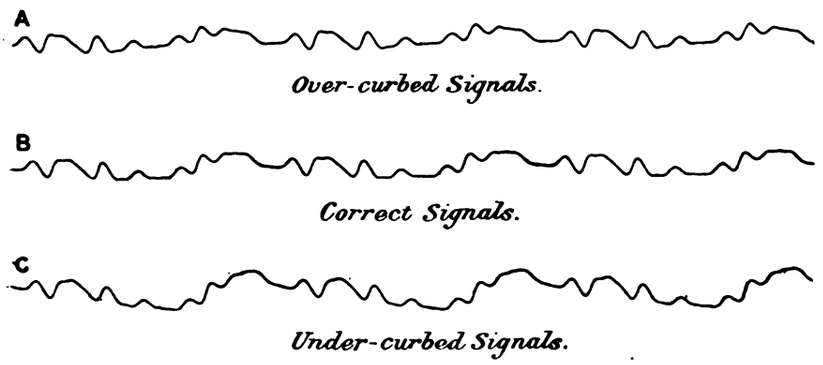


FIG. 6.

paper. Fig. 5 shows the appearance of a piece of the punched paper ribbon. A space between two letters is formed by one central hole, and a space between two words by three central holes. The spur or toothed wheel D, which carries the paper, is shown in front elevation in Fig. 4. It revolves in a slot cut in the guide plate G; and its teeth, after passing through the central holes in the paper slip which runs above them, engage with corresponding grooves cut in the circumference of the jockey roller J, which thus revolves with the spur wheel, and assists in drawing the paper forward. On each side of the slot in which the spur wheel D revolves a hole is cut in the guide plate for the passage upwards of the needles N attached to the upper levers $L_1$.

In Fig. 6 three specimens of signals are given to illustrate A, the effect of too much curb current; B, the shape of the signals when the amount of curbing is correct; and C, the effect of too little curb current.

## ACETYLENE REGARDED AS AN ELECTROLYTE.

Viewing acetylene as a simple hydrocarbon—a member of the $C_nH_{2n-2}$ series—there appears no ground for supposing that it can function as an electrolyte. Regarding its tendency to form metallic derivations, however, the belief in its essentially electrolytic character is not to be dismissed at a stroke as a chimera. There be those physico-chemists who engage with a praiseworthy persistency in seeking to extend the scope of the hypothesis of dissociation in solution which has fascinated and enthralled them, and they are never happier than when gathering data making for the inclusion within the bounds of that hypothesis of bodies not obviously subject to its sway. It is, therefore, not surprising that acetylene should have occupied their attention, nor that those convenient measurements in which the error of observation is of the same order of magnitude as are the quantities observed, should have plainly pointed to a solution of acetylene in water as definitely electrolytic. Messrs. Harry C. Jones and Charles R. Allen have found that the molecular conductivity of an aqueous solution of acetylene is similar to that of acetic acid; hence they have concluded that acetylene, on solution, suffers electrolytic dissociation. Attracted by this statement, and hoping to discover carbon acting as an anion in fused or dissolved salts of acetylene, *i.e.*, carbides, Herren G. Bredig and A. Usoff have studied bodies of the type $Ag_2C_2$ $CaC_2$, and detail their conclusions in the *Zeitschrift für Elektrochemie*. It is a regrettable circumstance which must now be chronicled, viz., that the repetition of the experiments of the former pair of investigators goes to show that their results are erroneous, and that the molecular conductivity of acetylene is exceedingly small, and is barely to be distinguished from that of the inevitable accompanying impurities.

Loth to abandon the opinion that acetylene may be looked at as hydrogen carbide in which the carbon is anionic, the

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present authors confine themselves to the cautious statement that in any case acetylene is a very weak electrolyte, and so must be ranked as an acid of the feeblest description. Hence they deduce certain conclusions which are best reproduced in a paraphrase of their own words. "The salts of acetylene must be almost completely hydrolysed in aqueous solution, a result to be expected from the known reaction of calcium carbide with water. On account of this fact, the old view (opposed recently by Keiser) that silver acetylide contains oxygen, becomes intelligible; for water, regarded as containing the ions H and OH, acts upon $Ag_2C_2$ and gradually forms from it silver oxide $Ag_2O$. The progress of this hydrolysis is dependent on the number of H and Ag ions, whence it follows that $Ag_2C_2$ is most readily prepared from an ammoniacal solution in which the number of H and Ag ions is considerably smaller than in pure water. A direct proof of the same tendency is afforded by the fact that a solution of sodium chloride becomes alkaline when shaken with $Ag_2C_2$." The ultimate conclusion reached by Herren G. Bredig and A. Usoff is that acetylene is not perceptibly dissociated in aqueous solution, and that it stands in a position intermediate between electrolytes and non-electrolytes.

The whole matter is more than commonly instructive. From data which are in direct contradiction to other data put forward by investigators of equal repute, data, too, of such small magnitude that no certain line can be drawn between what is essential and what adventitious, are deduced explanations of quite a number of disconnected phenomena. Truly it is the faculty of correlation run mad.

## A NEW VACUUM GAUGE.

BY JAMES MARK BARR AND CHARLES E. S. PHILLIPS.

Some recent investigations of M. Jean Perrin* upon the action of Röntgen rays in an electrostatic field have led the writers to utilise the principle explained for the construction of a gauge which will give readable indications of pressure in high vacua.

On investigating the discharge of an electrified body by X-rays, M. Perrin noticed a phenomenon which determines in a precise manner the part played by the surrounding dielectric. He allowed the rays to penetrate into the region under investigation, and found that the tubes of force encountered by X-rays behave as conductors, provided the tubes of force are in a gas. An electrified body placed in air discharges itself if some of the tubes of force which it emits are cut by the rays. To explain this he supposes that the rays dissociate certain molecules of the dielectric where they penetrate it, thus liberating positive and negative ions. He points out that if the medium is gaseous the two systems of ions may pass through each other, always, however, along the tubes of force. The X-rays furnish the energy necessary to separate the ions, and the electrostatic field the energy necessary for their transmission.

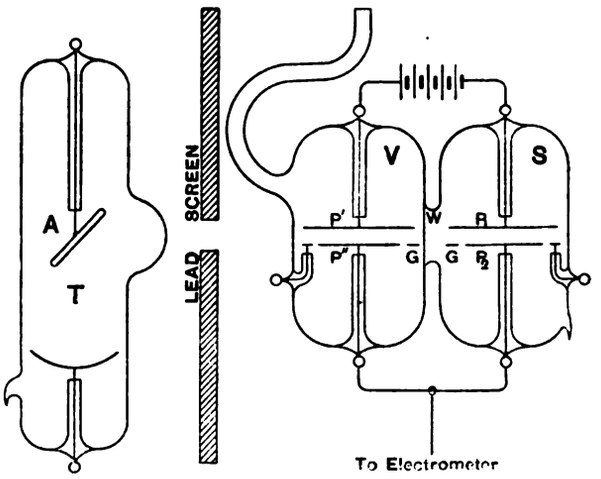
M. Perrin found that when the electrostatic field varied from 70 volts to 220 volts, the change in the rate of discharge was less than $\frac{1}{200}$. Hence one is practically independent of the potential difference; and it is obvious that one is also quite independent of change in the X-rays, provided a zero method is used.

We propose to utilise these results in their application to a new form of vacuum gauge, in the following manner:—

Two glass vessels, V and S, as shown in the figure, are joined by a common wall of window, W, and contain respectively two small condensers, P′ P″ and $P_1$ $P_2$, arranged so that they lie close together, with their plates in the same plane. The upper plates, P′ and $P_1$, are joined to the two terminals of a battery or other source of practically constant E.M.F., so that the lower plates, P″ and $P_2$ are oppositely charged. These latter (P″ and $P_2$) are connected together and to the needle of an electrometer, which remains at zero. If now a beam of X-rays passes through both condensers, and if the total rate of discharge (algebraic sum) is naught, the electrometer needle will still give no indication.

* See *The Electrician*, Sept. 4, 1896, p. 605.

Now the vessel S contains dry air (at, say, 30in. barometer) and is sealed off; but the vessel V is connected with the air pump. Hence, as the air expands more and more out of the chamber V, the number of ions which can be disassociated per second (by a beam of X-rays from a tube T, crossing the tubes of force in the condenser) grows less and less. [Signor A. Roiti* has observed this decrease of charge or discharge action as the pressure of the vacuum vessel is reduced. That the action depends entirely upon the presence of a *gaseous* dielectric there is little doubt. Prof. Righi has from the beginning of his investigations in this sphere disagreed with Prof. J. J. Thomson's opinion that even *solid* dielectrics

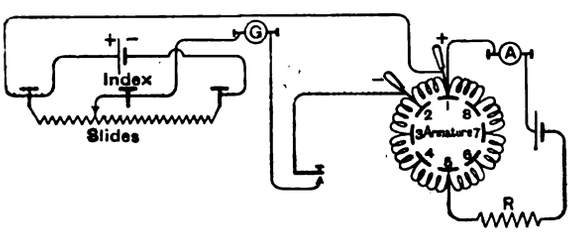



become conductors along the tubes of force traversed by X-rays.] Hence the needle of the electrometer begins to deflect, and the scale readings increase as the exhaustion of the vessel V proceeds. These readings form the criterion as to the degree of exhaustion.

## A PRACTICAL METHOD OF DETECTING FAULTS IN ARMATURES.

BY HENRY TINSLEY.

The importance of the proper condition of an armature when its manufacture has been completed cannot be over-estimated, as all who have had anything to do with this branch of dynamo construction will at once admit. Besides the usual tests for




insulation and resistance, it is important to know that the winding has been uniform and correct, and also to find out whether any faults have been developed in the final soldering up to the commutator. An excellent method of making the last test is afforded by means of a sensitive potentiometer, such as a set of Thomson and Varley's slides. This should be joined up in the usual manner for testing potential, as shown in the figure. The two wires which are used to measure the unknown potential may be conveniently joined to two metal spikes, fixed in insulated handles, and these spikes are then placed upon the sections of the armature which it is desired to test.

In the accompanying figure the armature is shown joined up in readiness for testing. Two wires are soldered to two sections of the winding at two points diametrically opposed to one another, these wires, of course, taking the place of the two brushes: or, if it is more convenient, the brushes themselves

* *Nature*, April 9, 1896.

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may be taken as a means of connection. Between these points an accumulator is joined in series with an ammeter (A in the figure) and a resistance, R. A current is thus allowed to flow through the windings of the armature, and this current should be of such a strength that half its product with the resistance of any one section—that is, the potential of that section—will be sufficiently high to give a suitable reading on the slides. A few amperes will usually suffice for this. The ammeter should be kept in circuit in order to detect any variation in the current strength, as this should be kept constant. Supposing the armature to be joined up, as shown in the figure, then each section may be tested by placing the two spikes leading from the slides on two adjacent segments of the commutator, commencing with sections 1 and 8, and passing on to 8 and 7 until the junction of the negative wire is reached, which in the above example will be at segments 6 and 5. When this point is reached and readings have been taken on the slides for each section, the spikes are brought back to segments 1 and 2 and readings taken on each section of the armature, working over to the left until the negative wire of the accumulator is again reached. Care should be taken that the wire leading to the + side of the slides should always be kept uppermost.

The following figures show the different slide readings taken round the commutator of a 30-section armature, ring wound, with 22 turns per section :—

| Section. | Slide reading. | | Section. | Slide reading. | |
|---|---|---|---|---|---|
| | R | L | | R | L |
| 1-2 | 1,030 | (*c*) 770 | 10 | (*d*) 1,040 | 880 |
| 3 | 1,030 | 880 | 11 | (*e*) 990 | 880 |
| 4 | 1,040 | 880 | 12 | 1,040 | (*h*) 840 |
| 5 | 1,040 | 880 | 13 | (*f*) 0 | 880 |
| 6 | 1,040 | 880 | 14 | (*g*) 0 | 880 |
| 7 | 1,040 | 880 | 15 | 1,030 | 880 |
| 8 | (*a*) 0 | 880 | 16 | 1,030 | 880 |
| 9 | (*b*) 0 | 880 | ... | ... | ... |

*a*, *b*, *f*, and *g* show that these sections are short-circuited through *no* length of wire; *i.e.* at the commutator. *c* has evidently got three turns cut out. *d* has been wound with one turn too many. *e* and *h* have each got one turn too few on these sections, caused either by a short circuit between two adjacent turns or by careless winding. The letters R and L show that we are working over to the right and left respectively.

It would only be necessary in the above case to compare the first few readings R and L to see that something was wrong. The higher slide readings in the R column are caused by the uneven shunting of the two halves of the armature. This is due to the right half having four sections short-circuited, and thus being made of much lower resistance than the left-hand half. Consequently, more current is flowing through this half, and so the potential for any section of the same resistance as a section on the other half, is also considerably increased.

In the case of a drum-wound armature of 48 sections of six turns each, the slide readings taken were very uniform, with the exception of one section. This section, instead of giving a reading of 59 on the slides, gave only 38. It was assumed that two turns approximately $\left(\frac{59-38}{59}\times 6\right)=2$, were cut out of circuit in some way, and on opening the armature at this particular section it was found that two turns were short-circuiting one another, owing to a flaw in the insulation in the windings of this section. Another fault detected in the above manner was a broken wire. In this case no reading at all was obtainable on the half in which the break was. It will be seen from the above examples that the above method of testing armatures is an excellent one, though I do not know if it is in general use. It is quick and accurate, and more tale telling than a resistance test might be, as that is not always convenient for such low resistances as armature sections usually are.

## BOOK RECEIVED.

"*Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils de France.*" August, 1896. Containing "La Traction Electrique des Chemins de Fer." By M. E. de Marchena. pp. 119.

## COMPARISON AND REDUCTION OF MAGNETIC OBSERVATIONS.*

*Introductory Remarks: Non-Cyclic Effect.*

§ 1. An analysis of the results from the Kew declination and horizontal force magnetographs during the selected "quiet" days of the five years 1890 to 1894, was submitted last year to the Committee, and adopted as its report for 1895. The corresponding inclination and vertical-force results had also been pretty fully worked up, but I held them over pending an inquiry into the sufficiency of the temperature correction. Some considerable time may elapse before these results can be utilised to full advantage. It has thus seemed inexpedient to defer dealing with one set of phenomena whose general character is unaffected by any uncertainty as to the temperature correction, and whose existence seems to render desirable a reconsideration of the whole system of "quiet" day observations. The phenomena in question bear on what I termed last year the *non-cyclic* effect. Supposing $H_0$ and $H_{24}$ to denote mean values of the horizontal force at the first and second midnights of a selected series of days, then $H_{24}-H_0$ was defined as the non-cyclic effect or variation of horizontal force ; and a similar definition applies in the case of any other element.

*Non-Cyclic Effects during Six Years*, 1890-1895.

§ 2. It is proposed to give here complete data as to the non-cyclic effects in the selected "quiet" days at Kew during the last six years. To some extent this incorporates results given last year ; but it seemed desirable to show side by side the results for all the elements throughout the same series of years. There are five selected "quiet" days a month, and so a total of 360 in the 72 months of the six years considered. In November and December, 1890, however, the vertical-force magnetograph was out of action, which reduces by 10 the number of days available in the case of the vertical force and inclination.

In the following table, I., the six Januarys, six Februarys, &c., of the six years have been combined together, so as to show the values of the cyclic effects at different seasons of the year. The figures under the heading "Individual Months" show in how many of the six Januarys, &c., the effect was an increase of the element in question, was *nil*, or a decrease. At the foot of the table appear the mean non-cyclic effects per "quiet" day throughout the six years, and the totals of the several columns under the headings "Individual Months."

Table II. gives the mean results for the several quarters of the year as deduced from Table I., while Table III. gives the annual means for the individual years.

*Relation of Non-Cyclic Effects to Annual Changes.*

§ 3. To see the full significance of these data regard must be had to the magnitudes of the annual changes of the several elements. Table IV. gives these for the period considered, along with the number of average "quiet" days, which, according to Table I., would have sufficed to produce changes numerically equal to the annual changes observed. The figures relating to the horizontal force and inclination are so significant that comment in their case seems unnecessary. As regards the declination and vertical force in individual months, notably January, the non-cyclic effects have been as large and consistent as with the other two elements ; but in general this has been far from the case. As Table III. shows, in two years out of the six both declination and vertical force have exhibited a mean non-cyclic effect opposite in sign to that supplied by the six years as a whole. In considering such a phenomenon, one ought, of course, to remember that it is contrary to probability that any 60 arbitrarily selected days—the number on which an annual mean is based—will produce a diurnal variation truly cyclic after allowance is made for the normal annual change ; and thus part of the irregularity exhibited by Table III. may reasonably be attributed to pure chance. When, however, one looks at the uniformity of sign in the non-cyclic effects in the horizontal force and inclination exhibited in Table I., and remembers that the monthly means in that table are based on only 30 days, one must, I think, conclude that the variability of sign in the declination† and vertical force‡ results, at least in Table III., has probably a true physical basis.

*Mean Annual Values from "Quiet" and Unrestricted Days.*

§ 4. Table IV. is merely a plain statement of facts ; but if too exclusively considered it might unquestionably convey an exag-

* Report of a British Association Committee, consisting of Prof. W. G. Adams (Chairman), Dr. C. Chree (Secretary), Lord Kelvin, Prof. G. H. Darwin, Prof. G. Chrystal, Prof. A. Schuster, Capt. E. W. Creak, the Astronomer Royal, Mr. William Ellis, and Prof. A. W. Rücker. (Drawn up by the Secretary.)

† In 1890 a *positive* non-cyclic effect appeared in only month (January) ; in 1891 a *negative* effect in only one month (November).

‡ In both 1890 and 1894, however, a slight majority of individual months exhibited a *negative* non-cyclic effect as usual.

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TABLE I.—*Non-Cyclic Effect from Six Years, 1890-1895 (Mean per "Quiet" Day).*

| Month. | Declination. | | Horizontal force. | | Vertical force. | | Inclination. | |
|---|---|---|---|---|---|---|---|---|
| | Effect. | Individual months. | (Effect) × $10^6$. | Individual months. | (Effect) × $10^6$. | Individual months. | Effect. | Individual months. |
| | Min. | + 0 − | | + 0 − | | + 0 − | Min. | + 0 − |
| January | +0'·63 | 6 | +50 | 5 1 | −52 | 6 | −0·47 | 1 5 |
| February | +0·33 | 4 2 | +57 | 5 1 | + 5 | 3 3 | −0·35 | 1 5 |
| March | +0·18 | 3 3 | +28 | 5 1 | +13 | 2 2 2 | −0·17 | 1 1 4 |
| April | +0·12 | 3 1 2 | +20 | 4 1 1 | −22 | 2 4 | −0·20 | 1 1 4 |
| May | +0·07 | 3 3 | +38 | 5 1 | −12 | 3 3 | −0·27 | 2 4 |
| June | −0·17 | 3 3 | +22 | 4 1 1 | −28 | 1 5 | −0·22 | 1 1 4 |
| July | −0·23 | 3 3 | +27 | 4 2 | −13 | 1 5 | −0·22 | 2 4 |
| August | −0·30 | 1 1 4 | +37 | 5 1 | − 8 | 3 3 | −0·27 | 1 5 |
| September | +0·12 | 3 3 | +38 | 6 | +30 | 3 1 2 | −0·18 | 1 5 |
| October | +0·03 | 2 1 3 | +50 | 6 | + 5 | 3 3 | −0·28 | 1 5 |
| November | +0·18 | 3 1 2 | +53 | 6 | −12 | 2 3 | −0·40 | 5 |
| December | −0·10 | 1 2 3 | +15 | 5 1 | − 6 | 2 3 | −0·12 | 2 3 |
| Annual mean. | +0'·072 | ... | +36·4 | ... | −8·3 | ... | −0'·263 | ... |
| Totals of months | .. | 35 6 31 | ... | 60 7 5 | ... | 25 3 42 | ... | 9 8 53 |

In the case of the declination + signifies a deflection to the west. The true secular variation at present is towards the east. The components of force are measured in C.G.S. units.

TABLE II.—*Mean Non-Cyclic Effect per "Quiet" Day for each Quarter of the Year.*

| — | Declination. | | | | (Horizontal force) × $10^6$. | | | | (Vertical force) × $10^6$. | | | | Inclination. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quarters. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Effect | +0'·38 | +0·01 | −0·14 | +0·04 | +45 | +27 | +34 | +39 | −11 | −21 | +3 | −4 | −0'·33 | −0·23 | −0·22 | −0·28 |

TABLE III.—*Mean Non-Cyclic Effect per "Quiet" Day for each Year.*

| Year. | Declination. | (Horizontal force) × $10^6$ | (Vertical force) × $10^6$ | Inclination. |
|---|---|---|---|---|
| 1890 | −0'36 | +23 | +15* | −0'10* |
| 1891 | − ·29 | +23 | −12 | −0·18 |
| 1892 | + ·14 | +53 | −20 | −0·41 |
| 1893 | + ·26 | +40 | +26 | −0·35 |
| 1894 | + ·15 | +33 | +12 | −0·18 |
| 1895 | − ·05 | +44 | −15 | −0·33 |

TABLE IV.

| — | Declination. | Horizontal force. | Vertical force. | Inclination. |
|---|---|---|---|---|
| Mean annual change, 1890–95 | −6'·8 | $21 \times 10^{-5}$ | $-19 \times 10^{-5}$ | −1'·9 |
| No. of "quiet" days producing equal change | 95† | 6 | 23 | 7½ |

gerated idea of the defects attaching to the ordinary use made of "quiet" days at the present time. At Kew Observatory they are employed to get out the mean diurnal inequality for summer and winter and the whole year, as well as the mean annual values of the several elements. As regards the mean annual value of an element, the quantity "mean value from 'quiet' days less mean value from all days" may be irregularly positive and negative, or like the non-cyclic effect in the element it may be normally of one sign. It would certainly be desirable to know which of the alternatives is true. The meaning to be attached to the secular variation deduced from two consecutive years or from a short series of years would be much more uncertain if the former alternative represented the facts than if the latter did. In the Greenwich "Magnetical and Meteorological Observations" tables are published showing the diurnal variations both in "quiet" and unrestricted days, but no apparently direct information as to the difference between the absolute values of means deduced from the "quiet" and from unrestricted days. At St. Petersburg, and then at Pawlowsk, it has, however, long been customary for Dr. Wild to select a series of normal "quiet" days whose results are dealt with alongside of those from unrestricted days. The principle of selection guiding the choice at Pawlowsk and Greenwich has probably been slightly different, but there is at least a strong presumption that the differences between the annual means from unrestricted days and from the Astronomer Royal's "quiet" days will prove to be of the same character as the corresponding differences observed in the case of Wild's "quiet" days.

* In 1890 the means of vertical force and inclination are based on the results of only ten months, in one of which (March) an abnormally large positive non-cyclic effect was recorded in vertical force.

† In the case of declination, and it alone, the non-cyclic effect is opposite in sign to the secular variation.

§ 5. The annual means for all the elements at St. Petersburg, from both "quiet" and unrestricted days, for some 12 to 16 years preceding 1885 are given in a Paper by Dr. Müller in the *Repertorium für Meteorologie*, Bd. XII. No. 8. In the case of every element, according to Müller's tables 20 to 23, the sign of the quantity "'quiet' day mean less unrestricted day mean" was uniformly, or practically uniformly, of one sign; and the secular variations deduced from the "quiet" and unrestricted day results, even for consecutive years, showed a remarkably good agreement. The following summary of the mean results deducible from Müller's tables is extracted from a recent Paper by Leyst* :—

*Wild's Normal Days—all Days (Annual Means).*

| | |
|---|---|
| Declination west | + 0'·25. |
| Inclination | − 0'·23. |
| Vertical component | $-10^{-6} \times 8$ C.G.S. units. |
| Horizontal component | $+10^{-6} \times 35$ „ |

Tables of the monthly and yearly means for Wild's "quiet" days and for unrestricted days at Pawlowsk continue to be given in the *Ann. des Phys. Central-Observatoriums*. The results from the last two volumes are as follows :—

*Wild's Normal Days—all Days (Annual Means).*

| Year. | Declination. | Horizontal Force. | Vertical Force. |
|---|---|---|---|
| 1893 | +0'·3 | $+10^{-6} \times 40$ | $-10^{-6} \times 30$ |
| 1894 | +0'·6 | $+10^{-6} \times 60$ | $-10^{-6} \times 10$ |

There would thus appear to be no essential change in the phenomena since the period to which Müller's Paper refers.

§ 6. Wild's "quiet" days numbered only 25 in 1893 and 33† in 1894, as against the Astronomer Royal's 60 a year; thus the results from the latter are likely to exhibit even less irregularity in their departures from the results of unrestricted days than the former. Mere surmises such as the preceding are vastly inferior to the actual numerical facts. Before deciding on the labour necessary to obtain the facts, one has first, however, to estimate their probable value. One factor in this consideration which the practical man can fairly urge is that accuracy in *absolute* value to anything like $1 \times 10^{-5}$, in the case even of the horizontal force, is an ideal we can hardly claim to have reached in this country.

*Relation of Non-Cyclic Effects to Diurnal Ranges.*

§ 7. An idea of the amount of uncertainty which the non-cyclic effect may introduce into the mean diurnal inequalities for summer, winter and the whole year may be derived from Table V. It gives the ranges of the elements, uncorrected for non-cyclic effect, as published annually in the Kew "Report," along with particulars as to the ratios borne by the mean non-cyclic effects to the corres-

* *Rep. für Met.*, Bd. XVII., St. Petersburg, 1894, No. 1, p. 109.

† The number in most of the earlier years dealt with by Dr. Müller seems, however, to have been considerably greater.

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TABLE V.—*Ranges of Elements from Annual Kew Reports.*

| | Declination. | | | (Horizontal force) × $10^5$. | | | (Vertical force) × $10^5$. | | | Inclination. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year. | Winter. | Summer. | Year. | Winter. | Summer. | Year. | Winter. | Summer. | Year. | Winter. | Summer. |
| | Min. | Min. | Min. | | | | | | | Min. | Min. | Min. |
| 1890 | 6·9 | 5·1 | 8·7 | 21 | 14 | 30 | ... | ... | ... | ... | ... | ... |
| 1891 | 8·2 | 6·0 | 10·2 | 29 | 20 | 40 | 14 | 9 | 20 | 1·7 | 1·1 | 2·3 |
| 1892 | 9·6 | 6·9 | 12·3 | 33 | 26 | 44 | 17 | 11 | 25 | 2·0 | 1·5 | 2·7 |
| 1893 | 10·1 | 7·4 | 13·0 | 37 | 29 | 46 | 18 | 10 | 25 | 2·2 | 1·7 | 2·8 |
| 1894 | 9·3 | 7·0 | 11·9 | 36 | 26 | 48 | 17 | 11 | 22 | 2·2 | 1·5 | 2·8 |
| 1895 | 8·5 | 5·6 | 12·1 | 33 | 30 | 46 | 15 | 10 | 23 | 2·0 | 1·2 | 2·8 |
| Means ..... | 8·8 | 6·3 | 11·4 | 32 | 23 | 42 | 16 | 10 | 23 | 2·0 | 1·4 | 2·7 |
| (Non-cyclic effect) + (Uncorrected range)... | +0·008 | +0·033 | −0·036 | +0·12 | +0·19 | +0·07 | −0·05 | −0·08 | −0·04 | −0·13 | −0·21 | −0·08 |

ponding ranges. In the case of the vertical force and inclination the year 1890 has been omitted, as the results for it are not altogether complete.

§ 8. Table V. shows how much more important relatively the non-cyclic effect is in the winter than in the summer half-year. In the winter half-year we see that the non-cyclic effect in both horizontal force and inclination is equal to about one-fifth of the range. This does not, of course, imply that there is an uncertainty of 20 per cent. in the range, because, whatever be the nature of the correction applied to eliminate the non-cyclic effect, it is hardly likely to introduce more than a small fraction of the observed difference between 0 and 24 hours into the algebraic difference of the maximum and minimum readings. The interval of time between these readings is in most cases nearer six hours than twelve. The fact, however, remains that in some individual winters the uncertainty as to the range must be very appreciable. When we come to individual winter months, notably January, when the observed range is least, the uncertainty is apt to be considerable. The preceding remarks refer exclusively to the uncertainties which the existence of the non-cyclic effect introduces into diurnal ranges deduced from "quiet" days. Previous reports of the Committee* have dealt with differences between the ranges deduced from unrestricted and from "quiet" days. It seems to me, however, that such comparisons are open to criticism so long as the proper treatment of the non-cyclic effect remains uncertain.

*Relation of Non-Cyclic Effects to Diurnal Inequalities.*

§ 9. In the yearly and half-yearly results the most critical point is the nature of the diurnal inequality in the late night and early morning hours. The observed variation is then small, especially in winter, so that a disturbing element of no great absolute magnitude might completely alter the character of the phenomena. This will appear at once on reference to the curves of declination and horizontal force in last year's report, pp. 212 and 220. The curves on p. 220 are certainly suggestive of the presence of some abnormal influence during the midnight hours; at the same time this is not more true of them than of curves of the same type for Greenwich, which Sir G. B. Airy† based on data derived from all days but those of considerable disturbance.

*Elimination of Non-Cyclic Effect.*

§ 10. If diurnal inequalities are to be got out at all from "quiet days" in a form suitable for harmonic analysis, they must be made cyclic, and there is certalnly no simpler way of doing this than that adopted last year, viz., treating the observed data as if the non-cyclic effect proceeded uniformly throughout the 24 hours. This method of treatment does not prejudice the facts. Supposing the non-cyclic effect to proceed irregularly throughout the 24 hours, then it may most conveniently be analysed into terms, one being a linear function of the time, the other periodic functions whose periods are 24 hours or submultiples thereof. The linear term is eliminated by the method adopted last year. The cyclic terms, of course, remain, and are incorporated with the other cyclic terms of like period which go to make up the diurnal inequality on "quiet" days. It would, however, be impossible to separate the two sets of cyclic terms by any mathematical device, without an addition of physical facts or a supply of theories in their place. One way of obtaining additional facts would be to compare for a series of years the constant coefficients in the harmonic analysis of the diurnal inequalities from "quiet" and unrestricted days. The accidental features introduced by the arbitrary nature of the choice of "quiet" days might, however, prove troublesome. The term in the non-cyclic effect treated as a linear function of the time may in its turn be composed of a series of terms, some possibly fluctuating regularly with the season of the year, others possibly of very long period; its magnitude, at least in individual months, may depend in large measure on the accidental preference of one set of "quiet" days to another.

* *B.A. Report*, 1886, p. 71. *See also* Paper by Messrs. Robson and Smith, *Phil. Mag.*, August 1890, p. 143.

† *Phil. Trans.* for 1863 and for 1885.

*Associated Phenomena.*

§ 11. It was pointed out last year that the elimination of the non-cyclic effect through a correction consisting of a linear function of the time was determined solely by considerations of convenience and mathematical simplicity. It was carefully explained (*l.c.* §§ 5, 6) that General Sabine and Dr. Lloyd had observed phenomena in magnetic storms so exactly the converse of those presented by the non-cyclic effect on "quiet" days as to suggest that the two classes of phenomena were interdependent; and the conclusion was drawn that if this interdependence were true the non-cyclic effect might be expected in reality to progress irregularly throughout the 24 hours. These conclusions may now, perhaps, be regarded as more than surmises. In the *Met. Zeitschrift* for September, 1895, Dr. van Bemmelen has described phenomena he terms *Nachstörung*, which appear to be of the same general character as, if not identical with, what has been termed here the non-cyclic effect. As the title he selected implies, Dr. van Bemmelen associates the phenomena very intimately with magnetic storms. His investigations have included data from a variety of stations; and whilst his theoretical conclusions may, perhaps, undergo modification in the future, his work certainly indicates that an increase of knowledge as to this outstanding phenomenon on "quiet" days is likely to be of service in the general theory of terrestrial magnetism.

§ 12. In the meantime it might be safest not to assume that the non-cyclic element is an effect, and a preceding magnetic storm a cause. The fact that the horizontal force, for instance, tends to rise abnormally fast during a "quiet" day may, of course, merely represent a recovery from an abnormal loss occasioned by a magnetic storm; but it is at least conceivable that the abnormal fall during a magnetic storm may be partly a consequence of abnormal increase preceding it, or the two phenomena may be effects of a common cause. If "quiet" days, with no appreciable disturbance, were the rule, one might possibly determine with ease the relationships of any given "quiet" day to a preceding or succeeding disturbed day; but appreciable movements will usually be found both before and after a "quiet" day at no great interval of time. If the causes operating in large and small disturbances are the same, then it is not improbable *à priori* that a small disturbance within a day or two of a "quiet" day may have more to do with it than a large disturbance a week before or after. It should also be remembered that General Sabine found that whilst, as a rule, large disturbances lowered the horizontal and raised the vertical force, the opposite results ensued in a very considerable number of instances. In proposing any additions to the existing "quiet" day system, or any substitute, it must be remembered that one of the main objects aimed at by its introduction was a substantial saving in the labour required to obtain comparable results from different observatories. The tabulation of the whole mass of curves was felt in most cases too serious a burden. Considerable light might be thrown on the question of the uniformity or variableness of the non-cyclic element throughout the day by a very simple addition, viz., curve measurements at the noons preceding and succeeding each "quiet" day. In the course of this Paper other suggestions have been made, but they could be put into effect only at observatories prepared to tabulate all the curves.

APPENDIX.—*Remarks by W. Ellis, Esq., F.R.S.*

Having had the opportunity of reading Dr. Chree's report on non-cyclic magnetic effects, I would beg to be allowed to offer the following remarks:—I had read with great interest Dr. Chree's "Comparison and Reduction of Magnetic Observations," forming the report of the Magnetic Committee for the year 1895, in which he discusses the Kew magnetic results on "quiet" days for the years 1890 to 1894. I had lately commenced to work up in a similar way the corresponding Greenwich results in order to make comparisons between Greenwich and Kew, when treated for the same years in a similar manner. Interesting questions are involved, since it cannot be said to be at present known how far the magnetic changes at two places not remotely distant one from the other



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should be expected to be similar, and if not similar to what extent there may be difference, and also whether any part of such difference might be instrumental. It is not satisfactory to compare results for one period with results for another place for a different period, because at any one place the phenomena may vary considerably at different times. But my work is not sufficiently advanced to enable me to put the results at present into shape; still I may perhaps give some information bearing on points now discussed by Dr. Chree. In Table I. he gives the mean non-cyclic effect for "quiet" days for different magnetic elements for each month of the year, deduced from the Kew observations of the six years 1890 to 1895. My numbers for Greenwich are for the five years 1890 to 1894. At Kew the non-cyclic change in declination is positive in the first five, and in the ninth, tenth, and eleventh months of the year, and negative in the remaining months. At Greenwich it is positive in the first five months and in the eleventh month, and negative in the other months. At both places the largest positive value in January, Kew = +0'·63, Greenwich = +0'·46; the largest negative value is in August, Kew = −0'·30, Greenwich = −0'·42. Mean for year at Kew = +0'·072, at Greenwich = +0'·007. In horizontal force the non-cyclic effect at Kew is positive in all months, and similarly at Greenwich. The greatest values at Kew are (effect × $10^6$ in C.G.S. units), in January, February, October, and November, +50, +57, +50, and +53 respectively; and similarly at Greenwich, the values being +62, +53, +73, and +57 respectively. Mean for year at Kew = +36, at Greenwich = +40. In vertical force there is considerable difference, both in magnitude and sign, between the non-cyclic effect in different months at the two places. The mean for year at Kew = −8, and at Greenwich = −18. In this comparison it is to be remembered that the Kew results depend on the observations of six years, and the Greenwich results only on those of five years.

As regards now the mean values in separate years (Table III.); of the five years 1890 to 1894 the non-cyclic change in declination is in the same direction in four of the five years at both places; in horizontal force in the same direction in all years, and in vertical force in three years. The actual numbers are:—

| Non-cyclic change. | 1890. | 1891. | 1892. | 1893. | 1894. | —— |
|---|---|---|---|---|---|---|
| At Kew ..... | −0'·36 | +0'·29 | +0'·14 | +0'·26 | +0'·15 | In declination. |
| At Greenwich | −0'·23 | +0'·08 | −0'·20 | +0'·15 | +0'·24 | In declination. |
| At Kew ..... | +23 | +23 | +53 | +40 | +33 | In horizontal force. |
| At Greenwich | +18 | +37 | +68 | +44 | +33 | In horizontal force. |
| At Kew ..... | +15 | −12 | −20 | −26 | +12 | In vertical force. |
| At Greenwich | −12 | −8 | −39 | −24 | −4 | In vertical force. |

In vertical force there is a tendency to a uniformly greater negative value at Greenwich than at Kew. Considering, however, the values at each station separately, the greatest negative values occur in the same two years, 1892 and 1893, at both places. One question that I had set myself to discuss was how far the absolute magnetic values, as, for instance, the mean monthly values, differ, as determined from the five "quiet" days in each month, and as determined from all days (excepting those of excessive magnetic disturbance). In the Greenwich "Observations" there are given in Tables I., III. and VII. of the magnetic section mean daily values of declination, horizontal force and vertical force respectively throughout the year (excepting days of excessive disturbance). The means of these values for different months are given in Table XI*. Extracting from the different tables the values for the adopted "quiet" days, and taking the mean in each month, the variation of these means from the corresponding means of Table XI. gives in each case the deviation of the "quiet" days mean from that for all days. Since the mean of the five selected days falls always near the middle of the month, the comparison, for a first inquiry, sufficiently eliminates the secular variation, considering it uniform, the only possible supposition. The excess of the "quiet" day monthly mean above the all day or unrestricted monthly mean is, in each month of the year, for each element, as shown in Table VI. (average of five years, 1890 to 1894).

I have not sufficient opportunity at the present moment to add much by way of discussion of these numbers, but taking the element in which the difference of absolute value is most marked, that of horizontal force, some few remarks may be offered. We see that the uniformly positive non-cyclic change on "quiet" days is accompanied by an increased absolute value of horizontal force on such days, as compared with the value from all days, as we should perhaps expect. At Greenwich magnetic disturbance commonly causes diminution of horizontal force, after which the value works back to a more normal one. But there are years in which the magnetic registers are unusually quiet, with few disturbances of even moderate amount, as in the years 1878 and 1879. The inference would be that in such years the difference between the absolute value for the especially "quiet" days and that for all days should be small, varying to a certain extent in different years with the more or less prevalence of magnetic disturbance. I cannot, however, for the moment refer to the Pawlowsk differences of which Dr. Chree speaks, to ascertain whether they exhibit variations of this character. Further, whether the rise of value on "quiet" days represents a recovery from abnormal loss during disturbance, or whether the abnormal fall during disturbance is in any way a consequence of preceding abnormal rise, may be a question. But the view that the recovery on "quiet" days is rather a consequence of abnormal fall during disturbance—that is, that the disturbance is really the primary dominating factor, appears to receive support from the following consideration:—When disturbance suddenly arises it seems to break out over the whole earth at precisely the same moment of absolute time (see *Proc.* Roy. Soc., Vol. LII. p. 191). But an instantaneous magnetic shock sensible over the whole globe could scarcely, one would imagine, arise from action from within alone; and since magnetic disturbances are more frequent when sunspots are numerically high, there seems reason to suppose that the exciting cause is in such cases mainly external. To pursue this matter is, however, rather to enter the region of speculation. It may perhaps be remarked that the mean non-cyclic change for horizontal force and vertical force on "quiet" days is +40 and −18 respectively; also that the mean excess of absolute value on such days over all days is correspondingly +34 and −8 respectively. Thus the relation in both elements is of the same character. A part of my work consisted of a comparison of diurnal inequalities of the magnetic elements on "quiet" days with those found by including all days (always excepting the excessive magnetic disturbances), and also of a comparison of diurnal range as given: (1) by "quiet" days as observed; (2) by "quiet" days corrected for non-cyclic change; and (3) by including all days, in all cases, for the different months of the year; but the work is not sufficiently advanced to enable any particulars to be given.

Dr. Chree, referring to a previous report of the Magnetic Committee and to a Paper by Messrs. Robson and Smith in the *Phil. Mag.* for August, 1890, speaks of the differences between diurnal ranges deduced from unrestricted days, that is all days, and from "quiet" days. I may perhaps point out that these comparisons were between "quiet" days at Kew and all days at Greenwich, and were for the element of declination only. In such a comparison the question of difference of locality must be taken into account, and also possibly to some extent the difference of instruments. But in a Paper which I communicated to the *Phil. Mag.* for January, 1891, I made a more direct comparison of results, for the one year 1889, comparing the diurnal inequalities for "quiet" days (five in each month) at Greenwich with those for all days at the same place. This comparison was made for all the three elements of declination, horizontal force, and vertical force. The five-day results were not corrected for non-cyclic change, but in declination and vertical force this was evidently small. The results show a marked difference between the diurnal inequalities for "quiet" days and for all days. The later work in this direction, yet incomplete, to which I have above referred, includes a discussion of the diurnal inequalities for the five years 1890 to 1894 for "quiet days" and for all days, and the results seem likely to support those found for the single year 1889.

TABLE VI.

| Greenwich. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | —— |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Excess of absolute "quiet" day value above all days' value ..... | −0'·04 | +0'·12 | +0'·24 | −0'·10 | +0'·12 | +0'·10 | 0'·00 | +0'·10 | −0'·06 | −0'·08 | +0'·24 | 0'·00 | In declination. |
| | +35 | +42 | +24 | +37 | +31 | +20 | +22 | +5 | +27 | +55 | +51 | +57 | In horizontal force. |
| | +31 | −26 | −10 | −13 | −11 | +10 | −17 | −2 | +3 | −40 | −5 | −17 | In vertical force. |

Mean yearly excess of "quiet" day value in declination = +0'·05
" " " " " " horizontal force = +34
" " " " " " vertical force = −8

The corresponding separate yearly differences are:—

| Greenwich. | 1890. | 1891. | 1892. | 1893. | 1894. | —— |
|---|---|---|---|---|---|---|
| Excess of absolute "quiet" day value above all days value. | +0'·01 | −0'·12 | +0'·07 | +0'·19 | +0'·12 | In declination. |
| | +11 | +37 | +31 | +37 | +53 | In horizontal force. |
| | −8 | −7 | −26 | −14 | +14 | In vertical force. |

* Greenwich "Observations" *loc. cit.*—ED. *E.*

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## THE EFFICIENCY OF RAILWAY MOTORS.*

BY W. BAXTER, JR.

The efficieney of railway motors has always been an interesting subject, but never more so than at the present time, when compressed air is making an effort to gain a foothold in the railway field. That cars can be propelled by compressed air motors there can be no doubt, and that they will be used in places like New York, Washington, &c., is not improbable, where, through unreasonable prejudice, the trolley is excluded. It is safe to say, however, that they will never be adopted where they are brought into direct competition with electricity. The latter system cannot be superseded in any case where merit decides the contest, unless it be by a more efficient method of transmitting energy. Compressed air is not new and untried ; it has been in use much longer than electricity, and the records of the past show that it is inferior not only in point of efficiency, but in flexibility, reliability, and in every other respect that makes one system superior to another. What history has shown to be true in other fields the future will demonstrate to be equally true in relation to railway work, for there are no special conditions in this field that will tend to modify the results.

In the minds of many there are doubts as to the correctness of such conclusions, doubts that are caused mainly by a comparison of the power-consumption in trolley cars and the old horse cars, from which it is inferred that the former are very inefficient. A simple investigation of the case will show, however, that the comparison is not so very unfavourable to the trolley after all. The fact that two motors of a rated capacity of 25 H.P. are used to replace two horses of not over-robust constitution certainly does not look encouraging ; but the two horses seen before the car do not represent all the energy that is used, for there are from four to eight more in the stable. The average weight of the cars is about 5,500lb., while that of the passengers is over 2,500lb., which makes the total average load about 8,000lb. This is drawn at a speed of not over five miles per hour. The weight of a trolley car is about 13,000lb., and if the average weight of passengers is taken at 3,000lb , which is very low, the total load will be 16,000lb., or double that of the horse car ; and as this is propelled at twice the speed, the power required will be four times as much. From the above it is evident that the average power required for trolley cars should be about 16 H.P., and this is probably somewhat above the actual amount used in practice.

Many of those who fear that electricity may not be able to maintain its supremacy, as well as those who hope that compressed air may be successful, claim that the single-reduction motors of to-day are far inferior in point of efficiency to the old double-reduction motors used in the early days of the electric railway, and that they use from 20 to 30 per cent. more current to do the same work, notwithstanding that the loss in friction of gearing is considerably less. While it is true that the modern motors take nearly as much more current as stated above, the cause thereof is not wholly the difference in efficiency ; the increased speed, as well as the increased weight, account for a large part of the extra current.

The energy lost in accelerating the velocity of the car is by no means a small amount, and on city roads, where frequent stops are made, it may become a large percentage of the total amount of energy used. The loss from this cause is greater with high velocities than with low, owing to the fact that the rate of acceleration is greater and the limit of velocity higher. On this account the increase in velocity can only be effected by a more than corresponding increase in current, as in addition to the greater energy required for the higher speed, a further amount must be provided to cover the extra loss due to the more rapid acceleration. By a very simple process of reasoning it can be shown that the acceleration loss is a formidable one, and that it may, in some cases, represent a large portion of the total energy used by a road. If we estimate the energy necessary to keep a car in motion at the average speed it will be an amount considerably less than the actual expenditure in practice. The discrepancy thus shown cannot be said to be due to the higher velocity at which the car runs, over some portions of the road, for the amount of energy required to move a load over a given distance is practically the same regardless of speed ; hence, if the car runs fast at one point and slow at another, the average power should be the same as if it moved uniformly at the average velocity ; therefore, the discrepancy must be accounted for in some other way, and this other way is by the amount lost in accelerating the velocity.

If we take the average power per car at 15 H.P. and the efficiency from trolley to axle at 75 per cent., we would have 11¼ H.P. to account for. Assuming the weight of car and load to be 10,000lb., and the tractional resistance 15lb. per ton, which is undoubtedly high, the horizontal effort would be 120lb., and this at 10 miles per hour would require 3·2 H.P. This would leave about 8 H.P., which would be sufficient to overcome a grade of about 1·9 per cent. As the average gradient of the average road is undoubtedly less than one half of this, it must be very evident that not over two-thirds of the power is used to overcome the tractional resistance and the grades ; the balance is used to accelerate the velocity.

The foregoing, to be sure, is only a guess, but any one who is familiar with the subject will admit that it is not very far out of the way, for the energy required to overcome grades cannot, on an average, amount to more than would be necessary on a continuous ascent of about ¾ per cent. In making such an estimate it must be remembered that where there are many up-grades there are a corresponding number of descents, and while no energy is recovered on the down-grade there is quite a considerable saved. It must also be remembered that there are many roads that are almost free from grades, so that the average road would be one where the power expended in lifting the load would not be more than that represented by a continuous ascent of small percentage.

The saving of power effected by a reduction in speed of motors is very much greater than the loss in average velocity of the car, and this is especially true of city roads where frequent stops have to be made. The correctness of this statement is proved by the difference in the current consumption of the single-reduction motors of to-day and the old double-reduction type, and also the difference in the average running velocity of the two. A modern car will run on a level track, and with an average load, at a speed of 20 or 22 miles per hour, and the old double-reduction motors under the same conditions would make about 14 miles. Through the crowded streets of cities the higher speed is of little value ; and this is also the case on down grades, where gravity is the impelling force. Owing to these facts the single-reduction motors of the present time cannot show much gain in running time from end to end of line. The gain certainly does not compensate for the difference in current consumption.

There are many who believe that the present railway motors are of the very highest efficiency, owing to the fact that they can make a very good showing when tested under special conditions ; and taking this view of the case, they conclude that if compressed air could show as high economy, it would at once become a rival of electricity. But the fact that a motor can show a high efficiency under special conditions does not prove that its working efficiency will be high. If it is wound for a high velocity it may give a high efficiency in a shop test, but will not on the track, unless it can develop a torque sufficient to keep the car in motion. If the torque at a given speed is less than the resistance to motion of the car, the velocity will be reduced until the current is increased to a point where the resistance and torque balance each other, and at this point the efficiency may be very low. This is the case with the present motors, their efficiency being high on a level road but on grades very low. It is also low when the car is started and the speed is accelerating ; lower than it would be if the motors were designed to run slower at their maximum efficiency. Under any conditions the efficiency of a motor is very low while the speed is building up ; but in single-reduction motors it is more so, owing to the fact that the cross-section of the field is small, and the magnetising current, long before reaching its maximum, is so great that the flux density reaches a point beyond which it cannot be pushed much further. In addition to this the armature magnetisation is very strong in comparison to the field, so that when the current increases the reaction materially reduces the torque below the value which it would have if the relation between field and armature were more favourable. If the motors were designed with a view to obtaining a higher efficiency at low velocity, the starting current, as well as that required on grades, would be considerably reduced ; and, as a result, the working efficiency would be increased. This can be done, and, if rendered necessary by competition, will be done.

* Abstract from the *Electrical World* of New York.

**Telegraph Relay Resistance.**—A Paper on "The Reduction of Relay Resistance" was recently read by Mr. U. J. Fry before the American Association of Railway Telegraph Superintendents. The author is superintendent of telegraphs on the Chicago, Milwaukee, and St. Paul Railway. The Paper, says the *Railway Review* of Chicago, records beneficial results from a change from the traditional high-resistance relays to those of much lower resistance, and from a rearrangement of the line batteries so as to place a portion of the power at points intermediate between the terminals. With the relays wound to 25 ohms Mr. Fry has greatly improved the service of lines 200 miles in length, and the working is made better in several different ways. The line battery is cut down, and this, by reducing the voltage, decreases the tendency to produce leakage during wet weather ; also the effect of lightning is considerably reduced. The principle of securing a balance between the resistance of the line and that of the instruments, causes a more efficient use of the current in the relays, which contributes to strong working.



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## APPLIED ELECTRO-CHEMISTRY.

To minds cast in a certain mould there is something peculiarly irritating in the stolid solemnity of the average Britisher, and to those who experience this feeling of subdued irritation there is something peculiarly pleasing in startling the good man out of his solemnity by interpolating, say, a personal attack in the middle of an equation, or suddenly diverging from the subject in hand to discourse on the idiosyncrasies of woman. But whilst we fully sympathise with this reaction against the monotony of dry facts and the dulness inherent to a plain straightforward treatment of the matter in hand, "there is occasions and causes, why and wherefore in all things," and we cannot agree that the publication of a series of Cantor Lectures is an appropriate occasion for sustained jocularity or applied electro-chemistry a sufficient justification therefor.

A perusal of Mr. SWINBURNE's four Cantor Lectures on "Applied Electro-chemistry," the publication of which was concluded in our last issue, will, we think, arouse a certain feeling of disappointment in the minds of many of our readers. The paucity of material is, of course, largely accounted for by the economic considerations which retard the introduction of new processes; but for the manner of telling his tale Mr. SWINBURNE is wholly responsible. No doubt many a simple seeker after knowledge sat down to the perusal of these lectures in the hope of finding a digestible loaf compounded of well-ascertained facts, full and clear explanations, thoroughly digested theory, and a moderate measure of useful references. Was it quite kind to put these foolish young men off with unleavened bread? The student cannot, it is quite true, live by books alone; but even those who hold in the most profound contempt knowledge derived from printed matter allow that *something* may be learned therefrom; and it is well for a writer to make that something as useful as possible. We had with us not long ago a major prophet who preached the gospel of silence in 32 shrill

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volumes; after that glaring instance our minor prophets, who contemn books, need not fear reproaches on the score of inconsistency if only they will take the trouble to write useful ones.

Applied electro-chemistry is undoubtedly a difficult subject to lecture on to a general audience; but we think Mr. SWINBURNE would have made it easier for himself, and rendered his theme more intelligible to his readers, if he had not assumed so much knowledge on their part. In the lecturer's opinion, no one would go to a Cantor Lecture except to see experiments, which, of course, cannot well be described, and, therefore, the lectures, as printed, differ from those delivered. But a large body of the public look to these lectures to give them, when published, reliable technical information in a fairly popular form. They do not, alas, all read the technical journals, but trust to the lecturer to give them a digest of their contents. Therefore, if conditions of time and space prevented an account of any process being given, reference might well have been made to the literature of the subject. Unless one knows where to find the description, it does not help one much to be told that such and such a process will not be described because it has already been dealt with in the technical press.

Mr. SWINBURNE has, however, done well to devote attention to the economics of his subject. In many quarters there is still a disposition to believe, or make believe, that there is some charm connected with electrical processes which renders them independent of economic laws; and in other quarters the slowness of the advance which has been made is ascribed to some inherent faults in electrical methods instead of to the fact that in most instances these have to supplant existing processes; and that this must naturally take time is clearly shown by the author. The remarks on the seat of the electromotive force in the electrolytic cell, and the criticism of Dr. HURTER's views on current efficiency, were scarcely suitable for delivery to a general audience, and would have been better reserved for a meeting of some specialist society, where they could have received adequate discussion. The first of these subjects has been already dealt with by Dr. OLIVER LODGE in these columns, so we need not pursue it further, but we trust that the latter may be brought before the Institution of Electrical Engineers during the forthcoming session, as it is a question of great importance to those engaged in electro-chemical work, and we are sure that Mr. SWINBURNE would be glad of an opportunity of again hearing from Dr. HURTER's own lips what his views really are. The exposition of the modern theory of electrolysis is good as far as it goes; but it deals only with the views put forward by the school of thought of which OSTWALD may be considered the leader, and takes no account of the interpretation of the electrolytic phenomena which is given by those who follow Prof. HENRY ARMSTRONG. The application of mathematics to chemistry has done much to further the latter science; but mathematical reasoning, like all other reasoning, is so much wasted brain matter unless there are accurate experimental data to go upon, and owing to experimental difficulties we cannot be sure in this instance that we have these as yet. For a long time the German school looked askance at FARADAY's deductions, and it was not until CLERK-MAXWELL put FARADAY's work into mathematical shape that it was accepted. It may well be that some mathematician is required to do the same for Prof. ARMSTRONG, whose views were clearly set forth in his Presidential address to the Chemical Society, of which we published an abstract in February last.

As yet the most successful applications of electricity to industrial processes appear to be those in which it merely acts as a heating agent, as, for instance, in the manufacture of calcium carbide. It is now clear that the production of this substance is not due to the chemical action of the current, but merely to the high temperature produced by it. The case of the Broken Hill ores is indeed an instance of the successful application of electro-chemistry where the heating effect of the electric current is not brought into play, but here the ores could not be worked successfully in any other way. No other treatment was possible, and therefore the electro-chemical method had no competitor to face. This is not said in any disparagement of electro-chemical methods, but rather with the view to pointing out the direction in which there is most hope of finding a successful application for them. There are doubtless plenty of other instances of ores which are refractory to the older metallurgical methods of treatment, but which could be treated electrically. Attempts of this kind are already being made. There are proposals to treat the poor iron ores of the Jura in the electric furnace so as to produce calcium carbide from the quick lime and carbon used as a flux, while the iron in the ore forms an alloy with aluminium or with manganese, as may be desired. Electrolysis has also found a successful application in the recovery of gold from the solutions obtained in the treatment of its ores by the cyanide process, and if the vision of wealth beyond the dreams of avarice, which was recently conjured up by Prof. LIVERSIDGE, of Sydney, fires the vivid imagination of the simple-minded Company promoter, we may expect to see an instance of misapplied electro-chemical knowledge more striking even han Mr. SWINBURNE'S entertaining and eccentric Cantor Lectures.

## REVIEWS.

**A Practical Treatise on the "Otto" Cycle Gas Engine.** By WILLIAM NORRIS. (London: Longmans, Green and Co. 1896.)

Mr. Norris commences his book by remarking that in the early stages of its use the gas engine was regarded as suitable only for small powers. We share his belief that the future will see many manufacturers turning their attention to large powers; but we do not admit his implication that manufacturers should have adopted large powers in the early stages. It was impossible at that time to do so, just as it would be impossible to-day to build a 5,000 H.P. gas engine or a 500 H.P. oil engine. The difficulties are not in the theoretical aspects of the problem, so much as in the practical mechanical questions involved in the building, starting and working of an internal combustion engine of so large a size. The rivalry between the gas engine and the steam engine, which Mr. Norris notices and predicts will grow, is confined to powers which for the steam engine are excessively low or, at most, but moderately large. After all, these considerations, rightly regarded, do but add interest to the fact that "more than 700,000 actual horse-power" is being developed at the present time, by "Otto" cycle gas engines, in Great Britain alone.

Rightly or wrongly, Mr. Norris has limited the scope of his treatise to gas engines worked on the "Otto" cycle principle. In adopting this course he has withheld from students of the gas engine many interesting and important considerations, which attach themselves to a broader and more comprehensive study of the subject. On the other hand, the practically complete exclusion of other cycles from modern gas engines gives to the "Otto" cycle a monopoly of practical interest. It is time to protest, however, when Mr. Norris, having, as it were, turned the non-Otto cycles out of doors, proceeds to malign them. He regrets the "lamentable errors and waste of time" which engineers indulged in before they "reluctantly adopted the Beau de Rochas cycle, as being the simplest system on which an engine can be constructed that will give satisfactory results." Now, it is a matter of history that, rather than reluctance, gas-engine makers displayed uncommon alacrity in adopting the

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"Otto" cycle immediately the master patent sustaining the monopoly of it had expired. And if Mr. Norris or anyone else will inquire of the large gas-engine builders of this country he will probably be frankly told that the present adhesion to the "Otto" cycle is the result, not of the intrinsic superiority of that cycle, but because of the mechanical difficulties in adopting a better one. From the reader's point of view, the unqualified advocacy of the "Otto" cycle means that the author presents him with but a poor account of its inherent defects, and in some instances those defects are passed over in silence. It would have been better, we think, if the author had held a brief for the reader, instead of for Otto; as in that case the reader would have had an opportunity to judge whether the "Otto" cycle really is the final solution of the gas-engine problem.

If, however, the reader is desirous only of learning about the details of construction of engines worked on the "Otto" cycle, and such practical matters as are connected with their use, he will find a great deal of useful information in the book under review. Indeed, the strong point of the work is the almost exhaustive way in which the construction of structural details of gas engines is explained; and as a treatise on this special branch of the subject we can thoroughly recommend it. Successive chapters deal separately with flywheels, crank-shafts, pistons, connecting rods, governors, shaft bearings, valves, starters, &c.; and an admirable chapter describes many existing types of engines. The author is evidently acquainted with the practical manufacture of the gas engine.

**Die Ankerwicklungen und Ankerkonstructionen der Gleichstrom Dynamomaschinen.** By E. ARNOLD. Second Edition. (Berlin: J. Springer. 1896)

No better evidence of the usefulness of a technical book can be found than the issue of another edition. This is the case with the work before us, which has also been in the first edition translated into English, and published by an American firm. The book is divided into two main parts. Part I. deals with the theory and arrangement of windings for armatures. Part II. deals with the practical construction of windings. The arrangement is clear and simple. Taking closed windings first, these are subdivided into ring windings and drum windings; and in each, two-pole, multipolar with parallel connection, multipolar with series connection, and the various combinations of these latter two, are given. Then follow disc armatures and armatures not falling under any of the above heads. After this, open windings, as represented by the Brush, Thomson-Houston, Westinghouse, and other machines, follow.

Part II., dealing with the construction of armatures, is thus divided: Construction of armature cores, construction of armature windings, construction of collectors, examples of ring armatures, examples of drum armatures, drum armatures with bar windings, and finally examples of disc armatures. The book is one which undoubtedly should be in the hands of all students and constructors. The illustrations (335 in number) are excellent, and are up to date. The least satisfactory part of such a book is that it treats of the armature as a thing complete in itself—in theory a geometrical combination of current paths, in practice a more or less mechanical combination of parts. But in reality it is more; it forms but one part of a whole, and on its relation to the whole, and on its electrodynamic as well as its geometrical and mechanical qualities will its success depend. This question is of special importance in the consideration of multipolar machines, and more especially with parallel and series connections and one pair of brushes, a point overlooked in earlier days by some very well-known designers in this country—one reason, perhaps, why such machines have never obtained the vogue here that they have on the Continent and in America.

**Der Drehstrom seine Erzeugung und Anwendung in der Praxis.** By JOSEF KRAMER. (Jena: Hermann Costenoble. 1896.)

It is curious how limited is the text-book literature of alternate-current motors. In this country we have one work "Polyphase Electric Currents," by Prof. Silvanus Thompson, and this hardly treats of motors outside of multiphase induction motors. The present work is perhaps the most complete that has appeared on the subject, embracing, as it does, descriptions of almost every kind of alternate-current motor that has been devised. And how many there have been, what ingenuity displayed, what hopes raised! And where are they all to-day? The discovery by several inventors, almost simultaneously, of the principle of currents of more than one phase was the solid fact that eclipsed the brilliancy of the many earlier attempts. For to-day there is no alternate-current motor in practical work which is not dependent on currents produced by two or more electromotive forces differing in phase. And hence it is that, interesting historically, and from the point of view of the student, as are many of these motors described, for practical purposes they are extinct. It is, perhaps, a pity that more stress is not laid on this point in the volume before us. "A man is judged by the company he keeps," says an old adage; and applying this to motors, when one finds the latest type of (so-called) single-phase induction motor described in a short paragraph in a chapter dealing with some ingenious but bygone arrangements by Hutin-Leblanc and Schuckert, one cannot help feeling that scissors and paste to some extent have been more active than a true regard to the real value of the machines described should allow. Passing, however, from some faults of arrangement, let us examine a little more carefully the points of view from which the author has written this work.

The author first deals (Part I.) with the history, theory and practical working of single-phase alternate-current machines, and then with single-phase alternate-current motors, of which we have already made some mention. Then (Part II.) he passes to "The Revolving Magnetic Field," and, perhaps, a little inverting matters historically, first deals with revolving fields due to two-phased electromotive forces, then with those due to two currents differing in phase produced by one electromotive force (Kunst-phase), and then with those produced by three-phased electromotive forces. Having thus dealt with the general principles of multiphase currents producing revolving fields, the author describes in Part III. dynamos for producing alternating currents of more than one phase, and in Part IV., really the most important in the book, deals with revolving field motors, and gives descriptions of the work of Tesla, Siemens and Halske, Bradley, Schuckert, Stanley, the Helios Company and others. In relation to these latter, which are types of motors with two distinct fields and an armature, or armatures, connected together mechanically and electrically lying in each (a type first introduced by Atkinson in 1888, and subsequently by Kennedy in England, by Helios Company in Germany, and later by Stanley in America), although included by the author in revolving field motors, they are not such, and indeed in this very book those of the Helios Company are fully illustrated and described as of a distinct class.

Part V., on the regulation of the speed and power of revolving field motors, is important, the methods described consisting principally in means for varying the number of pairs of magnetic poles by varying the coupling of the windings. Part VI., on transformers, and VII., on circuits and connections, call for no special notice. Then follows a useful chapter, Part IX., on measurement of alternate currents, and the book is completed by an appendix, in which some of the later developments of multiphase working, such as the monocyclic system of Steinmetz and the combined two and three-phase systems of Scott, are dealt with. Tables of sizes, outputs, and other details of the manufactures of a few prominent firms complete the work. The weak point of the book is that it is too descriptive, and scarcely deals in any way with actual dimensions or working designs. Yet we feel that it fills a gap, and have no hesitation in recommending it to our readers.

**A Systematic Course of Geometrical Drawing.** By T. A. V. FORD, M.R.C.S. (London: George Philip and Son.)

This is an elementary text-book, teaching the student sufficient geometrical drawing to enable him to attain the standard required for the Woolwich and Sandhurst entrance examinations. Both the instruction and the illustrations are very clear, and the print and paper is excellent. For an engineering student the book hardly reaches far enough, as it does not pretend to be an introduction to descriptive geometry or machine design.

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## "BREAKING DOWN" A FAULT.

On high-pressure alternating systems it often happens that a fault, of about a megohm or some thousands of ohms resistance, is known to have developed in one of the mains. Such a fault may break down at any moment, causing the main fuse at the station to blow. As soon as an engineer knows of the existence of this fault he should, of course, lose no time in finding and repairing it, before a catastrophe can occur. But so long as the fault has such a high resistance, he cannot force enough current through it to localise it by the ordinary means; and, on the other hand, if he waits for it to get worse, it may break down altogether at any moment, and cause trouble. The safest way to proceed is to choose a time when the portion of the cable containing the fault can be isolated for a few hours, and then to purposely break the fault down and localise it accurately by means of a loop test.

In the case of a concentric system in which the cables are insulated with paper or impregnated cotton or jute under a lead covering, it is doubly important to break the fault down without loss of time. An injury to the lead-covering of the cable will cause a fault to develop between the outer conductor and lead, due to moisture soaking into the insulation. If this fault is discovered in time the moisture will not yet have reached the insulation between the conductors, and, this insulation being still intact, the inner conductor can be used to

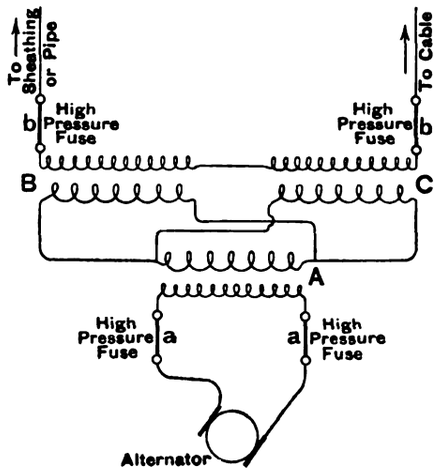


FIG. 1.

make up the loop for the localisation test. But if one has waited too long a fault will have developed between the conductors as well, and it may possibly break down when the fault to earth is broken down, if not before. In that case another return wire is required to make up the loop, and should this not be available nothing remains but to use one of the methods of localising without a return wire; or if the resistance of the short circuit is small, to localise it as a short circuit. These methods do not give nearly such an accurate result as a loop method, and it is always worth while to put oneself to some inconvenience to form a loop.

The way to break a fault down is as follows. (*See* Fig. 1.) The primary of a transformer A is connected to an alternator. The low-pressure windings of two other transformers, B and C, are connected in parallel, and to the secondary of the transformer A. The high-pressure windings of B and C are connected in series between the conductor and sheathing of the cable to be broken down. In this manner twice the pressure at the alternator terminals will be applied between the conductor and the sheathing of the faulty cable. The size of the transformers is immaterial, but the fuses must be so proportioned that none of the transformers can be overloaded. It must be remembered that twice as much current will flow through the primary of A as will flow through the high-pressure windings of B and C. Thus the fuses *b*, *b* must melt with less than half the current sufficient to blow the fuses *a*, *a*. The connections being made the alternator must be started slowly, and the voltage gradually increased until the fuses *b*, *b* blow. It is immaterial whether the voltage is gradually run up by increasing the exciting current or by increasing the speed of the alternator. As soon as the fuses blow, the cable must be disconnected and tested with a Leclanché cell and a current detector to see if the fault is broken down to a dead earth. It is sometimes necessary to repeat the process several times before the fault breaks down. The fuses often melt before the arc at the fault has had time to completely burn the insulation there. The number of volts used can be calculated from the readings of a voltmeter connected either across the primary or secondary of A. If twice the maximum pressure of the alternator is not sufficient to break the fault down, a third transformer may be connected with its low-pressure winding in parallel with the low-pressure coils of B and C, and with its high-pressure coils in series with the high-pressure windings of B and C. In every case one must make absolutely sure that the fault is in the cable itself, and that it is not surface leakage at the ends. When three transformers are used in series it is absolutely necessary to insulate the one connected to the conductor of the cable.

If the operation is carried out at a substation, or if a spare alternator is not to be had, the connections may be made to

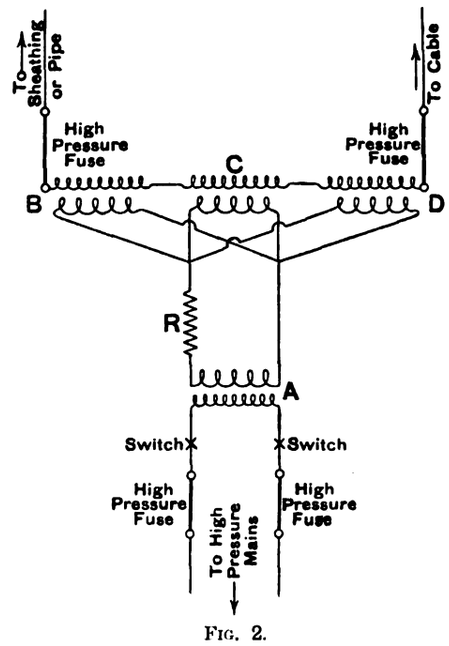


FIG. 2.

the high-pressure mains through switches and fuses as shown in Fig. 2. An adjustable resistance R is connected between the secondary of A and the low pressure-terminals of the "step-up" transformers, so that the full pressure is not on the cable at starting, and the pressure can be gradually increased by decreasing R. In Fig. 2 three step-up transformers, A, B and C, are shown so as to triple the pressure of the mains if required.

## THE JUBILEE OF THE BELGIAN TELEGRAPHS.*

The fiftieth anniversary of the introduction of the electric telegraph into Belgium has been commemorated in Brussels in a most charming, unostentatious manner, genuinely worthy of the brilliant epoch in the history of mankind which evoked the celebration. Of course, this commemoration did not stir the masses; but that was not to be expected. If it had been a case of some local celebration cannon would have been fired, and the streets would have been filled with people. But the world is almost indifferent to the jubilee of this marvellous discovery, which gave to man the means of being simultaneously at every point of the globe. The public considered that the occasion did not warrant any ringing of bells. Moreover, the thing commemorated is a little abstract, no individual name being prominently connected with it. Again, all of us have at one time in our lives been sincerely enthusiastic over this

* From *L'Electricien*, Oct. 17, 1896.

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troublesome manifestation of science. Finally, to tell the truth, the telegraph is somewhat of a nuisance. There is no getting away from it. It catches hold of one at least ten times a day. In one's home, or wherever you may be, it arouses us, every morning, every evening, every night. It crops up in the newspapers at every line, and every one passes his life in running after it. It is not surprising, therefore, that under the circumstances popular enthusiasm was wanting.

But the telegraph has its temples and its faithful followers in its telegraph offices, and telegraphists; and the latter, who know it well, have learned to venerate it. It is in these circles, in fact, that the idea originated in Brussels of celebrating the jubilee of the Belgian telegraphs.

In the telegraph offices it was considered that the head-quarters staff should take upon itself the duty of regulating the rejoicings. Fortunately, however, the head officials, and it is to their credit, considered that if the telegraphic hierarchy meddled with the matter it would become an "official" concern, with all the consequences following thereon. The delegates were, therefore, told that it was hoped that if there were found in the telegraph offices men of sufficient initiative able to organise a well-conceived plan on their own account, *carte blanche* would be given to them, and the sympathy of their chiefs would go out to them in their enterprise. On receiving this reply, everyone put his shoulders to the wheel, and it was resolved to have an exhibition of all telegraphic devices employed during the last fifty years, and, what was more, to make them work. Devoted employées passed long hours in studying the *modus operandi* of a whole series of ancient contrivances, and, after mending them, got them to work. At the pre-arranged hour, in a room decorated with considerable taste, the guests were invited to transmit what messages they wished, on what apparatus they liked. Everything went off admirably.

The Exhibition was opened by the following discourse, delivered by M. J. Banneux, chief engineer to the Belgian Postal Telegraph Department:—

The telegraph service, from the Director-General to the humblest workman, has combined to celebrate, with the benevolent support of its chief, M. Vandenpeereboom, the fiftieth anniversary of the introduction of the electric telegraph into Belgium. It was essentially a telegraphic fraternal feast; but the organisers considered it useful, and your presence here to-day in large numbers justifies them to associate the public with these humble festivities by exhibiting the means which science and inventive genius have placed at our disposal since 1846 to the present day, to carry out and to improve one of the most marvellous applications of that mysterious force known as electricity. We have endeavoured to increase the interest in this Exhibition by showing you in action the different types of apparatus employed in Belgium in the course of half a century—a display which has been attempted, I believe, to-day for the first time, thanks to the devotion of a group of young men, who, with great enthusiasm, undertook to investigate the method of working of all the ancient instruments reverently interred in the Telegraph Museum. These will transmit and receive before your eyes genuine telegrams, and will enable you, every day the Exhibition is open, from September 9th to September 27th, to communicate even with neighbouring countries—England, Germany, France, and Holland—which have been good enough to lend us their assistance. Explanations will be given as to the principle and scope of the different instruments. Everything will be done to render profitable the time spent by visitors to this Exhibition. We shall only resent one thing, that is if the public is afraid of exhausting the courtesy of the *personnel*.

All the world knows that the Belgian Government, by a decree dated December 23, 1845, granted to two Englishmen, Cooke and Wheatstone, a concession for a telegraph line along the railway from Brussels to Antwerp. At this date these inventors had established their apparatus along a certain number of railways in England, more especially in connection with the train service, and in addition these telegraphs were used for public communication.

Offices were opened at Brussels, Mechlin, and Antwerp, on September 9, 1846, under the superintendence of Mr. John Indell Gibbs. These offices were provided with double-needle galvanometric apparatus, connected by two conductors. To receive a message two operators were necessary. One watched the signals, and mentally transforming them into letters and figures, dictated each word or each number to a colleague, who wrote out the telegram. The public were admitted to witness the working of the telegraph at the rate of 1fr. a head. Public curiosity, however, only resulted in meagre receipts to the Company. Every day a few messages were exchanged between Brussels and Antwerp during Stock Exchange hours. During the events of 1848 the telegraph rendered great public service; but the net financial results of the enterprise were not satisfactory. Hence the concessionnaires made no difficulty about handing over their line to the State, although the expiry of their concession was still a long way off.

In 1849 the telegraph lines of Prussia and France began to approach ours. The Belgian Government, which up to then had attempted to temporise with the telegraph owing to the condition of the public treasury, came to the conclusion that it ought no longer to postpone grappling with the telegraph question. A Commission, composed of MM. Quetelet, Director of the Royal Observatory (President); De Vaux, Inspector-General of Mines (Secretary and Reporter); and Cabry, Inspector-General of Railways, was formed by decree of M. Rolin, the decree being dated December 31, 1849, for the study of the electric telegraph, with a view of its application more especially to the working of railways. The Committee reported on March 21, 1850. On the 22nd the Minister signed the preamble of a law authorising the Government to establish electric telegraphs along all the State railways, which then had a length of 609 kilometres. A grant of 250,000fr. was asked for. The law passed without opposition, and was promulgated on June 4, 1850. For a sum of over 60,000fr. the State was put in possession, on September 1, 1850, of the Brussels-Antwerp line, and also obtained the benefit of the patents granted in Belgium to Cooke and Wheatstone. The State displayed such activity that at the end of the same year a double-wire telegraph line extended from Ostend to Verviers viâ Ghent, Termonde, Mechlin and Louvain, a distance of 241 kilometres. In accordance with the advice of the Commission, it was decided that the conductors to be erected on posts should be of 4mm. galvanised-iron wire, and that the English double-needle apparatus should be employed for interior messages; whilst for international communications use should be made of whatever apparatus was preferred by the foreign country in question.

Up to the end of 1852—that is to say, up to the time of the advent of the Morse telegraph—every apparatus in use gave only fugitive signals. Telegraph apparatus may be divided into two classes. In one, which includes the devices of Cooke and Wheatstone and Foy-Bréguet, using respectively two conductors and one, the signals are formed by the deflections of a needle or two needles at the same time. A conventional meaning was given to these signals, in order that they might represent letters, figures, words, parts of words, and even common phrases. In the second class of instruments, for which a single wire is necessary, are comprised the alphabetical apparatuses, in which letters and figures arranged in a circle around a card are successively signalled by a needle which is moved by the operator. In this category came the Siemens and Halske instruments, and the Lippens and the Bréguet instruments, to which I will add the dial and letter instruments of Gloesener and Wheatstone, although these were never in use in our service. Our first international relations were with the Austro-Germanic Union (Prussia, Bavaria, Saxony, and Austria), with which we communicated in 1850 *viâ* Verviers, where there were both Belgian and Prussian offices in conformity with the International Convention of May 16, 1850, the earliest international convention known. There were at Brussels, Liége, and Verviers the dial and letter instruments of Siemens and Halske, which were later on used between Verviers, Dolhain, and Herbesthal.

On April 20, 1851, we entered into relations with France, communication being effected between Brussels and Paris by means of Foy-Bréguet apparatus, the two arms of which partly produced the signals of the aerial and purely mechanical telegraph of the brothers Chappe. It is well known that France organised in 40 years, from 1794 onwards, a system of semaphore telegraphy which was the most complete of its kind, and the ramifications of which were pushed in our country as far as Ostend and Antwerp.

Our interior network rapidly developed. The necessities of the railway service demanded telegraphic installations in localities of secondary importance, where no one would have thought of specially sending telegraphists. The Cooke and Wheatstone apparatus required a somewhat long apprenticeship, and aptitudes which are not to be found among lower-grade railway employées. Strong instruments easy to manipulate were required, such as would signal letters and figures without any labour of mental transformation, and would at the same time lend themselves to rapid transmission of messages. The dial and letter apparatus of Bréguet and Paris, of Lippens and of Eecloo, fulfilled these desiderata. These instruments were used together for many years. The Lippens, which was continuously improved, had an existence of 22 years, whilst the Bréguet apparatus only came into use later, in connection with railways worked by French concessionnaires. It is right to recall the fact that the Lippens apparatus involved the use of the principle of reversed currents in the electro-magnets, a principle due to Prof. Michel Gloesener, of the University of Liège.

But the American system of Samuel Morse was destined to progressively dethrone every other. The Morse method presented in addition to the advantage of easy manipulation that of making durable marks on a strip of paper; these signals, dots and dashes, were at first embossed, but in 1856 and 1857 they were written in ink, thanks to Thomas John, an Austrian, and to Beauduin and Digney of Paris. From that date the Morse apparatus was sufficiently well equipped to conquer the world. By its means, as Vinchent put it, telegraphy won free trade.

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On January 1, 1861, the State offices possessed 91 Morse apparatus, 130 Lippens, 10 Bréguet, and 3 Siemens. On January 1, 1870, there were 623 Morse, 29 Lippens, and 11 Bréguet. At that time there were 305 offices open to the public and 128 offices at railway stations, where the telegraphic apparatus was used for private work; the Belgian telegraph network having a length of 15,000 kilometres of wire. Finally, during the year 1869 there were transmitted 1,722,586 private telegrams and 315,722 Government messages, the receipts amounting to 1,323,000fr.

It was at this date that the Hughes apparatus arrived in this country—a marvellous piece of mechanism, printing letters and figures at lightning speed. This apparatus demands a somewhat longer training than the others, and more extensive scientific and technical knowledge. But what an admirable instrument it is, capable of dealing with more than one complete message a minute when it is regularly fed. It came at the proper moment to enable us, without extending our wire mileage, to cope with the great traffic of our big offices. Like the Morse, it has become the grand international instrument.

During the last decade a very interesting phenomenon has been observed. On the one hand we have returned to the fugitive signals of the early days; on the other hand, we have increased tremendously the working efficiency of our lines by applying sometimes to the Morse, sometimes to the Hughes, duplex arrangements which enables us to exchange by a single wire two opposite messages at the same time. The Morse apparatus no longer writes. It sounds. It is no longer the eye which intervenes, it is the ear. It is the acme of simplicity. Nevertheless, the speed and accuracy of transmission have been sensibly increased. In parallel with this, the combinations of apparatus and circuits have become more complex, more scientific, and their management is only within the reach of an experienced and trained *corps d'élite*. But I hasten to say that the Belgian operators are and ever will be equal to the task, difficult as it may be.

At the moment of celebrating the jubilee of the Belgian telegraphs it is right and necessary to carry our thoughts to those of our own countrymen who battled with the numerous difficulties of early days, and contributed to raise telegraphy to the great place it occupies today. The names of Gibbs, Gloesener, Lippens, and Girardin, will be remembered by all. But there is one who represents for Belgium the organisation of the telegraph service, the distinguished engineer and eminent administrator, one of the leading lights of our conferences and international congresses, an official who, to the glory of the Belgian name, has won the respect of his colleagues of all nations. I refer to Julien Vinchent, who was the right man in the right place. We who have been able to appreciate his high qualities, his kindness, and his justice, render to him, from the bottom of our hearts, the homage which is due to him, and we shall piously guard the memory of the brilliant services rendered by him to the telegraphic enterprise of the country.

I declare the Exhibition of telegraphic apparatus open.

## WATER RHEOSTATS.*

BY GEO. T. HANCHETT.

Many practical men do not know how universally water resistance may be applied, both for temporary and permanent service, in electric lighting and power work. It is often the case that a resistance of some kind is greatly desirable, if not absolutely necessary, and a few practical suggestions concerning the use of water resistances in such cases may not be amiss.

The fluid in a water rheostat is not wholly water, as the name might imply, but consists of a mixture of water and some acid, usually sulphuric, which is added to vary the specific resistance. As the range obtainable by this procedure extends from one-tenth of an ohm, or even less, to several thousand ohms, the flexibility of the device is obvious, and it is practicable to prepare a water resistance to suit any voltage by varying the degree of acidulation.

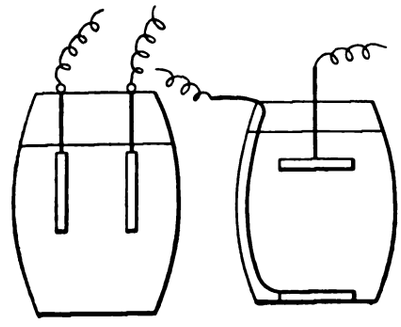
In the liquid are placed two metal terminal pieces, identical as to material, so as to obviate electrolytic action, and to these are attached the circuit wires. The proper shape and size of these terminals depend upon the volume of current to be passed through the device, and are also affected somewhat by the voltage. With large currents or very low voltage, or both, the terminals should be of large superficial area, and *vice versa*.

Water resistances are more often temporary devices, and, therefore, barrels, pails, &c., are frequently pressed into service. In cases where the apparatus is to be used for a few moments only, and the voltage is not dangerously high, a metal vessel is very convenient and satisfactory, the vessel itself constituting one terminal, and the other terminal being suspended therein. The resistance is decreased by gradually lowering the suspended terminal until it touches the bottom of the vessel, when the resistance is, of course, entirely cut out. However, it is not desirable to use any device in which the terminals tend to come together, except in cases like the one just mentioned, for the sudden removal of resistance from the circuit, caused by the accidental dropping of the suspended terminal, might result disastrously.

A water resistance may be adjusted either by varying the distance between the terminals or by varying the terminal area submerged.

The first method is preferable with heavy currents, and the second is better with small ones. The bulk of fluid necessarily depends upon the watts to be absorbed, regardless of voltage and current. For a steady load, free from sudden fluctuations, 20 kilowatts per barrel of fluid will be found to be a very satisfactory working figure.

If a comparatively wide tank or tub is used, whereby a large surface of water is exposed as compared with its bulk, a higher figure may be taken.



FIGS. 1 and 2.—Forms of Water Rheostats.

The most satisfactory method of arranging a barrel of water for voltages under 220 is shown in Fig. 1. Rods are laid across the top of the barrel and the plates hung therefrom. The rods can readily be arranged to admit of the adjustment of the distances between the plates, and should one of the supports break it would not cause trouble by a short circuit.

Unfortunately, the arrangement shown in Fig. 2 does not possess this advantage, but, barring this feature, it is well adapted for voltage up to 500. For 1,000 volts two such barrels in series can be advantageously used.

For starting a motor it is surprising how small a rheostat (mechanically) will suffice. A 25 H.P. motor can readily be started under load with a water resistance contained in a two-quart pail, and a 5 H.P. motor can be handled with the resistance contained in an ordinary cup. In each case the starting will be perfectly smooth and free from sparking.

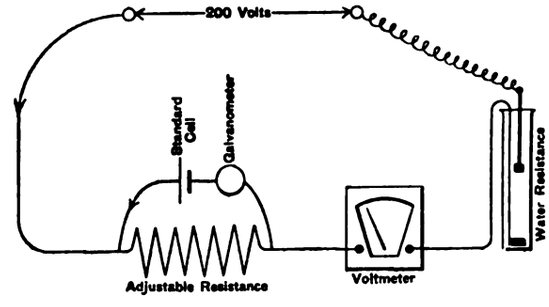



FIG. 3.—Water Resistance in Voltmeter Calibration.

In using a rheostat of this type to control a shunt field circuit it is well to have it amply large mechanically, in order to avoid instability due to the excessive heat which would be produced by the use of too small a body of liquid.

In making up a water rheostat the acid should be poured in a very little at a time, and the fluid thoroughly stirred.

If this is neglected the resistance of the liquid will later on suddenly decrease, it may be to a point that allows a dangerous current to flow.

Experiment is usually the better way to determine how much acid is necessary, but for those who desire a guide to follow the accompanying table is given.

Resistance of a body of liquid 1 sq. ft. in cross-section and 1ft. long:—

| | | | |
|---|---|---|---|
| Pure water | | | about 100 ohms. |
| 0·174 | per cent. | acid | 4·12 " |
| 0·435 | " | " | 1·75 " |
| 0·724 | " | " | 1·10 " |
| 0·985 | " | " | 0·85 " |

* From the *Electrical World* of New York.



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The proportion of acid should be sufficient to enable the solution to absorb about one-third the desired energy. The rest can readily be obtained by the adjustment of plates. In some cases, where a high voltage and a very small current are involved, as in voltmeter circuits, a water rheostat in column form will be found to give satisfactory results. Unfortunately, water resistances are prone to develop annoying back E.M.F.'s, which preclude accurate measurements. To avoid this as far as possible in voltmeter circuits, use a solution of zinc sulphate and two zinc terminals; these produce a

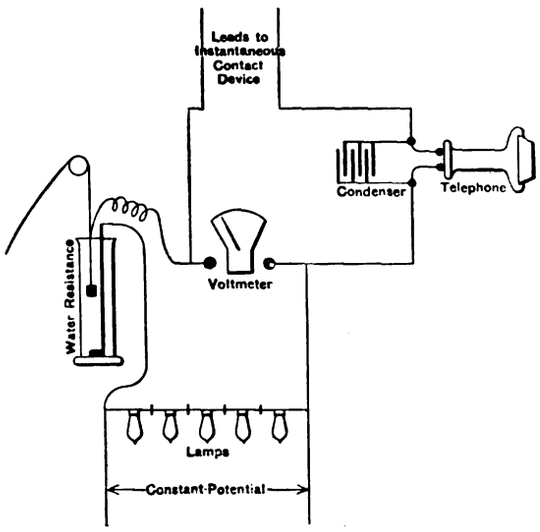


FIG. 4.—Taking Alternating-Current Curves.

minimum back E.M.F. Fig. 3 shows the much-used method of calibrating a voltmeter with a standard cell, in which a water rheostat is almost invariably used. With a 30in. column of solution 100 volts drop can be obtained with the usual voltmeter current passing.

In the method shown in Fig. 4, for taking alternating-current curves by instantaneous contact, in which a liquid rheostat is used, voltmeter readings to within $\frac{1}{10}$th of a volt can be obtained by two independent observers.

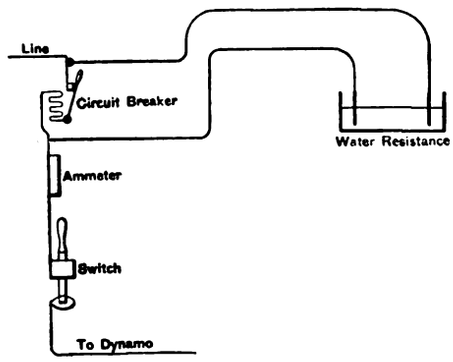


FIG. 5.—Water Resistance as a Safety Load.

Fig. 5 illustrates diagrammatically an application of a water resistance to railway work. A rheostat capable of furnishing half-load to the dynamo is connected in shunt to the circuit-breaker, so that when the latter opens the arc is much reduced, and the load is not entirely taken off the dynamo and engine. This not only reduces wear and tear on the circuit-breaker, but may prevent a disastrous runaway.

## THE TELEPHONE SITUATION.*

BY FRED. D. LAND.

The progress made by opposition telephone companies in establishing exchanges, toll lines, and toll stations, and the annoyance and expense that the Bell licensees have been subjected to by reason of this competition, is attracting the attention of investors in many localities where competition has not made its appearance. Naturally these investors wonder whether the parent Company—the American Bell Telephone Company—has awakened to a clear understanding of the strength of the enemy in Pennsylvania, Ohio, Indiana, Michigan, Illinois and Iowa? And after a visit from the sleek telephone promoter, they wonder if the Bell officials realise that, once the interests of all these hundreds of competing companies are harmonised, the enemy's present strength will be so materially reinforced by the interlinking of all these exchanges and toll stations by toll lines radiating out from every town and every city, that within a year or two the country will be so covered by the opposition that the linking together will afford connecting toll lines from the Hudson to the Mississippi?

But the investor need not feel alarmed about the stability of the Bell interests, for the Bell officials keep posted on every move that is made by the opposition, as becometh men of wisdom and experience, having their millions invested in a permanent and rapidly increasing form of public service. Nor do they fear that the progressive business man in any community will ever dream of patronising the opposition toll lines so long as the direct and heavy copper circuits of the American company are maintained in their present perfect condition. For the successful business man realises that it is *service*, and not *cost*, that he must consider, when discussing important questions with customer or client. A "deal" that may have required months in the arrangement of certain details, and now requires but a few moments' personal conversation to close, may be blasted by the annoyances that have ever been associated with imperfect and interrupted telephone service. To patronise a long-distance circuit made up of a variety of interconnecting lines, some of steel wire, some of B B, some of E B B iron wire, with now and then a copper circuit, and supported on poles of tamarack, or black ash, or whatever timber the immediate locality may afford, or on insulators bracketed to trees, is just about as sensible as it would be to journey to New York over a succession of short and ill-constructed railway lines, each under a separate management, using a different system of switches, in place of making a trip over a heavily-ballasted and efficiently-managed trunk line.

These new toll lines and small competing exchanges are the best advertisers the Bell interests have ever had. They introduce the service among those who have had little or no experience with the telephone, and who heretofore have refrained from leasing an instrument on the ground that "we supposed we could not afford it." But personal experience has given an insight into the value and the economy inherent in the telephone, both as a time-saver and a business-bringer, and now only the best will satisfy these subscribers. And to this desire for the best may be traced the true reason for the closing of the many competing exchanges that have gone out of business, not by reason of litigation for infringements of patents, or for any pressure brought by the Bell interests, but simply to an inability to supply a quality of service satisfactory to the experienced user. And only from the regular user of the telephone can an assured and definite income be obtained by any exchange. The irregular user of the telephone is an expense and an annoyance. Not only is this proving true in the smaller towns, but also in cities like Grand Rapids, where some of the shrewd citizens, having the best interests of the city at heart, are questioning the permanency of their competing exchange that is probably the largest of its kind in the country. This exchange is reported to have fully 1,800 subscribers with 400 applicants on its books, and a prospective annual income of $50,000 on a reputed investment of $100,000. Could a more desirable condition of affairs be imagined? But, unfortunately, the Bell instrument forms a standard by which the quality of the service supplied in Grand Rapids is unconsciously being measured and often found wanting by the active, hustling business man holding no stock in either exchange, uninfluenced by the false sentiment aroused by the promoter, and only asking value received for his money.

If we look at the question from a local point of view, the telephone appears to be a natural monopoly, and the highest returns on the rental of an instrument can be secured where there is but one exchange. Thus, to encourage and support two exchanges is to add an additional burden on the business community, for the progressive business man must have telephonic communication with all subscribers to every exchange in his city, whether there be but the one or a dozen exchanges, each competing under circumstances that can only tend to destroy the efficiency of the service each supplies. And the merchant realises that it is not competition that he desires so much as high-class service, and the better the service becomes the less he objects to the cost. For there are houses that receive more business through the telephone door than ever enters through the doorway planned by the architect. Again, these merchants appreciate that when an intelligent public comprehends how intricate and varied are the problems facing the telephone question in every city, an earnest effort will be aroused to unitedly make the one exchange as complete and serviceable to the city as is possible. For the greater the number of subscribers connected to a telephone exchange the more valuable the service becomes to each subscriber, and the larger return each receives for the rental paid.

The competing telephone exchange craze appears to be running its course, like many another disease. Bankers and lawyers, manufacturers and dealers, all appear to have laid aside their usual business

* From *Electrical Engineering*, Chicago.

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prudence and sagacity, and to have passed under the hypnotic spell of a set of men who never had any standing among the electrical fraternity, yet have the nerve to appear before a public meeting of interested citizens and there talk glibly about the enormous profits that will follow the building of a competing telephone plant to cost $30 or $40 a subscriber, though well aware that the plants they constantly refer to as ideal competing exchanges cost more than $100 a subscriber, and that the modern Bell exchange costs from $150 to $450 a subscriber, according to the population and the magnitude ofthe plant. These promoters will grow enthusiastic over the many plants they report as being in operation or in process of construction in many States; but will forget to say that not a single competing exchange has declared a clearly-earned dividend, and will be very silent on the large amounts lost for ever in the thirty or more competing exchanges that have fizzled out. Can the promoters point to a single one of these many exchanges that have been closed or sold out, from which the original investors ever received back one-fifth of their investment, to say nothing about dividends? Yet, in many cases, these investments represented the earnings of the widow, the orphan, the toiler in many lines of industry. This class of investors may be credulous, and may rarely fight for their rights; but it is doubtful if they ever forget the names of the good citizens who blindly helped the strange promoter to line his own pockets with the savings set aside for times of stress. Who ever heard of a sleek promoter telling about the men whose political future has been blasted by allowing their names to be used to further the promotion of fraudulent schemes to the detriment of citizen and city? Yet the plain people have a sharp memory. And does not the investor pass by the town or city whose leaders are thoughtless of the vested rights of their taxpayers, hesitate not to ignore the opinions of the judiciary, and find pleasure in aiding the promotion of schemes foredoomed to failure?

## ELECTRIC TRACTION.*

BY PROF. R. H. SMITH.

The subject of electric traction is at last forcing itself upon the British public in a prominent fashion; and, as it promises to occupy much of the attention of English engineers during the next decade, it will be well if the members of our profession will study the experience gained by our brethren in America and elsewhere. Much instructive information is obtainable from the important volume entitled "American Street-Railway Investments," published a few weeks ago as an annual supplement by the *Street-Railway Journal*.

Fifteen years ago I ventured to express the opinion that the main future of electric engineering lay in the direction of haulage, and the transmission of power for other mechanical purposes. The progress of events has developed nothing to change this view. During the last ten years electric lighting has occupied chiefly the energies of European engineers; but there are very evident and somewhat narrow limits to the business of electric lighting by present methods; and the growth of invention in incandescent gas lighting is likely to make these limits a great deal narrower than had been hoped for by electricians a few years ago. Recently estimates were made for the radical and liberal improvement of the lighting of a large installation at present illuminated by ordinary gas jets. It was found that the outlay required for the desired results by electric plant would be from eight to ten times that required if incandescent gas lamps were employed; while the annual cost in interest, depreciation, &c., wages, and materials, would be with electricity more than double that with incandescent gas. Another more curious illustration may be cited. A certain engineering station was lighted with oil lamps. Although the lamps were of good construction, it was decided to substitute electricity; and, although there was ample excess steam generating plant already *in situ*, oil engines were employed to drive the dynamos. The result was that the engines used more oil of the same quality than the lamps had previously used, and the illumination was not so good as before. The field for the transmission of mechanical power by electric current is practically unlimited. The possible progress of its competitors, namely, transmission by shafting, spur and belt gearing, air, water, or other fluid, is about exhausted; no important further improvements in these directions are probable, and the conditions under which they are, or can be, fairly efficient are not tolerably well and certainly known.

The use of electric power for passenger and freight locomotion may be said to be still in its first infancy. The first really altogether satisfactory form of electric locomotion was in launches, the secondary battery method having for boating many advantages not appearing in land locomotion, and most or all of those special disadvantages which have made it a failure on tramways being absent. Sir William Siemens' launch on the Danube at Vienna during the Exposition of 1883 was the parent of the splendid flotilla of launches and gondolas on the picturesque lakes of the World's Fair at Chicago in 1893.

In spite of the original tramway installations in Ireland and the various interesting and instructive short lines in Germany and Switzerland, no fair-minded observer can dream of denying to the United States the honour of practically solving in a commercially successful form the great problem of light railroad traffic with electric propulsion. The honour belongs quite as much to the people as to the engineers of the States. It is due to no war of skill on the part of German, French, and English engineers that electric tramways have only now begun to show a prospect of making some headway in our Old World. It is the conservatism, the hardly vanquished prejudices against all new things, of the English people that have prevented English engineers seeing a prospect of profit in devoting their time and energies to the promotion of electric locomotion in this country. The American people are not without these same prejudices; they operated there severely against the first introduction of the new style tramway. But resistance of this kind dies out more quickly in the rapid and feverish life-conditions of the States; and luckily for the juvenescent growth of electric traction, the American public has never demanded the same almost absolute safe-guarding from accident that has been insisted on in European railway traffic. Thus the overhead system met no such strenuous and, to a certain extent, unreasonable opposition there as is now receiving, and will receive for many years yet, in this country. It is the cheapness of the overhead system that has been the essential and critical condition that has led to practical success in America. The whole American railway system was born, and could never have grown to adolescence, except under conditions of cheap construction and moderately low operating expenses. The main steam railroad systems have now grown to mature strength, and during the last decade have gradually thrown off these hampering conditions of their youth; so that there are now thousands of miles of railroad in the States as well ballasted, railed, bridged, and engined as any in Europe. The electric tramway systems are passing through the same sort of history. Every year the cost per mile is becoming more expensive, and the engineering standard of efficiency, safety, and general excellence is being rapidly raised. In European electric engineering—inclusive of lighting—our public has endeavoured to impose upon us from the first conditions of comparative perfection, which up till now, or recently, have offered no reasonable prospects of commercially profitable investment. These councils of perfection have undoubtedly greatly delayed the dawn of the new era. On the other hand, it may be opined with, perhaps, as little doubt that they have increased to almost a certainty, the probability of steady and rapid progress once a fair start is made, on account of the higher level of knowledge and skilled experience from which we build as our basis. The universal American and Canadian experience has been, that in the minds of urban and suburban publics, the slight disfigurement to the highways and streets—which no reasonable person denies—caused by the overhead wires, is only a small set-off against the greatly increased cleanliness, comfort, and speed obtained from electric propulsion. The amount of this disfigurement varies greatly with the general character and the details of the design, and we need entertain little doubt that in the near future it will be reduced considerably below the degree at which it now stands in the best existing installations. In works of this kind municipalities do right to insist very strongly on what I may call the æsthetic rights of the public, which engineers have sinned against far too much in the past. In not a few places extensive electric light installations have been put up and taken down again. But it is safe to say that nowhere where an overhead electric tramway has been started and its comfort been since experienced, will electric traction be subsequently abandoned; although the overhead arrangement may very well be improved or possibly replaced by underground conductors. In 1892, Mr. A. Reckenzaun published an excellent treatise giving much accurate technical information as regards the constructive details of both motor cars and lines. Since Mr. Reckenzaun's book was published there have been many developments, but his book appears to be still the best on the technique of the subject published in our language, and it is still of the greatest value to practical engineers. A new edition bringing the illustrations and descriptions fully up to date would be very welcome at the present time.

I believe that the overhead systems in use are still capable of very considerable improvement in detail; and that, in spite of the small successful progress made hitherto in underground construction, radical changes which will solve this problem to the satisfaction both of the public and the shareholders will ere long be found in operation. At the date of issue of his book Mr. Reckenzaun seemed to believe in such future improvement of secondary batteries as will still give them a chance for tramway purposes. I confess I do not share these sanguine expectations, although I fully

* From the *Engineer*, October 16, 1896.



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admit the useful sphere of activity of accumulators for water traffic, and, of course, for many land purposes outside the running carriage.

In the coming English development of urban and suburban electric traffic English engineers and financiers will have the benefit of experience accumulated over a very large area in the United States and Canada. It may surprise many of your readers to learn that there are now at work in the United States over 12,100 miles of electric street railway, and in Canada about 450. A study of the statistics given by the *Street Railway Journal* in its supplement, entitled "American Street-Railway Investments," is of the greatest interest. I can only here give the briefest *résumé* of the more important results; but a detailed examination of the volume will well repay engineers who may be looking forward in this direction. The mass of information supplied may be judged from its being packed in condensed form into 274 large quarto pages. All the more important systems of urban railroad are shown on excellent maps, many of them to large scale. The information is fully up to date—viz., May 31, 1896; but naturally, in the majority of cases, it is by no means complete or detailed. Still, what is given is sufficient for many purposes; and it may be surmised that in those cases where few figures have been obtainable they have been either of little importance, or else referred to cases which have shown no satisfactory measure of success. Much as we might like to learn about these latter as being often more instructive than those where complete success has been attained, it is obvious that it would be impracticably difficult to obtain figures of recent date. The mass of statistics given in the above volume is summarised to a certain extent in the July and August issues of the *Street-Railway Journal*.

While there are in the United States at this date 12,133 miles of electric railroad, the horse-tramway mileage is no more than one-tenth of this, viz., 1,219; cable mileage, 599; and "miscellaneous," which I presume means for the most part steam, is no more than 519. Thus, out of a total of 14,500 miles of single track 84 per cent. is now electric. This mileage, owned by 916 companies, is worked by 26,242 motor cars and 8,729 trail cars. This gives 2·09 motor cars per mile, and 0·72 trail cars per mile. The capital employed on this mileage is about £231,000,000, or nearly £19,000 per mile. This capital is nearly equally divided between share capital and one or other form of borrowed capital.

The New England States have within their boundaries 1,729 miles out of this electric total, this figure being largely brought up by the 1,093 miles in Massachusetts. The Eastern States have 3,884 miles, of which 1,382 are in New York State. The Central States lead the way with 4,105 miles, of which Ohio owns 1,073. The Southern States own only 793 miles, and the Western 1622.

These different sections of the country spend very different amounts of capital per mile upon their roads. Thus, while the average is £19,000 per mile, the maximum, £36,500, is found in New York; over £27,000 prevails in Pennsylvania, Columbia District, and Illinois; about £23,000 in Rhode Island, New Jersey, Minnesota, and Louisiana; from £15,000 down to £10,000 per mile applies to some 5,000 miles, and this figure goes down as low as £3,500, this being the average for 49 miles in Florida, of which 37 are electric. Here, however, there are only 23 motor cars for the 37 miles; while on those lines absorbing the greater capital the number of cars per mile is well above the average of 2·09. For instance, in New York State it is 3·3, and in Pennsylvania 2·53. In Illinois, however, where the employed capital is over £27,000 per mile, the ratio is 2·03 motor cars per mile, that is, slightly under the average. But in this case there are 1·5 trail-cars for each motor car, a very abnormally high proportion—the average being 0·35 trail car per motor car. The evident reason for the low proportion of motor cars and the high proportion of trail cars is the extremely level nature of the country. Of the 877 miles in Illinois, 597 are within the Chicago system, which may be described as dead level, and outside Chicago there are none but the easiest gradients.

Of the 916 electric tramway companies, only 215 have supplied particulars of working costs and receipts in complete enough form to enable deductions to be drawn. Of these, 35 have done so for the last year only; 53 have done so for two years only; 31 for three years only; and 96 give four years' reports. Of course, the one year's reports are not so valuable as those issued for a longer period; but it is most interesting and instructive to compare the results, and it is possible to draw from the comparison conclusions as to the direction of progress and development which have a fair degree of probability.

I here endeavour to give the results of my analyses of these results in as simple and comprehensible a form as possible. To facilitate reference, it may be useful to name the four classes of reports A, B, C and D, thus:—

(A) Four years' reports of 96 companies.
(B) Three " " 96 + 31 = 127 "
(C) Two " " 127 + 53 = 180 "
(D) One " " 180 + 35 = 215 "

The following table gives the miles of track appearing in these reports:—

TABLE I.—*Miles of Single Line.*

| | A | | B | | C | | D |
|---|---|---|---|---|---|---|---|
| Electric | 2291 | | 3157 | | 3847 | | 4291 |
| Increase | | 866 | | 690 | | 444 | |
| Horse | 321 | | 414 | | 566 | | 611 |
| Increase | | 93 | | 152 | | 45 | |
| Cable | 147 | | 162 | | 195 | | 277 |
| Increase | | 15 | | 33 | | 82 | |
| Miscellaneous | 207 | | 209 | | 234 | | 243 |
| Increase | | 2 | | 25 | | 9 | |
| Total | 2966 | | 3942 | | 4842 | | 5422 |
| Increase | | 976 | | 900 | | 580 | |

Although these reports cover no more than three-eighths of the total mileage in the States, still they may be considered as fairly representing the proportionate progress in the various modes of traction. It is evident that the increase of over 80 per cent. in a three-year period is almost entirely due to progress in electric traction. The increase in electric mileage shown here is 87 per cent.

The capital employed under these four headings, roughly translated into English money, is as follows:—

TABLE II.

| — | A | B | C | D |
|---|---|---|---|---|
| Total capital (shares and debt) | £ 70,850,000 | £ 86,790,000 | £ 110,160,000 | £ 122,770,000 |
| Ditto per mile | 23,900 | 22,000 | 22,800 | 22,600 |

The share capital included here is the paid-up, not the subscribed capital.

This table includes the lines operated by every kind of traction; but as electric traction covers from 75 per cent. in A to 80 per cent. in B of the total mileage, the amount stated here per mile may be taken as nearly accurate for the electric roads separately. The increased capital is not quite in proportion to the increased mileage. The increase of 866 miles from A to B appears to have been accomplished at the cost of £18,400 per mile.

In the next Table III. I have tabulated the annual receipts and expenses obtained from the above reports. I have reduced them to English money per mile, as this is what is of direct technical interest to engineers, and I have omitted all fractions and small quantities, as has also been done in Tables I. and II. I have not included Class D in this table, as one year's receipts and expenses are of little interest.

TABLE III.—£ *per Mile per Annum.*

| — | A | B | C |
|---|---|---|---|
| Gross receipts | 3,620 | 3,280 | 3,340 |
| Working expenses | 2,250 | 1,970 | 2,020 |
| Fixed charges | 697 | 708 | 825 |
| Total annual cost | 2,947 | 2,678 | 2,845 |
| Net income | 673 | 602 | 495 |

Here, unfortunately, the phrase "fixed charges" is somewhat indefinite; it does not appear to mean the same in all reports. In all cases it appears to include interest, or other charges upon the funded debt, that is to say, upon nearly one-half of the employed capital. But in some cases it includes fair depreciation on plant, &c., and in others no allowance for depreciation of any kind appears to have been included in the accounts as reported. Of course, its inclusion or omission would wholly change the character of the "net income." In many cases the company owns so much line, and leases so much more. The rents paid on the leased lines are presumably included in the fixed charges. The proportion of leased to owned lines no doubt considerably influences the ratio of fixed charges.

In Table IV. are given the percentage ratios to total capital, to share capital, and to gross receipts. Here again minute accuracy is of no real interest, and only rounded-off figures are inserted.

TABLE IV.—*Percentage Ratios.*

| — | A | B | C | D |
|---|---|---|---|---|
| Gross receipts to total capital | 15·8 | 14·9 | 14·5 | 14·0 |
| Working expenses to gross receipts | 61·3 | 60·9 | 61·0 | 61·1 |
| Fixed charges to gross receipts | 21·1 | 21·9 | 25·0 | 24·0 |
| Net income to gross receipts | 17·6 | 17·2 | 14·0 | 14·0 |
| Net income to share capital (paid up) | 5·6 | 5·1 | 4·0 | 3·8 |

It is necessary to explain that the tables I have given refer to the operations during the year 1895-6, and to the status at the end of that year. The comparison is much clearer, and less ambiguous, and fairer, if made between the different classes A, B, C, and D for

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TABLE V.

| — | Total miles single line (owned and leased). | Electric miles. | Motor cars per electric mile. | Trail cars per electric mile. | Total capital (stock and funded debt) per mile. | Road and equipment cost per mile owned. | Gross receipts per mile. | Working expenses per cent. of gross receipts. | Fixed charges per cent. of gross receipts. | Net income per cent. of gross receipts. |
|---|---|---|---|---|---|---|---|---|---|---|
| Albany ..... | 34 | 34 | 2·9 | ... | £11,800 | £11,800 | £3,080 | 60 | 17 | 23 |
| Atlanta ..... | 65 | 65 | 1·5 | 0·15 | 12,800 | 13,400 | ... | ... | ... | ... |
| Baltimore Traction. | 101 | 83 | 0·36 | 0·42 | ... | ... | 2,340 | 54 | 35 | 11 |
| Boston West End... | 250 | 250 | 6·9 | ... | 19,400 | 14,200 | 6,200 | 73 | 10 | 17 |
| Lynn and Boston ... | 153 | 149 | 2·3 | 0·52 | 8,340 | approx. 7,700 | 1,800 | 57 | 28 | 15 |
| Brooklyn Heights... | 204 | 204 | 8·45 | 0·10 | *3,700 | *19,000 | 4,000 | 68 | *51 | 17 loss |
| Buffalo ..... | 143 | 143 | 1·35 | 0·43 | 14,600 | 16,400 | 1,900 | 48 | 31 | 21 |
| Chicago City..... | 162 | 118 | 4·5 | 8·7 | 18,000 | ... | 5,500 | 63½ | 6½ | 30 |
| North Chicago ..... | 100 | 81 | 2·86 | 1·94 | 22,500 | ... | 5,500 | 47 | 17 | 36 |
| West Chicago ..... | 201 | 122 | 2·75 | ? | 27,700 | ... | 4,180 | 54 | 22 | 24 |
| Louisville ..... | 150 | 110 | 1·82 | 1·5 | 12,650 | ... | 1,700 | 52 | 28 | 20 |
| Montreal .. ..... | 75 | 75 | 2·76 | 1·59 | 13,400 | 10,900 | 2,940 | 59 | 9 | 32 |
| Toronto ..... ..... | 80 | 80 | 1·875 | 1·875 | 17,000 | †23,800 | 2,480 | 50 | 20 | 30 |

* "Capital" includes "bills payable," as the bulk of the liabilities are in this form. The whole line is leased, and "rentals" form 80 per cent. of the fixed charges. The cost of road given is almost wholly that spent by the lessor.

† Includes buildings and real estate.

one year than if made, for instance, between the average of the four years of A and the average of the two years of C. Table IV. does not show directly the differences between the working of the older and that of the newer lines, because B includes the lines in A, and C includes all those in B. In ratio of working expenses to gross receipts the drop of 61·3 (A) to 60·9 (B) really means that the 31 three-year-old companies (B – A) gave 58 per cent. as this ratio in 1895-6. Similarly the two-year-old lines (C – B) gave 61½ per cent. as this ratio, and the one-year-old (D – C) gave the same, 61½ per cent. The low ratio, 58 per cent., is for the same lines—866 miles—as gave (*see* above) the low capital expenditure of £18,400 per mile.

On the other hand, in the ratio of fixed charges to gross receipts, the rise from 21·1 to 21·9 (A to B) really means that the three-year-old lines made this ratio 27 per cent., and similarly for the two-year-old lines made it 38 per cent.; both these in the year 1895-6. In the same year this ratio for the one-year-old lines was 25 per cent. This suggests the influence of a prudent resolve to check the rapid rise of fixed charges that had become plainly visible in the previous years. If we had space to exhibit this ratio from year to year, this rise would be recognised more readily. For the four-year-old companies for the four successive years it was 17·3, 17·9, 20·4, 21·1.

Thus there has been a serious rise in this respect in the management of all the companies; but the chief reason for the rise in the average is the ever increasing expensiveness of the organisation and equipment of the more recently established lines. The others may possibly have had to follow suit for competitive reasons. It is to this rise in the fixed charges that is evidently due the fall in the net earning on share capital; this is not due to increasing working expenses, these remaining steady in proportion to receipts.

In Table V. I have worked out these percentages for 1895-6 from the last reports of thirteen of the largest individual electric railway systems, together with the total and the electric mileage, the motor and trail cars per mile, and the capital and gross receipts per mile. I have also added a column, "Cost of Road and Equipment per Mile Owned." This can only be taken as a roughly approximate figure, somewhat indefinite in meaning. For instance, sometimes power-station buildings seem to be included, and oftener these are not so included. Much of the line also is leased, and as the earnings depend as much upon the leased us upon the owned lines, the figures in this column have no very intimate relation to those in the succeeding columns. All the figures are well rounded off; and as these and most of those in the other tables are the results of my own calculations, the *Street-Railway Journal* must not be held responsible for their accuracy, although it is upon the reports given by it that our tables are based.

San Francisco has over 100 miles of electric tramways, and St. Louis over 200; but the accounts being split up between many companies, and greatly complicated by the admixture of other systems than the electric, I have not included these towns. The surface tramways of New York are now being converted to the electric system; but the conversion has not yet proceeded to a sufficient extent to present any instructive results.

A careful inspection of this table will prove most interesting. Chicago, Montreal, and Toronto come easily first in profitable working. Chicago City and Montreal have kept down "fixed charges" to an extremely low percentage; but the prime condition of special success is heavy traffic per mile. Boston West End heads the list in this respect with over £6,000 per mile of gross receipts, but the working expenses are excessive—73 per cent. of gross receipts, and 23 per cent. of the employed capital—and therefore the net earnings are brought down to 17 per cent. of gross receipts, not so much as one-half of those made in North Chicago. Naturally, with the heavy receipts per mile, we find a large ratio of motor cars to mileage; but the highest ratio, viz., 8·45 motor cars per mile, is found on the unfortunate Brooklyn Heights system, which, in 1895, worked at a loss of 17 per cent. of gross receipts, chiefly on account of the excessive rental of $1\frac{6}{10}$ million dollars paid to Brooklyn City Railroad Company for the use of its lines. It owns the modest mileage 1·17, and leases 204 miles from the Brooklyn City Railroad Company. It is clear that the working or "operating" expenses should not rise above 60 per cent. of the gross receipts.

## NEW AMERICAN RAILWAY GENERATORS.*

There has recently been added to the Brooklyn Nassau Electric Railway power-house equipment a pair of new generators, which compare favourably in output with the largest hitherto installed for railway service. These generators are direct-connected to Cooper-Corliss' compound engines, having crank-discs on either side of the generator armature. The engines are controlled by the ordinary pendulum governor, which regulates both the high and low-pressure cylinders. The high-pressure cylinder has but a single wrist-plate operated by one eccentric, while the low-pressure cylinder has two wrist-plates, each having its own eccentric. The governor rods controlling the cut-off collars operate by means of two geared segments. This method avoids a long reach-rod to the cut-off valve stem on the head end, and the vibration and consequent irregularities of governing incident thereto. A hand-wheel adjustment varies the cut-off of one cylinder with respect to the other, and thus the work may be divided, within certain lines, between the cylinders in any desired ratio. The speed of each engine is 76 revolutions per minute and the stroke 4ft. The high-pressure piston is 28in. in diameter, while the low-pressure piston is 56in. in. diameter, and about 14in. deep, making a massive affair. Liability to cutting has been anticipated by the builders by placing a band of phosphor bronze about the junk-ring which bears on the cylinder. Either set of wrist-plates is designed to be worked by hand if necessary, while the reach-rods can be disconnected and held thus by the throw of a lever. Means are provided for admitting steam to the low-pressure cylinder in case the high-pressure crank becomes stalled on a dead centre.

The crank-pin bearing is adjusted by two wedges, which are drawn together by a screw and nut, the customary strap and half-box being used. The crank disc is cast and counterbalanced and secured to the shaft by a heavy key. The journals are adjusted by wedges and screws, of which there are two, each having a diameter of 24in. and a length of 36in. The total weight on the journals is 107 tons, or about 80lb. to the square inch. The flywheel is exceptionally heavy, and is cast in sections and bolted together, each section having but one spoke. On the side next to the generator is a cast-iron guard plate, placed between the bearing and the commutator. The engine cylinders, together with the receiver used, are all steam-jacketed. The engine takes steam at 145lb. gauge-pressure, and exhausts into a Worthington jet condenser, the condenser water being thrown away.

The generators are Westinghouse machines, capable of supplying 2,000 amperes at 560 volts. The field-frame of each is of cast-iron, and is composed of two massive castings, bolted together in a verti-

* Abstract from the *Electrical World* of New York.

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cal line passing through the armature shaft. The pole-pieces are of laminated iron, and are cast in one with the field-frame. No pole-shoes are used. The shunt and series coils are not wound on forms, but are strapped together with cord and tape. They are held in place on the field-poles by knobs screwed thereto, the two coils being separated from each other fully an inch. The armature is of the T-toothed ventilated type. The winding is parallel, and as there are 12 poles, there are also 12 brushes. The coils are wound on the spiral and connector system. The commutator has 780 bars, and is bolted to the armature spider. The brushes are mounted on arms projecting from an iron ring which is machine-fitted into the edge of the field frame. A bevel gear and worm wheel serves to manipulate this frame over the commutator. The generators were designed to carry an enormous over-load. They were originally compounded for a 10 per cent. loss, but the fields have since been shunted, in order to improve their operations in multiple with the other units. Before this was done considerable trouble was experienced, due to motoring. A unique feature in the installation of these generators is that the equaliser circuit is broken by the circuit-breaker, all of the actuating mechanism of which is located back of the switchboard.

## WATER POWER TRANSMISSION IN UTAH.*

Nearly a year ago some interesting details were given in the *Electrical Engineer* (September 11, 1895), of the work about to be done by the Big Cottonwood Power Company in utilising electrically the water power of eight of the lakes in the Wahsatch Mountains and distributing it throughout the valley around Salt Lake City. We are now glad to report that the plans as first proposed by Mr. R. M. Jones and his associates have been carried out, and that the plant is to-day in successful operation. A few notes of this plant will, therefore, be in order. It should be premised that the lakes emptying into the Big Cottonwood Canyon, lie at altitudes of from 11,000 to 13,000ft. above the sea, so that the difference of level is considerable even when the water is made to give up its energy at a point some 13 miles south-east of Salt Lake City. As a matter of fact, the Company has available over 1,000ft. of fall, in various spots, but at present is using less than 400. The power-station to which we now direct attention is situated in the Canyon at "The Stairs," about 14 miles by pole line from the distributing or "step down" station of the Salt Lake and Ogden Gas and Electric Light Company, in Salt Lake City. At this point there is a minimum flow of 3,400 cubic feet per minute, which, working under 380ft. head, produces 2,447 horse-power. During nine months of each year, it will give nearly 4,000 horse-power. The storage reservoir at the head of "The Stairs," has an available capacity of 24 hours' continuous flow of the stream, making all of the water available by using an excess during maximum loads and allowing the reservoir to accumulate during minimum loads. 58,800 horse-power hours per day of 24 hours, is looked for from this source, of which 68 per cent. can be delivered in Salt Lake City in contract form, making 40,000 horse power hours net daily. The 68 per cent. efficiency is derived from: Pelton water wheels, 80 per cent.; General Electric Company generators, 94 per cent.; G. E. transformers (raising), 97½ per cent.; line transmission, 95 per cent.; G. E. transformers (reducing), 97½ per cent., or a total of 68½ per cent.

A pipe of steel-banded redwood is anchored to the bottom of the reservoir by rock piles, and is to be used in the event of its being necessary to drain the reservoir without interfering with the runing of the station. This is accomplished by closing the head-gate valves, and the station can thus be supplied from the natural flow of the stream, during such time as the reservoir may be empty.

The outside dimensions of the generating station are 34ft. by 100ft. The generating plant consists of four 450-kilowatt three-phase 60-cycle General Electric generators, separately excited, non-compounded, set with armatures parallel to each other. Each generator is driven directly by one heavy special Pelton wheel, 60 inches in diameter, provided with two nozzles of 3¼in. diameter. The nozzles are provided with hood valves for shutting off, so that both good regulation and economical use of water are secured. Each nozzle at 370ft. effective head produces 310 mechanical horse-power, and drives the wheel at 300 revolutions per minute, its economical speed. The water wheel is keyed directly on the armature shaft in lieu of a pulley. There are six raising transformers, 265 kilowatts each, of General Electric make. The apparatus is protected by ball lightning arresters, and the transformers are cooled by two Sturtevant exhaust fans, driven by two 5 H.P. induction motors.

The 915 poles for the line construction were selected from live growth of Sand Point (Idaho) cedar. The smallest are 40ft. long and 8in. diameter at the top. They are placed 100ft. apart. The line conductors consist of twelve wires, four circuits of three wires each; all No. 2 soft-drawn bare copper, and connected to the same common "bus line" at the generating and at the distributing station. The line loss in delivering 1,520 kilowatts at 10,000 volts is something less than five per cent.

The transmission line from generating to distributing station is 14 miles by pole line. The distributing station is owned by the Salt Lake and Ogden Gas and Electric Light Company, who rent it to the Big Cottonwood Power Company at a nominal rent. It contains for "step-down" transformation, nine 160 kilowatt air-blast transformers, from the secondary side of which the Electric Light Company buys the current wholesale by meter. This arrangement is a most convenient one for both companies. The actual terms of the contract are that the Electric Light Company is to be supplied with all the current it can dispose of for electric lighting and power, in units of 10 H.P. and under, the Big Cottonwood Company reserving the right to supply power to motors in units exceeding 10 H.P., and the right to reach such wholesale users of power by wires erected on the Electric Light Company's poles, throughout all the districts within the city limits. The contract dates from January 1, 1896, and runs for a term of five years. Its conditions are that the current is bought at 2,000 volts, three-phase, at a stipulated price per kilowatt-hour, which will be used to supply electric light and power for any purpose up to 10 H.P., and for elevator service up to any limit desired by the lessees. 2,000,000 units annually is the minimum limit of the consumption of current.*

* Abstract from the *Electrical Engineer* of New York.

* For particulars of the system of distribution in Salt Lake City, see *The Electrician*.

## CORRESPONDENCE.

### ATLANTIC TELEGRAPH CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the review of my little book on p. 786 of *The Electrician* of the 16th inst., allow me to say that it was quite through inadvertence that no reference was made to the permission given me to use the copyright pictures referred to.

In the event of any further issue of the book care shall be taken that the acknowledgment is added.—Yours, &c.,

242, Winchester House, E.C., O. MOLL.
October 22, 1896.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October 9, 1896.*

**Storage Battery Traction.**—On Monday last a new type of electric locomotive was placed upon a short branch of the Third Avenue Elevated Railway in this city for trial. The branch line runs from the main Third Avenue Line to the 34th-Street ferry, on the East River, a distance of about a quarter of a mile. The electric locomotive took the place of one of the steam locomotives, and has been in active and satisfactory service ever since it first started. As far as known it is doing fully as well as the machine it supplanted; but the main point to be determined is the question of economy. The electrical and mechanical systems are conceded to be correct; all that is now left to settle is the cost of operation. This locomotive differs from all its predecessors in that it carries quite a large plant of accumulators with it. A third-rail conductor placed outside of the main track, and parallel thereto, supplies the current at 500 volts pressure to the locomotive, which is equipped with two 125 H.P. General Electric 2,000 single-geared motors, controlled by the ordinary series-parallel controller. The current is taken from the third rail by means of two trolley shoes supported directly under the journal boxes of the two main driving wheels. The battery equipment of the locomotive consists of 256 chloride accumulator cells, which are connected in multiple with the motors. The object of this battery equipment is to equalise the load on the generating plant. When the locomotive is not absorbing current the batteries are being charged, and should an excessive demand for current lower the potential at any point on

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the line both generator and battery deliver their current, thus equalising the load. The batteries are charged and discharged automatically. They charge when the car is descending grades, and they discharge in ascending grades, or where there is congested traffic. Thus the conductors can be proportioned for, and always carry the average load, and the potential at the locomotive is practically a constant quantity. This experiment is attracting much attention among electrical and railway engineers, and the projectors of the system are sanguine as to the final results. So far the locomotive has proved itself well able to handle the traffic on the line, which is severe at certain times of the day.

**The Drawbaugh Case.**—The Drawbaugh telephone case again came to the surface on September 29th, when the Court of Appeals of the District of Columbia, in Washington, rendered a decision in the case of Daniel Drawbaugh, who was unable to obtain patents for certain alleged new improvements in telephone transmitters. The decision affirms the decree of the Commissioner of Patents, and holds that Mr. Drawbaugh was not the inventor of the transmitter in question.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

**SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d.; abroad 9s.**

**The New Edition for 1897 is in active preparation, and circulars and full information have already been forwarded to the Colonies, India, Asia, Africa, and North and South America. British and Continental circulars and particulars will shortly be forwarded. The Subscription price remains 5s., postage 9d.; abroad, 6s. 6d. post free. After publication, 7s. 6d., by post 8s. 3d., abroad, 9s. post free.**

### NEW BOOKS AND EDITIONS.

*The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London:—*

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A Fleming, M.A., D.Sc., F.R.S. *The New Edition is now ready.* Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free, is also ready.

"MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY."—By E. Tremlett Carter, C.E., M.I.E.E. *Ready in a few days.* Price 12s. 6d., post free; abroad, 13s. 6d.

TENDERS INVITED.—Particulars will be found in our advertisement columns of tenders required by the Town Council of Torquay for the supply and erection of plant, &c., at the electricity works which are about to be erected. Specifications, &c., can be obtained from Mr. W. H. Trentham, consulting engineer to the Council, 39, Victoria-street, London, S.W., or of Mr. Fredk. S. Hex, the Town Clerk, Town Hall, Torquay, to whom tenders have to be sent in not later than 3 p.m. on Tuesday, Nov. 3.

——— The borough electrical engineer of Bradford (Mr. Alfred H. Gibbings) invites tenders for the purchase of 117 Aron, 86 Frager, 24 Edison and 21 Oulton-Edmondson electricity meters. Lists giving details and capacity of the meters may be obtained from the Electricity Office; and tenders should be sent in to Mr. Gibbings, Town Hall, Bradford. Further particulars appear in our advertisement columns.

——— The Council of the County Borough of West Ham require tenders for four steam alternators and exciters, surface condenser and pumps, station switchboard, &c., high and low tension mains, &c., transformers, sub-stations, &c.; instruments, arc lamps, posts, &c., and crane, for their electricity supply works. Plans, specifications, &c., can be obtained at the office of the Borough Electrical Engineer (Mr. John J. Steinitz), Town Hall, Stratford, E.; and tenders must be sent in to Mr. Fred. E. Hilleary, Town Clerk, the Town Hall, West Ham, E., not later than four o'clock on Tuesday, Nov. 24. Some further particulars are given in our advertisement columns.

——— The Highways Committee of the Leeds Corporation require tenders for the erection of the side and centre poles and brackets for the new electric tramway from Roundhay to Kirkstall. Particulars can be had from the Highways Department, Whitehall-road, Leeds. Tenders by 26th inst.

——— The Spanish Minister of Marine invites tenders for the laying of a submarine telegraph cable between the islands of Luzon, Panay, Negros, and Cebu (Philippine Islands). Provisional deposit, £2,000; definite deposit, £4,000. All particulars from the Ministerio de Ultramar, Madrid. Tenders by Dec. 13.

TENDERS INVITED.—Tenders are invited for the concession for the establishment of electricity works at Homburg. A consumption equal to about 500,000 lamp hours per year will be taken by the municipal authorities. Tenders to Der Magistrat (Bau Verwaltung), Homburg v. d. Höhe, by Nov. 1.

——— The municipal authorities of Ayelo de Malferit (Valencia) invite tenders for the concession for the electric lighting of the town for five years. Tenders to El Secretario del Ayuntamienta de Ayelo de Malferit (Valencia), by 27th inst.

——— The French Posts and Telegraphs Department requires tenders for the supply of telegraphic apparatus on the Baudot system. Particulars can be obtained at the office, 103, Rue de Grenelle, Paris, to which address tenders must be sent by 29th inst., addressed to the Sous-Secrétariat d'Etat des Postes et des Télégraphes.

OFFERS INVITED.—An Advertiser wishes to negotiate for an electric-light installation of about 500 lamps. Mr. R. A. Came, the Spa Hydropathic, Woodhall Spa, Lincs., invites replies.

TENDERS ACCEPTED.—The tender of Messrs. Laing, Wharton and Down (Limited), for wiring and providing the necessary mains and plant for the electric light installation at the Hackney Town Hall for the sum of £1,254, has been accepted by the Hackney Vestry. Boiler power from the public baths will be utilised in connection with this installation. The necessary excavation work will be done by the Vestry's employees at a maximum estimated cost of £120.

——— The Directors of the Dundee Royal Lunatic Asylum have accepted the following tenders for the supply of plant, &c., for the installation at the asylum:—

For wiring and fittings, engine, dynamo, &c., switchboard and accumulator for the lighting of the asylum, superintendent's house, lodge and grounds—Messrs. Lowden Bros., North Tay-street, Dundee, **£2,281. 17s.**

For boiler, steam pump, piping, &c.—Messrs. McFarlane, Machan and Co., Dock-street, Dundee, **£265.**

For complete installation at "Gray House" private asylum, including oil engine, dynamo, switchboard, accumulator, and all fittings—Messrs. James Maxwell and Son, King's-road, Dundee, **£501. 15s.**

——— The Leyton (Essex) District Council have received the following tenders for wiring and fitting the Town Hall for the electric light:—

| | | | |
|---|---|---|---|
| Spagnoletti and Crookes, Goldhawk-road, London, W. (*accepted*) | £131 | 15 | 6 |
| T. H. Taylor | 225 | 8 | 3 |
| Roff and Sons | 224 | 19 | 6 |
| Buchanan and Co. | 187 | 14 | 10 |
| Paterson and Cooper | 159 | 0 | 0 |
| Douglas C. Bate | 158 | 15 | 8 |
| L. Alwyn | 147 | 14 | 11 |

SALE BY AUCTION.—Messrs. Protheroe and Morris, of 67 and 68, Cheapside, London, E.C., will sell by auction, on the premises, 89, Worship-street, London, on Tuesday, Nov. 3, at one o'clock, a quantity of valuable electrical plant and machinery, belting, overhead gears and slides, lathes, shafting, &c., and a 3 H.P. Spiel oil engine, together with furniture and effects. Some additional particulars will be found in our advertisement columns.

SALE BY TENDER.—Mr. Edward Cecil Moore (trustee *in re* Paterson and Cooper), 3, Crosby-square, London, E.C., invites tenders for the purchase of the goodwill, fixtures, fittings and furniture, as a going concern, of the old-established and profitable electrical contracting business carried on for so many years by Messrs. Paterson and Cooper. The particulars, which will be found set out in our advertisement columns, state that the average turnover for the past six years has exceeded £10,000 per annum, and has shown a satisfactory gross profit.

REMOVAL NOTICES.—Messrs. Mavor and Coulson notify that they have removed from 57, West Nile-street, to 47, King-street, Bridgeton, Glasgow.

——— The British Thomson-Houston Company (Limited) notify that they are removing the head offices from 38, Parliament-street, S.W., to more commodious offices at 83, Cannon-street, London, E.C.

APPOINTMENTS.—Mr. A. E. Whitwham, of Huddersfield, has been appointed mechanical engineer to the Huddersfield electric supply station, and Messrs. E. W. Dunton and A. H. French, both of London, as electricians-in-charge.

——— Mr. C. M. Mayson has been appointed electrician in charge at the Whitehaven electric works, *vice* Mr. Watts resigned.

APPOINTMENT VACANT.—The Electricity Committee of the City of Worcester are prepared to receive applications for the post of electrician-in-charge at the electricity works, at a salary of £90 per annum. Some further particulars are given in our advertisement columns, and applications must be sent in by the 31st inst. to Mr. E. T. Ruthven Murray, city electrical engineer.

———The Corporation of the Borough of Blackpool require a mains superintendent. Must be a capable and experienced elec-

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trician. Salary £2. 10s. per week. Applications must be sent to Mr. Robert C. Quin, Borough Electrical Engineer, by Nov. 2. Some further particulars appear in our advertising columns.

PARTNERSHIP.—Mr. Guy C. Fricker, 149, Fleet-street, London, E.C., has taken Mr. Francis Miller into partnership. The firm will be styled Fricker, Miller and Co.

EXTENSION OF WORKS.—The Consolidated Telephone Company notify that, although they have found their new works at Coventry more commodious than the old shops at Farringdon-road, London, it has yet been found necessary to considerably extend the works, owing to the extent of orders in hand.

NEW WORKS.—Messrs. W. H. Willcox and Co., the well-known manufacturers of and dealers in engineer's stores, &c., have recently taken new works in which to manufacture their patent wire-bound hose. This hose was originally all manufactured in Ireland, but owing to increased demand it has been found necessary to establish works in London to execute English orders. A very large business is done by Messrs. Willcox and Co. in wire-bound hose, which is supplied for a large variety of uses. The list of users includes the various Government Departments, Municipal Authorities, and the leading commercial houses

AGENCIES WANTED.—An English export house wishes to negotiate with engineers and manufacturers who are not represented in the Argentine Republic with a view to securing agencies for their representatives in that country. Some further particulars are given in an advertisement elsewhere.

——— An established firm of engineers in South Africa requires the sole agency of a manufacturing firm for electrical fittings, cables and accessories. See advertisement.

DISSOLUTION OF PARTNERSHIP.—The dissolution of the partnership between Mr. H. Thorpe, 59, Theobald's-road, W.C., and Mr. H. Waring, 18, Berkeley-road, Crouch Hill, N., carrying on business as mechanical and electrical engineers at 59, Theobald's-road, and 34, Eagle-street, W.C., London, is announced. Debts will be received and paid by Mr. Thorpe.

PRESENTATION.—Mr. George C. Sillar, works manager of the Brush Electrical Engineering Company, who has been in the service of the Brush Company for 15 years, was married last week, and his friends and colleagues in the Company celebrated the occasion by presenting him with a clock.

PATERSON AND COOPER (IN LIQUIDATION).—The public examination of Messrs. E. J. Paterson and C. F. Cooper took place at the Court of Bankruptcy, London, on Friday, before Mr. Registrar Brougham. The bankrupts stated that their solvency or insolvency depended entirely upon the price obtained for their patents. A summary of the affairs of the firm was given in our issue of Oct. 9; and beyond the details then furnished nothing of importance transpired at the examination. The following is a list of trade creditors for amounts over £10 :—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Edison and Swan Co. ... | £945 | 0 | 0 | T. A. Parry and Co. ..... | £33 | 6 | 0 |
| Jaeger Gebrüder ..... | 650 | 6 | 0 | Nettlefold and Sons..... | 32 | 15 | 11 |
| W. T. Glover and Co. ... | 395 | 0 | 0 | Midland Lighting Co. ... | 28 | 12 | 6 |
| Robey and Co. (Limited) | 319 | 14 | 0 | L. Williams and Co..... | 27 | 16 | 8 |
| F. Paterson ..... | 310 | 0 | 0 | Thames Iron Works Co. | 26 | 10 | 0 |
| Telegraph Manufacturing Company ... .. ..... | 266 | 17 | 10 | Lawrie and Bishop ..... | 25 | 7 | 0 |
| | | | | Dalziel and Co..... | 26 | 1 | 3 |
| H. B. Barnard and Sons | 259 | 13 | 6 | Magnet Forge ..... | 24 | 17 | 0 |
| Beecroft and Wightman. | 231 | 6 | 3 | Lankester & Sons (Ltd.) | 24 | 9 | 2 |
| Armend et Cie..... | 228 | 9 | 0 | Parsons, Fletcher and Co. | 24 | 5 | 6 |
| Société Française des Procèdes Hermite.. ... | 215 | 4 | 11 | W. Preston and Son..... | 24 | 5 | 6 |
| | | | | A. and R. Cochrane..... | 23 | 2 | 2 |
| E. G. Lidd..... | 200 | 0 | 0 | Hulbert Bros..... | 23 | 7 | 6 |
| United Gutta Percha Co. | 179 | 10 | 6 | Whitehouse and Thomas | 23 | 0 | 9 |
| A. E. Cooper..... | 157 | 9 | 2 | E. Tautz and Sons ..... | 22 | 0 | 0 |
| McGeoch and Co. ..... | 138 | 7 | 0 | London Electric Wire Co. | 21 | 0 | 0 |
| Smith and Sons..... | 133 | 8 | 10 | Johnson, Matthey & Co. | 20 | 7 | 3 |
| Henley's Telegraph Works Company ..... | 133 | 7 | 6 | M. Spencer and Sons ... | 20 | 5 | 2 |
| | | | | Woodhall and Sons ..... | 20 | 4 | 7 |
| Abel and Imray ..... | 122 | 18 | 10 | St. Bride's Press ..... | 19 | 16 | 6 |
| Conze and Simon ..... | 121 | 18 | 4 | Pfeil, Steddall and Co.... | 18 | 11 | 8 |
| A. Vandam and Co..... | 115 | 7 | 7 | Moss and Co..... | 18 | 4 | 10 |
| Northey and Cooper ... | 105 | 10 | 0 | J. Esson..... | 17 | 10 | 10 |
| Bilbie, Hobson and Co .. | 98 | 4 | 0 | Callenders Co. ..... | 17 | 8 | 9 |
| L. Hervé..... | 94 | 11 | 1 | G. P. Wall..... | 15 | 17 | 6 |
| J. Richards ..... | 84 | 16 | 2 | W. H. and A. Nutting... | 15 | 14 | 2 |
| W. R. Saltrich ..... | 77 | 14 | 5 | Sheppard, Allerton and Madeley ..... | 15 | 9 | 10 |
| Johnson and Phillips ... | 73 | 16 | 6 | T. Sanders..... | 13 | 9 | 7 |
| B. Verity and Sons ..... | 54 | 0 | 0 | Brush Co. ..... | 13 | 7 | 6 |
| Archibald Campbell..... | 53 | 10 | 0 | Morgan Crucible Co. ... | 12 | 18 | 9 |
| E. Harding ..... ..... | 51 | 2 | 8 | Stewart and Clydesdale (Limited) ..... | 11 | 6 | 8 |
| J. E. and S. Spencer..... | 50 | 6 | 3 | | | | |
| Playfair and Toole ..... | 49 | 5 | 0 | Starnes and Son..... | 10 | 3 | 3 |
| Markt and Co. ..... | 49 | 0 | 0 | Gabriel and Angenault ... | 10 | 0 | 0 |
| General Electric Co..... | 47 | 13 | 10 | Bankers' claims..... | 779 | 19 | 2 |
| Britannia Rubber Co. ... | 37 | 6 | 7 | | | | |

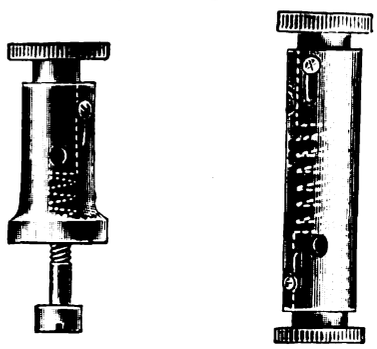
BANKRUPTCY.—Proofs of claims against G. H. Barnes, 11, Chestnut-road, Moseley, Worcestershire, and A. T. Barnes, 25, Drayton-road, King's Heath, Worcestershire (trading as makers of electric light fittings, &c., under the style of G. H. Barnes and Co., at Bissell-street, Birmingham), must be sent in by Nov. 4, preparatory to payment of dividend. Mr. L. H. Elkington, 39, Newhall-street, Birmingham, is trustee.

BANKRUPTCIES.—At the London Bankruptcy Court the public examination took place of Ronald H. Bridie. From 1888 to 1891 the debtor was an electrical engineer's assistant, then commenced business as a consulting engineer with £600 capital, and removed to 8, St. Benet's-place, London, E.C., in 1893. Against unsecured liabilities amounting to £2,149. 16s. the assets are £41. 6s. At the first meeting the creditors accepted a composition of 7s. 6d. Failure attributed to speculations on the Stock Exchange. Examination concluded.

——— A meeting is to be held at 50, Frederick-street, Edinburgh, on the 28th inst., *in re* Wm. Gray, jun. (trading as the Scottish Electrical Engineering Company, and as Gray and Son, at 52, Frederick-street) to consider trustee's memorial to counsel.

——— John William Grieves, described as "exhibition promoter," of St. Martin's House, Gresham-street, London, trading as "The International Trade Exhibition Syndicate," has failed. The International Trade Exhibitions (Limited) write to say that Mr. Grieves has no connection with that concern.

"J. K." PATENT TERMINALS.—Messrs. J. Kandt and Co., of 12, Shaftesbury-avenue, Piccadilly-circus, London, forward samples of "J. K." terminals, which are claimed to be particularly adapted for general experimental purposes. It will be seen that by pressing the terminals and inserting the wires, the wires are immediately clipped without any screwing. The illustrations show clearly



the simplicity of this design of terminal. The terminals are made in five different styles, to suit various requirements, and should prove especially useful where rapid and temporary connections have to be made. These terminals were exclusively used at the recent Berlin exhibition.

CRYSTAL ELECTRIC LAMP COMPANY.—An extensive range of premises known as the Bedford Iron Works at Bedford passed about 12 months ago into the hands of the Crystal Lamp Company, of St. Stephen's-chambers, Telegraph-street, E.C. The premises have now been altered to meet the special requirements of an electric lamp factory, including the complete equipment of the special plant and machinery which such manufacture requires. Steam motive power to the extent of 100 H.P. is provided. The conduct of the works is under the direction of Mr. Harrison, assisted by Mr. Pickering, and about 60 hands are already employed.

SIEMENS AND HALSKE ELECTRICAL ORE REDUCTION PROCESS.—This process is, says the *African Review*, now being used at a number of the principal mines in South Africa, and is about to be adopted by many others. Out of 45 mines at present producing gold, one-sixth are already using the process. Altogether the outlook for the electrical treatment of refractory ores and slimes seems most promising.

POWER PUMPS.—An illustrated catalogue of hydraulic and pumping machinery for all purposes, including electrically-driven pumps, reaches us from Messrs. Rumsey and Co. (Limited), of Seneca Falls, N.Y., U.S.A. The catalogue is neatly got up, and the illustrations show clearly a number of machines of the Company's manufacture.

COMMERCIAL CABLE COMPANY.—We have received an excellent print of the huge building block forming the principal offices of the Commercial Cable Company, New York. The picture is well set off by a comparison being possible with the surrounding structures, the highest of which does not reach to the middle of this tremendous pile, representing no less than 20 storeys, surmounted by huge domes, these being surmounted again by flagstaffs, from which the Company's flag floats proudly. We earnestly trust nothing will ever happen to this great building, which, we presume, is more or less filled with the operators and staffs of the Commercial Company and its Postal Telegraph ally.

ELECTRICAL ACCESSORIES LIST.—Mr. Archibald J. Wright forwards his new list of electric bells, batteries, pushes and other

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accessories. This is a well-illustrated 4to list, in which a variety of electrical accessories are illustrated, described and priced.

FREEMASONRY.—The installation of W. Bro. Thomas Wholey as Worshipful Master of the Telegraph Cable Lodge was celebrated on Monday last at the "Ship and Turtle," Leadenhall-street, London, E.C. At the banquet which followed a lengthy musical programme was an enjoyable feature.

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BATH.—At the Urban Sanitary Authority's meeting Mr. Alderman Sturges, Chairman of the Electric Lighting Committee, recommended that permission be obtained to borrow £58,000 for electric lighting purposes, in place of the previously sanctioned amount of £45,000. He explained that the necessity for the increase was a desire on the part of the Committee to provide for a much larger extension of the electric mains than that originally contemplated. Mr. R. Hammond, consulting engineer to the Corporation, explained the details of the extension scheme; and the proposal was, after a lengthy debate, agreed to. The Local Government Board inquiry is fixed for the 30th inst.

BRAY.—At the meeting of Township Commissioners on Monday, after the election of Sir Henry Cochrane, D.L., as Chairman of the Commissioners, a deputation was received, who laid before the Board particulars of a scheme for electric tramways in Bray. Mr. Molloy, who introduced the deputation, said that it was intended to run trams along the Esplanade-road and other main thoroughfares in the direction of Enniskerry, and later on the tramway would extend through Novara and other parts of the township. The promoters were not tied to any particular system, but the cost of the conduit system would be £3,000 or £4,000 a mile in excess of the overhead system. After the deputation had withdrawn it was resolved to ask Mr. Molloy to supply the Commissioners with all plans in reference to both the electric tramways and the pier schemes.

BURTON-ON-TRENT.—The Library Institute buildings are to be lighted electrically.

CARDIFF.—The Cardiff Lighting and Electrical Committee have approved the minutes of a sub-committee recommending that the electric lighting works shall be constituted a separate department, distinct from that over which the Borough Engineer has supervision. The accounts for the financial year to March 31, 1896, just issued, show that for the period from July 30, 1894, to March 30, 1895, the total expenditure on electric lighting account, including loan charges, was £7,414, and the receipts during the same period £4,660. To make up this deficiency contributions were taken from the district rates. It is not, however, anticipated that there will be any further call necessary, the nett rentals having increased from £666 for the quarter ended September, 1895, to £1,641 for the three months to March, 1896.

COLWYN BAY.—The local authorities are discussing the lighting of the promenade, and it has been decided to ascertain the relative cost of gas and electric light.

CORPORATIONS AND TRAMWAYS.—An interesting discussion took place at the meeting of the Association of Municipal Corporations in Manchester on Wednesday, when it was agreed to urge upon the Government the necessity of passing a Bill through Parliament conferring upon Municipal Corporations the power to place and run carriages upon the tramways constructed under the Tramways Act, 1870, notwithstanding anything in that Act to the contrary. The Mayor of Blackpool pointed out that the Tramways Act prohibited Corporations working their own tramways, but that the Light Railways Act, recently passed, practically recognised municipal control. Sir Albert Rollit, who presided at the meeting, pointed out that he had several times introduced such a Bill, but considered it impossible for a private member to carry such a measure through the House. It was a matter for the Government.

DUBLIN.—The Lord Mayor and other members of the Corporation and the City Engineer on Saturday visited Pigeon House Fort (which the military authorities are vacating) with the object of ascertaining its suitability as a site for an electricity supply station, and unanimously approved it. Amongst the advantages of the site would be a large saving in cost of carriage of coal.

DOUGLAS (ISLE OF MAN).—A scheme for lighting the Loch Promenade electrically, as well as other portions of the district, is now before the Town Council. It is suggested that an installation costing £10,000 would provide plant sufficient for the initial work in connection with the scheme, which could be worked at a profit. The Council are being advised in the matter by Mr. S. V. Clirehugh.

EALING.—At last week's meeting of the District Council the surveyor reported that the number of 8 c.p. lamps connected was equivalent to 9,130, and he anticipated that at the end of the second year the receipts in the electricity department would more than cover liabilities.

EXETER.—At the last meeting of the City Council a special Committee on electric lighting reported that a difficulty had been experienced at the Electric Light Works owing to the non-delivery of plant ordered from the Brush Company, and that in consequence two transformers had to be purchased elsewhere. It was stated that the order to the Brush Company had been cancelled. No opportunity was given to the members of the Council to hear the Company's explanation regarding tho non-delivery of the plant.

EXHIBITION.—Mr. H. Engel has issued particulars relating to the proposed Electrical and General Engineering Exhibition to be opened at Newcastle-upon-Tyne in February next. The plans for the new buildings have been duly passed, and, as noted elsewhere, the contract for the building has been let. The exhibition will be an international one, and one of the chief objects is to illustrate as accurately as possible the changes and developments that have taken place in electrical and general engineering since the accession of her Majesty in 1837.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from October 14th to October 20th, with the ports of destination:—

*Argentina*—Buenos Ayres, £380 (including £15 telephones). *Australasia*—Adelaide, £15; Brisbane, £781 (telegraph material); Christchurch, £16; Launceston, £116; Melbourne, £333 (including £201 telegraph material); Perth, £623 (including £98 telegraph material); Sydney, £328 (including £140 telephone material). *Belgium*—Antwerp, £26. *Burmah*—Rangoon, £29. *Canada*—Halifax, (N.S.), £8,309 (including £8,257 telegraph material); Montreal, £25. *Canary Islands*—Teneriffe, £120 (telephone material). *Ceylon*—Colombo, £168 (including £62 telegraph material). *China*—Shanghai, £69 (telephone stores). *Cochin China*—Saigon, £20. *Denmark*—Copenhagen, £268 (including £227 telegraph material). *Egypt*—Alexandria £140 (including £22 telephone stores) *Holland*—Amsterdam, £50; Flushing, £45; Rotterdam, £11. *Hong Kong*, £55 (telephone stores). *India*—Bombay, £31; Calcutta, £47 *Japan*—Yokohama, £240. *Norway*—Christiania, £50 (telegraph material) *Russia*—St. Petersburg, £75. *South Africa*—Cape Town, £2,504 (including £2,222 telegraph material); Durban, £44; East London £1,539; Port Elizabeth, £1069. *Spain*—Pasages, £83. *Sweden*—Gothenburg, £67 (telegraph material); Stockholm, £92 (telegraph material) *Uruguay*—Monte Video, £186. Total, £17,954.

FATALITY.—A boat carrying two operators from the Anglo American cable station at Valentia capsized during a squall, one of its occupants, George Hutton, being drowned, and the other, William Thompson, narrowly escaping the same fate.

GLASGOW.—The Corporation are experimenting with lamp-posts 6ft. to 8ft. higher than those hitherto used, and a globe lamp on a projecting arm instead of octagon lanterns.

GRIMSBY.—The Town Council have decided to shelve the question of applying for a Provisional Electric Lighting Order for twelve months.

HAMMERSMITH (LONDON).—The Vestry announce, under date of Oct. 16, that they will shortly be prepared to supply electric current to private houses and business premises in Hammersmith-road, Broadway, King-street, Brook Green-road, Shepherd's Bush-road, Shepherd's Bush Green, Goldhawk-road, and Uxbridge-road.

HANLEY.—The Town Council have adopted a report of their Gas and Electric Light Committee containing a recommendation that the necessary mains be laid down Union-street for supplying electric current to the Infirmary and Free Library.

HOLBORN (LONDON).—The Board of Works have decided to remit the whole question of the electric lighting of the Holborn district to the Works Committee to consider and report.

HOVE.—The Urban Council have agreed to a modification of their agreement with the Hove Electric Lighting Company, so as to permit the Company to supply current at 220 volts to new consumers.

HUDDERSFIELD.—At the Town Council's meeting, on Wednesday, it was proposed to light portions of the central wards by electricity, in place of gas, which it was estimated would effect an annual saving of about £130. This was agreed to.

IPSWICH.—An important and protracted discussion took place at the last meeting of the Town Council on the details of the electric lighting schemes prepared by Prof. A. B. W. Kennedy and presented by the Electric Lighting Committee. Three schemes are before the Council: one in which an estimated outlay of £18,000 is involved, the second representing £30,200, and the third and largest scheme £41,900. The Committee made no recommendation to the Council and it was, therefore, left for the members to discuss the matter from a general standpoint. The discussion opened with the interminable question of the position of gas shareholders in regard to their votes, after which Mr. Pratt moved that instructions should be given to the Electric Lighting Committee to take steps to apply for a Provisional Order under the Electric Lighting Acts next Session, the Order to embrace the area covered by Prof. Kennedy's largest scheme. Mr. Pratt pointed to the success of the electric light at Yarmouth, and in alluding to the fact that on the first year's working of that town's undertaking there was a deficiency of £766, said that, considering the very greatly superior lighting which the town possesses, he did not con-

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sider this was a deficiency at all. Mr. Pratt was careful, while urging the adoption of his motion, to refer to those towns where the electric light was regarded as only partially successful, and urged that this partial success was practically an entire success from the fact that the vast improvement in the lighting of the town was worth a great deal more than the insignificant sums shown as debits in the electric lighting accounts. There were already 16 private installations in Ipswich, and these could be taken as conclusive evidence that there was a demand for the electric light. Mr. Pratt's remarks were received with general approval, and the motion was finally carried by 21 votes to 6.

KESWICK (CUMBERLAND).—The District Council are negotiating with the local Electric Light Company for the purchase of the Company's works.

KINGSWOOD (BRISTOL).—At Tuesday's meeting of the Lighting Committee of the Urban Council consideration was given to a proposal that the Council should purchase Parfitt's electric lighting plant, which is now rented by the Council. The matter having been discussed, it was decided to recommend that an expert be called in to value the plant with a view to the final decision of the Council being given.

LIVERPOOL.—The Corporation have decided to enter into negotiations with the Tramways and Omnibus Company with the object of acquiring and working the tramway service of the city. A special meeting of the Corporation is shortly to be held to consider the question of applying for a Provisional Order, enabling the Corporation to take over the tramways and work them by mechanical power. On Tuesday the Lighting Committee of the Corporation discussed at its final meeting for the present municipal year the work of the Committee during the past 12 months. The lighting by electricity of a number of the chief thoroughfares of the city had been authorised, but only slow progress had been made owing to the unavoidable delay in perfecting the details of a satisfactory system of street lighting. These difficulties were now well overcome, and there was every probability of the whole of the work being completed by the end of November. It was anticipated that by the end of October the total lamp connection would be equivalent to 48,500 8 c.p. lamps against 41,500 when the Liverpool Company's business was taken over by the Corporation in July. The new supply station in Paradise-street would be opened some time in November. The Board of Trade has signified its approval of the system on which the Corporation has decided to supply electrical energy. The Directors of the local gas company do not take at all kindly to the altered position brought about by the transfer of the Liverpool Electric Supply Company's undertaking to the Corporation. Suggestions have been made to the gas company that the Corporation should be allowed to appoint two or three of the Directors of the gas company, with a view, we presume, to the better safe-guarding the interests of the gas-consuming public. This proposal has been very peremptorily declined. However, the Lighting Committee of the Corporation do not appear to have taken the refusal meekly, and are making requests for information regarding various points —amongst others, as to the quality of the illuminant supplied by the Gas Company.

LLANDUDNO.—At Wednesday's meeting of the District Council a letter from Messrs. Dickinson and Co., of Birmingham, asking for the support of the Council to their scheme for the construction of an electric tramway to connect Colwyn Bay, Llandudno, and Conway was discussed. Messrs. Dickinson intimated that the idea had been approved by the Colwyn Bay authorities. The Council resolved to consider the plans.

LONDON COUNTY COUNCIL.—At Tuesday's meeting the Finance Committee reported upon the application of the Shoreditch Vestry to borrow £31,381 for the purpose of its electric light and dust-destructor scheme. The Vestry asked that the whole should be treated as one loan, and the repayment spead over 42 years. The Committee, however, could not accept this suggestion, and recommended that a loan should be granted to the extent of £15,415 for electric lighting purposes for repayment in 42 years; and, further, that the Vestry be notified that, as they had elected to spread the whole of the initial cost of the electric light installation over 42 years, the Council would decline to give its sanction to the raising of any loan to replace plant and machinery during the currency of the loan, and would expect the Vestry to provide for all renewals required during that period out of a sinking fund to be provided for the purpose or from the maintenance account. This recommendation was agreed to. Mr. Goodman asked if in November last the Islington Vestry applied for a loan of £25,000 for electric lighting purposes, and had only just received permission from the Council to use the money. Mr. Hoare replied that this was the case; he could not account for it, and the matter was receiving the attention of the Finance Committee

LONG-DISTANCE TELEPHONY.—It is stated that recent trials of the telephone between Antwerp and Berlin have proved sufficiently successful to warrant the respective Governments in placing the two cities in direct telephonic communication.

MANCHESTER.—It is stated that the Corporation propose to include in a Bill about to be promoted a clause authorising them to supply electric current to local authorities outside the City boundaries.

MARKET LIGHTING.—The Markets Committee of the Liverpool Corporation have decided to light St. John's Market electrically early in the new year.

MEXICAN PATENT LAW.—Some important amendments have recently been made in the Patent Law of Mexico. The owner of a patent of invention or improvement must prove at the end of stated periods of 5, 10, and 15 years the existence of his patent; and in order to secure possession of his invention must lodge at those periods $50, $75, and $100 respectively. Other modifications affecting existing patentees have also been made.

MIDDLESBROUGH.—The Imperial Tramways Company having proposed to introduce an electric system of traction similar to that in use at Hartlepool, members of the Corporation inspected the Hartlepool tramways on Wednesday, and were much impressed by the swift and easy working of the system.

MINERS' SAFETY LAMPS.—In the course of his presidential address at the annual meeting of the South Staffordshire and East Worcestershire Institute of Mining Engineers on Monday last, Mr. R. S. Williamson, referring to the question of miners' safety lamps, said the day was not far distant when the use of naked lights underground would be prohibited by law, and electricity would no doubt form a more important factor in the lighting of mines. All safety lamps should indicate the presence of firedamp and stythe.

NEWCASTLE.—Messrs. Bruce and Still, builders, of Liverpool, have secured the contract for erecting the Newcastle Electrical Exhibition buildings.

NEW DEER (ABERDEEN).—The New Deer Lighting Committee have resolved to communicate with several firms of electrical engineers with the view of obtaining information as to the probable cost of the establishment of electricity works for public and private lighting. The Committee consider that sufficient water-power is available in the district for power purposes.

RATING ACTION.—Mr. J. B. Wood, of Henley Hall, near Ludlow, successfully appealed against a valuation recently made of a turbine and dynamo plant used in lighting his private residence by electricity. Part of the plant was at a flour mill on the estate and part at the Hall. The plant at the mill, which cost £230, was rated at £30, the rate payable on that assessment being 30s. per annum. After a long hearing the rating value was reduced to £5 per annum. Mr. Wood obtained the costs of the action.

ROCHDALE.—A recent issue of the *Rochdale Observer* enters fully into the advantages which must accrue to the town by the introduction of a comprehensive electric lighting scheme. It refers to the large number of private installations which have been erected in the town, and to the fact that these include many of the most important mills, workshops and factories in the district, all of which it urges will ultimately take current from a central supply station. The writer refers to the advantages which the electric light possesses for dyeing works, raising mills, corn mills, weaving sheds, paper mills and machine works. In the majority of these establishments naked gas flames are extremely dangerous, and this accounts for the popularity of the electric light. He urges the Corporation to take the supply into its own hands, and refers to the electrical installation which the Council already have at work on the sewage farm and sanitary works.

SOUTHAMPTON.—Mr. J. H. Lee has been instructed to submit a report and estimate of the cost of lighting the municipal buildings and guildhall by electricity.

SWANSEA.—Tenders for the electric lighting of Swansea Market were considered by the Market Committee of the Town Council last week; but as the offers were in excess of the contemplated expenditure, no decision was come to.——The Town Council have finally decided to promote a bill in the next session of Parliament to acquire the tramway undertaking upon the terms of an agreement recently made with the local tramways company.

TARIFF CHANGES.—Under the new Customs law of Victoria bell fittings, bells (6in. and under), electric light fittings (including arc lamps without globes), carbons, incandescent lamps, transmitters, transformers, storage batteries, miners' safety lamps, scientific instruments, lightning conductors, machinery for telegraphic purposes, and tools for trade purposes, not being machinery, are admitted free of duty.

TRAMWAYS AMALGAMATION.—A Birmingham journal states that the whole of the existing tramways in South Staffordshire, excepting the Walsall lines, are shortly to be amalgamated and acquired by a London Syndicate in no way connected with the syndicate which has recently acquired the Birmingham tramways.

WATFORD.—The Urban District Council has discussed Mr. Hawtayne's report on a proposed electric lighting scheme for the district,

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estimated to entail an expenditure of about £20,000. In spite of some opposition the scheme was approved.

WEST HAM (LONDON).—The public library is to be lighted by electricity, and a number of firms in the Stratford district have expressed their readiness to purchase current from the Corporation as soon as it is in a position to supply.

# PATENT RECORD.

*A record of Applications for Patents and Patent Specifications Published is compiled for this journal by* MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

## APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

September 22, 1896.

20,984. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED). London. Improvements in electric brakes. (A. F. Macdonald, United States.)*

21,009. F. E. ELMORE. London. Improvements in construction of low-tension dynamo electric machinery.

21,027. W. L. WISE. London. Improvements in electrolytic apparatus (The Aluminium Industrie Aktien Gesellschaft, Switzerland.)

September 23, 1896.

21,055. E. J. PIPER. London. Improvements in electric fittings.

21,116. J. P. O'DONNELL. London. Improvements in ticket-issuing apparatus for the electrical staff instruments on single lines of railways. (J. W. W. Hopkins, Argentine Republic.)

September 24, 1896.

21,147. G. ELLIS and G. H. NISBETT. Liverpool. Improvements in or connected with coin-freed or actuated electricity meters.

21,218. C. H. STEARN and C. F. TOPHAM. London. Improvements in or connected with means or apparatus for producing radiation of electricity.

September 25, 1896.

21,236. W. EMMOTT. Halifax. An electric regulator.

21,267. P. LÖWENBERG. London. Composition to be used in the manufacture of glow bodies for incandescent lamps.*

21,273. J. E. LIARDET. London. Improvements in or relating to electric storage batteries.

21,293. S. F. PAGE. London. Improvements in electrical door bolts.*

September 26, 1896.

21,340. R. H. SMITH. Birmingham. Insulated conductors and improved collectors for electric tramways.

21,365. E. BERGMANN. London. Improvements in electric meters.

21,380. W. L. WISE. London. Improvements in apparatus for supplying electricity to electrically-propelled railway and tramway vehicles. A. Diatto, Italy.)

September 28, 1896.

21,449. H. ARON. Liverpool. Improvements in apparatus for measuring and recording electric currents.

September 29, 1896.

21,487. G. ELLIS and G. H. NISBETT. Liverpool. Improvements in or connected with coin-freed or actuated electricity meters.

21,488. G. H. NISBETT. Liverpool. Improvements in or connected with coin-freed or actuated electricity meters.

21,509. J. G. A. RHODIN. Manchester. An improved electrolyser or electrolytic apparatus.

21,527. J. J. WILSON. London. Improved door or sash bolt for use in connection with electric circuits.

21,532. G. W. MOORE. London. Improvements in graphophones.*

21,539. A. J. BONET. London. Improvements in or relating to telephones. (G. M. Bair and C. W. Ream, United States.)

21,559. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED). London. Improvements in dynamo electric machines. (C. P. Steinmetz, United States.)*

21,560. THE BRITISH THOMSON-HOUSTON COMPANY (LIMITED). London. Improvements in tandem-parallel controllers for induction motors. (W. B. Potter and F. E. Case, United States.)*

21,561. F. J. WARDEN-STEVENS. London. Improvements in the means of supplying currents to electrically propelled railroad vehicles.

21,583. J. G. HAMERTON. London. Improvements in or relating to electrically signalling apparatus.

21,591. F. R. J. JURASKE and H. BROCKETT. London. Improvements in or connected with electric circuits for telephonic communications.*

September 30, 1896.

21,617. W. E. HEYS. Manchester. Improvements in electric heating devices. (D. Chedville, France.)

21,632. E. W. DONOVAN. Salford. Improvements in electric light fittings.*

## SPECIFICATIONS PUBLISHED.

NOTE.—All specifications can now be obtained at the uniform price of 8d. each.

1895.

15,564. EPSTEIN. Electro propulsion of vehicles or vessels.

18,697. LORRAIN (Esmond). Electric railways or electric transport.

18,822. CRAWSHAW and BEVIS. Mounting electric incandescence lamps for orchestral, reading, and like purposes.

19,669. SCHANSCHIEFF. Secondary battery plates.

20,681. PENSON. Ventilation of transformer boxes, road and junction boxes, conduits, and the like, used in the distribution of electrical energy.

20,828. ROWBOTHAM. Primary electric batteries.

20,821. FABRIS. Reflector for electric arc lamps.

20,925. BURNETT. Primary and secondary batteries, applicable for use with pocket electric lamps and for other purposes.

21,283. ELMORE (Elmore). Electro-depositing of metals.

21,433. EVERED. Holders of electrical glow lamps.

21,830. SIEMENS BROS. AND CO., LIMITED (Siemens and Halske). Electrical apparatus for firing fuzes for mines and other purposes.

22,234. SIEMENS BROS. AND CO., LIMITED (Siemens and Halske). Protecting electrical, &c., apparatus against disturbing effects of adjacent electric railways.

22,586. SIEMENS BROS. AND CO., LIMITED (Siemens and Halske). Single-phase alternate current motors.

1896.

14,463. ESSICK. Telegraphic alphabets.

14,846. SIEMENS BROS. AND CO. (LIMITED) and OBACH. Conducting contacts with carbon or other non-metallic electrodes.

15,074. HENCKEN and MEYER. Electrically ignited torches, cigar-lighters, or the like.

15,966. LEITNER. Electric arc lamps.

16,168. SMOCK. Electric insulators.

16,421. HENSCH and BRANDT. Regulator for dynamo machines.

16,457. BRANDT and HENSCH. Solenoid cores for voltmeters.

16,726. SCHNEIDER. Electrodes for secondary batteries.

16,790. EHRICHT. Telegraph-wire reel.

17,122. LAKE (Greenfield). Metallic junction boxes.

17,123. LAKE (Greenfield). Insulating joints for metal or armoured conduit-tubes, more especially suitable for electrical conductors.

# COMPANIES' MEETINGS AND REPORTS.

## Monte Video Telephone Company (Limited).

The annual meeting of this Company was held at Winchester House London, E.C., yesterday (Thursday), Mr. Herbert Ward presiding.

The SECRETARY (Mr. E. M. Reiss) read the notice calling the meeting, the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN said: Gentlemen, on reviewing the accounts it will be seen that the business of the Company has steadily increased. The figures in the report do not fully show the extent of the actual improvement. The amount of our subscriptions is some £300 less than last year; but when it is remembered that last year's accounts included 9½ months service to the Police Bureau, representing a value of £740 the particulars of the loss of which service were stated at our last annual meeting, it will be seen that we have recovered lost ground to the extent of £440. The interest received on our securities is appreciably more this year than last; London office expenses are somewhat lower, and loss in exchange £190 less than last year, these three items showing a net gain this year of £293. 17s. 3d. The principal difference in this year's accounts, compared with those of last year, is the amount for working expenses at Monte Video, showing an increase of £1,400. The actual working expenses are less than last year by some £390; but an important improvement has been made in our service this year by substituting one of the newest and latest patented microphones, for the transmitter formerly used. The change has proved most successful, and has given great satisfaction to our subscribers, and the whole cost thereof has been charged to maintenance. In addition, further extra expenditure was thrown upon the Company by the cyclone which swept over the city of Monte Video in January last, causing great damage to our plant. Fortunately, no damage was done to the multiple board, and the task of repairing was confined to the streets and housetops. Much new material had to be bought in and put down, and the opportunity was taken of using bronze wire and putting up substantial new posts, which it is hoped will resist any future storms. Our whole plant is therefore to-day in a complete state of efficiency, and with the new transmitters proving most successful after some months' use, I may say our telephone sevice is now as near perfection as is perhaps possible, and our future prospects look promising. The Directors consider the same payment as last year on the Four per Cent. Preference share capital may safely be recommended, leaving a sum of £120 in excess of last year to be carried forward.

The report and accounts were then adopted, and the Preference dividend approved unanimously.

The retiring Director, Mr. F. W. Jones, was unanimously re-elected; and the auditors, Messrs. Gerard Van de Linde and Son, having been re-appointed, the proceedings ended with a vote of thanks to the Chairman and Directors.

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## Bordeaux Tramways and Omnibus Company (Limited).

An extraordinary general meeting of this Company was held on Wednesday, under the presidency of Lord Richard H. Browne, to consider a resolution expressing the desirability of adopting a system of electricity as the motive power on the tramways belonging to or which might be constructed by the Company, and authorising the Directors "to carry on and complete the negotiations which have been entered into with the Municipality of Bordeaux for the adoption of such system upon such terms as the Directors may approve, and to take such further steps as may be necessary for the above purposes."

The SECRETARY (Mr. C. T. Oldham) having read the notice calling the meeting,

The CHAIRMAN, in proposing the resolution, said: I presume that all the shareholders who take a real interest in tramways, and who have been for some time connected with them, will have already thought over the whole question of the substitution of mechanical power for animal traction, as we have at present; and, indeed, we have received some letters from shareholders who appear to approve very strongly of the broad principle we have laid down here. Your Directors have made investigations into the subject generally, and have done what we can to obtain information from other places. The result is that we have resolved to recommend you to adopt electrical traction in lieu of horses. But even if we had not pushed this matter forward, and made a first move in the matter, I think it would have been forced upon us very soon, because the Municipality of Bordeaux, who are a very able and intelligent body of men, have also been thinking over the question. I think they are very proud of their tramways, believing them to be well managed and conducted, and they are anxious to have the best and latest inventions in traction adopted. The Municipality have appointed a committee of their body to inquire into the matter. They have been about France, and have inspected other towns where electricity is being used, and in their report, as far as we are able to ascertain, they recommend the use of the overhead system throughout the greater part of the system, with the exception of four or five kilometres, where they desire to have the underground or conduit system—I suppose with some idea of preventing the particular beauty of some spots in the town from being interfered with by overhead wires. That, however, is a matter on which we shall have to say something afterwards. The committee also recommend the town to extend the tramways further, and to construct certain new lines, as well as to double certain existing lines. We have not the definite plans, and therefore I cannot speak decisively about them; but at all events we know that the total amount of new lines which will have to be constructed, in addition to the conversion of the old ones, will be between 15 and 20 miles. I may say that our present rail is an excellent one for the purpose of animal traction; but for the heavier cars which will go over it, after the proposed alterations are carried out, we shall have to adopt a better and a heavier rail. The work before us is, therefore, pretty considerable. We have at the present moment about 39 miles of line, including sidings and lines into the depots, and the capital which we have invested is £332,000—that is the issued amount—out of the capital of £350,000 sanctioned. These additional lines, together with the additional stations and machinery for generating the electricity, will necessitate a doubling of the present issued capital. I do not desire to-day to commit myself to anything definite, because we do not yet know precisely what the Municipality will require; but I will ask you to regard the figure I have mentioned as what you may expect, speaking roundly. I need hardly say that this is a very serious step for us to take—to make this large further issue of capital; but, at the same time, we have looked into the matter very carefully, as I have said, and are prepared to recommend it to you strongly. We are in negotiation with the French Thomson-Houston Company. We have no definite contract with them for the construction of the lines; but they are willing to work with us, and to construct the lines if we can come to terms, and I think it most probable that we shall do so. I do not say that we shall in every way strictly keep to the details and principles of the Thomson-Houston system; it may be that in certain points we shall not follow their principles exactly; but I think I am justified in saying we have reason to believe that they will carry out the construction of the overhead wire exactly as we wish. The main questions for the shareholders to consider in regard to this proposal are the cost of electricity compared with that of animal traction; whether this new system will be sufficiently attractive to the public to increase its popularity, and consequently bring more passengers; and whether a more rapid service can be run without involving a large amount of capital expenditure on it. These are certainly very important questions. With regard to the cost of working, in order to make a proper estimate I should have to go into the figures of our present traction, and that is a very difficult thing to do; but we are able to estimate the cost per mile approximately; and we are also able to ascertain from various sources the approximate cost of working by electricity. The result is that we can speak with considerable confidence in stating that the saving in cost, even with our present service, would be sufficient to justify the expenditure of the additional capital, as the profit would be so much larger. Another matter which is of very great advantage should not be forgotten. Suppose you have 20 cars running on a particular line 20 journeys each in a day, if you wanted to increase that number to 30 journeys, you would, with horse traction, have to buy 50 per cent. more horse stock; but with electricity you could run those 10 extra journeys per car per day at a very trifling expense. I wish to impress on you the very great advantage of electricity in that direction, as you will be able to increase the number of car journeys, and thus give a much better service to the public for a very small addition to the expense. In asking you to pass this resolution we are certainly asking you to repose a good deal of confidence in us: but I may say that we were legally advised that there was no absolute necessity to call this meeting to-day. Your sanction would have been necessary before anything definite was done, and before any capital was raised; but it was not necessary to call you together to ascertain your views in connection with this resolution. The relations between the shareholders and the Directors have, however, always been so pleasant, and you have shown so much confidence in us, that we did not wish to take even the preliminary steps in this matter without ascertaining the views of the shareholders at large. This is an indefinite resolution; but if you approve the general principle, we must ask you to continue your confidence, and allow us to negotiate with the authorities broadly on this basis, coming to you again when anything definite is settled. Without such confidence in us we cannot carry on this business as successfully as we hope.

Mr. E. W. RUCK, in seconding the resolution, remarked that the carrying out of the proposed alterations depended on the conditions which the Municipality might desire to impose. If the Company accepted the terms offered or succeeded in modifying them, well and good; if not, and they refused them, the Municipality could buy them out on terms already fixed, which were by no means disastrous terms.

Mr. J. B. CONCANON said he desired to endorse the points which had been mentioned as to the advantages of electricity. The Chairman had not mentioned that the concession they were now working would expire in 1910, and he assumed that one of the requirements of the Directors would be a considerable extension of the period of the concession before they embarked on the expenditure which the proposals in question would involve. His own impression was that the capital would be very much more than doubled; but there would be nothing to be afraid of in that if the concession were extended.

Mr. K. HEDGES also spoke in favour of electrical traction.

The CHAIRMAN, in answer to questions, stated that they did not know at present what lines they would make; but he took it that between £300,000 and £400,000 would be necessary. There was a possibility of their acquiring some suburban lines. If they found the Municipality stiff and difficult to come to terms with, they would refuse to make any lines whatever, and then the Municipality could exercise their option—they could do so whenever they pleased—of buying the Company out on certain terms. Those terms were fair; but they would do much better by continuing. They had been gradually improving their property, and, on the whole, he did not think they had done badly. They would not, of course, think of spending this additional capital without a very considerable extension of their concession. He then put the resolution, which was carried unanimously.

A vote of thanks to the Chairman and Directors closed the meeting.

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## Eastern Extension, Australasia and China Telegraph Company (Limited).

The report of the Directors of this Company for the half-year ended June 30th last, to be submitted to the general meeting, to be held at Winchester House, Old Broad-street, London, E.C., on Wednesday next, the 28th inst., at 2:30 *p.m.*, states that the gross receipts, including Government subsidies, have amounted during the period to £313,914. 18s. 11d., against £264,138. 10s. 5d. for the corresponding half-year of 1895. The working expenses, including £19,916. 13s. 8d. for cost of repairs to cables and expenses of ships, absorb £87,256. 3s. 9d., against £95,254. 14s. for the corresponding period of 1895, leaving a balance of £226,658. 15s. 2d. From this is deducted £4,028. 8s. 6d. for income tax, £20,000 transferred to the fire insurance fund, £31,895. for interest on debentures, debenture stock, and contribution to sinking fund, leaving £170,735. 6s. 8d. as the net profit for the half-year. Two quarterly interim dividends of 1¼ per cent. each, amounting to £62,500, have been paid for the half-year, and £75,000 has been transferred to the general reserve fund, the balance of £33,235. 6s. 8d. being carried forward.

The working of the Australasian tariff arrangement for the fifth year of guarantee ended April 30th last resulted in the guaranteed figure being again exceeded. This was due to the heavy gold mining traffic with Western Australia during the past year.

In addition to the revision of the local rates referred to in the last report, and which took effect on July 1st last, the Directors have decided to make substantial reductions of tariff between India and China, Japan, &c., to come into force on January 1, 1897. Reductions in most of the Company's through rates were also agreed upon at the International Telegraph Conference recently held at Budapesth, several of which will come into force on January 1st, and the remainder on July 1, 1897. The immediate effect will undoubtedly be a falling off of revenue; but it is hoped that in time the loss will be diminished by increase of business.

The long pending negotiations between the Company, its partners in the China traffic (the Great Northern Telegraph Company), and the Chinese Telegraph Administration, for a friendly working arrangement, have at last been brought to a satisfactory conclusion. The arrangement restores amicable relations between the Administration and the Companies, and settles the troublesome question of exchange, from which the Company has so severely suffered in the past, by enabling it to collect in Chinese currency a fair equivalent for its sterling charges. The agreement was ratified by all the interested Governments on July 31st last, and brought into operation on the following day.

The Directors record with deep regret the death, on July 7th last, of their esteemed colleague and Chairman, Sir John Pender, G.C.M.G., who had presided over the affairs of the Company since its inception, and to whose untiring energy and devotion to its interests, the satisfactory position which the Company has attained is largely due. The Directors have appointed the acting chairman, the Most Hon. the Marquis of Tweeddale, Chairman of the Company, and have also appointed Mr. F. E. Hesse Manager as well as Secretary of the Company.

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## Brazilian Submarine Telegraph Company (Limited).

The following Report of the Directors of this Company for the half-year ended June 30th last will be presented to the general meeting to be held at Winchester House, London, E.C., on Wednesday, the 28th inst. :—

The revenue for the period amounted to £92,071. 1s. 9d., and the working expenses to £19,210 4s. 4d. After providing £3,200 for debenture interest and sinking fund, and £1,649. 10s. 7d. for income-tax, there remains a balance of £68,011. 6s. 10d. ; to this is added the sum of £15,049. 2s. 2d. brought forward, making a total of £83,060. 9s. A quarterly interim dividend, amounting to £19,500, has been paid, and £20,000 transferred to the reserve fund. The Directors recommend the declaration of a final dividend of 3s. per share, making, with the interim dividends, a total of 6 per cent. for the year, and also the payment of a bonus of 2s. per share (both free of income-tax), which together will amount to £32,500, leaving £11,060. 9s. to be carried forward.

The receipts for the half-year include the sum of £1,500, dividend to December 31st last on the Company's shares in the African Direct Telegraph Company (Limited). The Company's lines are in good working order.

The Directors record with profound regret the death of their highly esteemed colleague and Chairman, Sir John Pender, G.C.M.G.

The retiring Directors, Mr. J. Denison Pender and Mr. Frederick Youle, offer themselves for re-election ; as do also the auditors, Messrs. Deloitte, Dever, Griffiths and Co. and Messrs. Game, Jackson, Jefferys and Wells.

## NEW COMPANIES, STATUTORY RETURNS, &c.

*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1896, pages *318-346, &c., &c.*

**CALVERT'S CIRCULATION FUEL ECONOMISER (LIMITED).**—This Company was registered on Oct. 9, with a capital of £10,000, in £1 shares, to carry on the business of Mr. J. G. Calvert, at 4, St. Mary's-street, Manchester, and to acquire certain patents relating to his manufactures.

**COWPER-COLES ZINC EXTRACTION COMPANY (LIMITED).**—This Company was registered on Oct. 12, with a capital of £3,000, in £1 shares. Registered office, Mella, near Hayle, Cornwall.

**HARTLEPOOLS ELECTRIC TRAMWAYS COMPANY (LIMITED).**—This Company was registered on Oct. 15, with a nominal capital of £50,000, in £10 shares, to enter into an agreement between Stephen P. W. D. Sellon and Francis Ashby and the British Electric Traction (Pioneer) Company (Limited), to construct and work the tramways authorised by the Hartlepools Electric Tramways Order, 1895. The subscribers, with one share each, are : P. W. Sellon, engineer, Emile Garcke, electrical engineer, J. J. V. Kitchener, D. Doyle, T. Rossiter, electrical engineer, C. H. Dade, and H. S. Hodgson.

**INDIARUBBER AND CONTRACT CORPORATION (LIMITED).**—This Company was registered on Oct. 9, by Waterlow Brothers and Layton (Limited), Birchin-lane, E.C., with a capital of £2,000, in £1 shares, to carry on business as manufacturers of and dealers in india-rubber, guttapercha, &c.

**WESTMINSTER MANUFACTURING COMPANY (LIMITED).**—This Company was registered on Oct. 16, with a capital of £50,000, in £1 shares, to take over the business of Messrs. George H. Kenning and Co., and to carry on the business of metal stampers, mechanical and electrical engineers, wire drawers, tube makers, &c. The first Directors are Maurice Lachman, Charles A. Barrett and Alfred Barrett.

**VAUGHAN AND BROWN (LIMITED).**—The annual return of this Company to Aug. 13 has been filed. The nominal capital is £40,000, in 2,000 Preference and 2,000 Ordinary shares of £10 each. 2,849 of the former, and 2,630 of the latter have been taken up, and 2,000 of each class have been issued as fully paid. Calls of £5 per share have been made on the remaining 849 Preference and 630 Ordinary, which has been paid.

**WOODFIELD SYNDICATE (LIMITED).**—The annual return of this Company to June 15 has been filed. The whole nominal capital of £12,000 in £1 shares has been subscribed for and allotted, and the full amount called and paid.

## CITY NOTES.

**MEMORANDA.**—Bank rate, 4 per cent. (Oct. 22, 1896). Price of silver 30½d. per oz. (Oct. 22nd). Consols (2¾ per cent.) 107⅛—108⅛ for money 108—108⅛ for account ; 2½ per cent. 104¾—105¼ (Oct. 22nd). Stock Exchange Settling Days : Consols, Nov. 5th ; Stocks and Shares Continuation Days, Oct. 27th and Nov. 10th ; Ticket Days, Oct. 28th and Nov. 11th ; Pay Days, Oct. 29th and Nov. 12th ; Mining Share Carry-over Days, Oct. 26th and Nov. 9th.

**BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).**—Notice is given that an extraordinary general meeting of this Company is to be held at the Cannon-street Hotel, London, E.C., on Monday, Nov. 2, at 12 o'clock, when the resolution for reducing the capital of the Company from £750,000 to £660,000, which was passed at an extraordinary general meeting of the Company, will be submitted for confirmation. A circular accompanies this notice in which the secretary states that the Directors have desired him to explain the effect of the proposed reduction in greater detail than appeared in the report. This circular is as follows :—"Under the constitution of the Company, the holders of Preference shares have a preference in dividend, but not as regards capital ; and therefore, in the event of the Company going into liquidation (a remote contingency), the holders of Ordinary shares would be entitled to receive three-fifths and the holders of Preference shares two-fifths of any surplus assets, after payment of Debentures and other debts and liabilities and the expenses of liquidation. After the capital has been reduced in the manner proposed, the holders of Preference and Ordinary shares will be entitled to participate in equal shares in the assets on winding-up, and neither class of shareholders will be in any way prejudiced as regards dividend. The Directors, who hold a large number of Ordinary shares themselves, have, after careful consideration, decided that under all the circumstances the proposed mode of reduction is the best available, and wish to point out that, as it will facilitate payment of dividends, the holders of Ordinary shares will reap the main benefit of the proposed reduction so long as the Company is a going concern. A reduction of the Preference capital would entail an immediate and continuing loss on the holders of Preference shares, and would have the effect of transferring part of the dividend to which they are now entitled to the pockets of the holders of Ordinary shares. The resolution for reduction was discussed at some length at the meeting of the Company held for the purpose on the 5th inst., and was eventually passed by a majority of 42 to 10."

**CAMBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED).**—The revenue returns for the quarter from July 1 to Sept. 30 show a sale of 17,025 units, against 13,027 in the corresponding period of 1895. The revenue from electricity supply was £467. 15s. 10d., against £354. 16s., and from meter rents and other sources £62. 13s. 9d., against £56.

**CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).**—The traffic returns of this Company for the week ended Oct. 18th were £1,012, against £927 in the corresponding week of 1895, an increase of £85. The total receipts for the half-year amount to £14,693, against £13,701 for the corresponding period of 1895, an increase of £992.

**HOVE ELECTRIC LIGHTING COMPANY (LIMITED).**—The Directors of this Company notify that the business continues to improve. The number of consumers has increased to 305, and the lamps connected to the mains are equivalent to 20,911 8 c.p. lamps, while the net revenue for the half-year ended June 30 was nearly 25 per cent. in excess of that of the corresponding period last year. The Five per Cent. Debentures were paid off on July 1, and the loan from the Company's bankers has been extinguished. The total Debentures now issued are £7,300 at 4½ and £14,600 at 4 per cent. The whole of the share capital has been subscribed, the last 922 shares at a premium of 10s. The reserve fund amounts to £1,287. Extensions are being made to the mains to meet increased demands.

**LIVERPOOL OVERHEAD RAILWAY COMPANY.**—The traffic receipts of this railway for the week ended 18th inst. amounted to £1,081. The amount for the corresponding week last year was £1,104. Decrease, £23.

**ROLLER BEARINGS COMPANY (LIMITED).**—The statutory meeting of this Company is to be held at 1, Delahay-street, Westminster, on Thursday next. The Company is said to be making good progress. At recent trials on the Liverpool Overhead Railway on the occasion of the meeting of the British Association, it was demonstrated that three cars fitted with these bearings could be run with the same expenditure of electrical energy as is required for two fitted with ordinary bearings ; and the Overhead Railway are, we learn, about to fit up their new rolling stock with these bearings. Orders are in hand from the tramway companies of Edinburgh, Burnley, Croydon and other towns. Major John Hutchinson, C.B., late Chief Inspecting Officer to the Board of Trade, is Chairman of the Company.

**RUSTON, PROCTOR AND CO. (LIMITED).**—The Directors of this Company have declared an interim dividend of 5s. per share for the half-year ended September.

**STOCK EXCHANGE NOTICE.**—Application has been made to the Stock Exchange Committee to appoint a special settling day in 10,000 Four and a-Half per Cent. Preference shares (Nos. 1 to 10,000) of the Charing Cross and Strand Electricity Supply Corporation (Limited).

**SUBMARINE CABLES TRUST.**—An extraordinary general meeting of the certificate holders in this Trust will be held at the offices, Winchester House, Old Broad-street, London, on Friday next, the 30th inst., at 12:30 p.m., for the purpose of electing a new trustee.

**SWANSEA TRAMWAYS COMPANY (LIMITED).**—At a meeting of the shareholders of the Swansea Tramways Company in London on Friday a motion was passed empowering the Directors to take steps for carrying into effect the preliminary agreement with the Swansea Corporation which stipulates for the electrical equipment of the Company's lines on the overhead system and the sale to the Corporation in exchange for a fresh lease.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—The Directors of this Company decided yesterday, after placing £5,000 to debenture redemption fund and £3,000 to reserve, to recommend (subject to audit) at the forthcoming meeting a dividend at the rate of £2 per cent. per annum, free of income tax, for the six months to June 30th, carrying forward £3,530. 5s 7d. This Company's traffic receipts for the week ended Oct. 16th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,849.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—Subject to audit, the Directors of this Company (after placing £1,000 to reserve) have decided to recommend the undermentioned dividends for the six months ended 30th June :—6s. per share on the First and Second Preference shares, and 1s. 6d. per share on the Ordinary shares. The estimated amount of the traffic receipts of this Company for the half-month ended Oct. 15th is £1,900, against £2,101 in the corresponding period of 1895. The June receipts (estimated at £4,830) realised £4,839.

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# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price October 14. | Price Wednesday, October 21. | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Oct. 17. Highest | Lowest |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | £ s. d. | | | |
| £1,012,880 | Stock | 12/0 | Anglo-American ..... xd | 50 53 | 49 52 | 5 0 0 | Jan., Apr., July, Oct. | 53 | .. |
| £2,993,560 | Stock | 24/0 | Do. Preferred ..... xd | 96 97 | 95 96 | 5 8 4 | " " | 97 | 95 |
| £2,993,560 | Stock | 5/0 | Do. Deferred ..... | 8¾ 9¼ | 8¼ 9¼ | .. | .. | .. | .. |
| £173,400 | 100 | 4¾ | *African Direct Teleg. 4% Deb. (Reg. & Bearer) .. | 100 104 | 100 104 | 3 17 8 | January and July .. | .. | .. |
| £250,000 | £10 | .. | Amazon Telegraph (fully paid) ..... | 8½ 9½ | 8½ 9½ | .. | .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine ..... | 14¾ 15¼ | 14¾ 15¼ | 4 11 10 | Mar., June, Oct., Dec. | 15⅝ | .. |
| £75,000 | £100 | 5% | * Do. 5 per Cent. Bonds (2nd Series, 1906) .... | 112 116 | 112 116 | 4 7 4 | June and December | .. | .. |
| 10,000,000 | $100 | 7% | Commercial Cable Capital Stock ..... | 145 150 | 145 150 | 4 13 8 | Jan., Apr., July, Oct. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine ..... | 11½ 12½ | 11½ 12½ | 6 8 0 | February and August | 12 | .. |
| 6,000 | 10 | 10% | Do. Preference 10 per Cent. ..... | 18½ 19½ | 18½ 19½ | 5 2 7 | " " | .. | .. |
| 12,931 | 5 | 2/0 | Direct Spanish (fully paid) ..... | 3¾ 4¼ | 3¾ 4¼ | 4 8 11 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10 per Cent. ..... | 10 10½ | 10 10½ | 4 11 6 | " " | .. | .. |
| £30,000 | Stock | 4½% | Do. 4½% Debentures of £50 each ..... | 107% 110% | 107% 110% | 4 2 9 | .. .. | .. | .. |
| 60,710 | 20 | 2/6 | Direct United States Cable, 1877 ..... xd | 9½ 10 | 9¼ 9¾ | 4 12 4 | Jan., Apr., July, Oct. | 9⅝ | 9½ |
| 400,000 | 10 | 2/6 | Eastern ..... xd | 17¾ 18½ | 17½ 18 | 3 12 3 | " " | 18 | 17¾ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference ..... xd | 18½ 19½ | 18½ 19½ | 3 1 6 | " " | 19 | 18⅝ |
| £1,297,837 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock .... | 131 134 | 131 134 | 3 0 7 | May and November | 133½ | 131 |
| £102,100 | 100 | 5% | * Do. 5 per Cent. Debentures, 1899..... | 104 107 | 104 107 | 4 14 4 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension ..... xd | 17½ 18 | 17½ 18 | 3 17 9 | Jan., Apr., July, Oct. | 18½ | 17¾ |
| £320,000 | Stock | 4% | Do. 4 per Cent. Debenture Stock ..... | 130 133 | 130 133 | 3 0 6 | February & August | .. | .. |
| £54,100 | 100 | 5% | * Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900 .... | 100 104 | 100 104 | 4 17 7 | January and July .. | .. | .. |
| £80,600 | 100 | 5% | *Eastern and S. African 5 p. Cent. Mor. Deb.,1900 .. | 101 105 | 101 105 | 4 16 7 | " " | 102 | .. |
| £300,000 | 100 | 4% | * Do. 4% Mortgage Debentures, 1909 (regd.) .. | 106 109 | 106 109 | 3 13 11 | February & August | .. | .. |
| £200,000 | £25 | 4% | * Do. 4% Mauritius Sub. Debs. (regd.)..... | 110% 113% | 110% 113% | 3 12 1 | May and November | .. | .. |
| 180,227 | 10 | 3/9 | Globe Telegraph and Trust..... | 10¾ 11¼ | 10¾ 11¼ | 3 15 7 | Jan., Apr., July, Oct. | 11⅛ | 10¾ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference ..... | 17½ 18 | 17½ 18 | 3 6 8 | " " | 17⅞ | .. |
| 150,000 | 10 | 5/0 | Great Northern..... | 24¼ 25 | 24 25 | 4 0 0 | Jan., April, and July | 24½ | 24⅛ |
| £180,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1883 issue..... | 104 107 | 104 107 | 4 13 11 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European ..... | 52 55 | 52 55 | 4 10 11 | May and November | 53¾ | .. |
| 37,548 | 10 | .. | London Platino-Brazilian ..... | .. .. | .. .. | .. | " " | .. | .. |
| £100,000 | 100 | 6% | * Do. 6 per Cent. Debentures ..... | 109 112 | 109 112 | 5 7 10 | March & September | .. | .. |
| £100,000 | £100 | 4% | *Pacific European Tel. 4% Guar. Debs. "Red" 1942 .. | 108 111 | 108 111 | 3 12 9 | .. .. | .. | .. |
| 11,839 | 8 | 4/0 | Reuter's ..... xd | 7 8 | 7 8 | 5 0 0 | April and October .. | .. | .. |
| 3,381 | £100 Cert. | 47/6 | *Submarine Cables Trust 6 per Cent. ..... | 138 143 | 136 141 | 4 5 1 | " " | .. | .. |
| 15,609 | 10 | 6/0 | West African Telegraph ..... | 5 6 | 5 6 | 5 0 0 | January and July .. | .. | .. |
| £238,300 | 100 | 5% | * Do. 5 per Cent. Debentures (red.)..... | 102 105 | 102 105 | 4 15 8 | March & September | .. | .. |
| 30,000 | 10 | 2/0 | West Coast of America ..... | ½ 1½ | ½ 1½ | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | * Do. 8 per Cent. Debentures, 1902 ..... | 98 103 | 99 103 | 7 18 5 | June and December | .. | .. |
| 88,321 | 10 | 0/8 | West India and Panama ..... | 1½ 1⅝ | 1½ 1⅝ | .. | .. | 1 1/16 | .. |
| 34,563 | 10 | 6% | Do. 6 per Cent 1st Preference ..... | 11½ 12 | 11½ 12½ | 4 16 0 | May and November | 11½ | 11½ |
| 4,669 | 10 | 6% | Do. 6 per Cent. 2nd Preference ..... | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| £30,000 | 100 | 5% | * Do. 5 per Cent. Debentures, 1917 (red.) .... | 108 111 | 108 111 | 4 11 4 | June and December | .. | .. |
| 64,251 | 15 | 5/3 | Western and Brazilian..... | 8¼ 8¾ | 7¾ 8¼ | 5 9 1 | May and November | 8⅝ | .. |
| 33,129 | 7½ | 3/9 | Do. 5 per Cent. Cumulative Preferred ..... | 6½ 7 | 6¼ 6¾ | 5 11 1 | .. .. | .. | .. |
| 33,129 | 7½ | 1/6 | Do. Deferred Ordinary ..... | 2¼ 2¾ | 1¾ 2¼ | .. | .. | .. | .. |
| £158,100 | 100 | 6% | * Do. 6 per Cent. Debs., Series "A" 1910 .... | 103 107 | 103 107 | 5 13 2 | February & August | .. | .. |
| £197,600 | 100 | 6% | * Do. 6% Mort. Debs., Series "B" 1910 ..... | 103 107 | 103 107 | 5 13 2 | " " | .. | .. |
| $1,177,000 | $1,000 | 7% | * Western Union 7% 1st Mort. (Building) Bonds.... | 110 115 | 110 115 | 6 5 7 | May and November | .. | .. |
| £164,300 | £100 | 6% | * Do. 6 per Cent. Sterling Bonds (red.) ..... | 100 105 | 100 105 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | |
| 44,000 | 5 | 4/0 | Chili Telephone (fully paid) ..... | 3¼ 3½ | 3¼ 3½ | 5 6 8 | .. | .. | .. |
| 224,850 | 10/0 | 1½d. | Consolidated Telephone Const. & Manufacturing .. | ⅞ 1 | ⅞ 1 | .. | .. | .. | .. |
| 171,504 | £1 | 1/0 | Oriental Telephone and Electric (fully paid) .... | 1⅛ 1⅜ | 1⅛ 1⅜ | 6 3 1 | Yearly ..... | ⅞ | .. |
| 484,597 | 5 | 2/6 | National ..... | 7¼ 7½ | 7¼ 7½ | 3 13 4 | June and December | 7 7/16 | 7¼ |
| 15,000 | 10 | 6% | Do. 6 per Cent. Cumulative 1st Pref. ..... | 17 19 | 17 19 | 3 3 2 | " " | 17⅜ | .. |
| 15,000 | 10 | 6% | Do. 6% Cumulative 2nd Pref. (fully paid).... | 17 19 | 17 19 | 3 8 7 | " " | .. | .. |
| 119,234 | 5 | 2/6 | Do. 5% Non-Cumulative 3rd Pref. ..... | 6¾ 7 | 6¾ 7 | 3 11 5 | .. | 6¾ | .. |
| 1,100,000 | Stock | 3½% | * Do. Debenture Stock, 3½% (red.) ..... | 108 109 | 108 109 | 3 4 9 | January and July . | 107⅜ | .. |
| 58,000 | 5 | 4/0 | United River Plate ..... | 3¾ 4 | 3¾ 4 | 5 0 0 | July ..... | .. | .. |
| £146,733 | Stock | 5% | * Do. 5 per Cent. Debenture Stock (red.) ..... | 101 103 | 101 105 | 4 15 8 | January and July .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| .. | 5 | .. | Birmingham Electric Supply (fully paid) ..... | 9 9½ | 9½ | .. | .. | .. | .. |
| .. | 5 | .. | Do. (£4 paid) ..... | 7¼ | 7½ | .. | .. | .. | .. |
| 40,000 | £10 | 10/0 | City of London Electric Lighting (fully paid) .... | 16 17 | 16 17 | 2 18 10 | February & August | 16⅝ | 16½ |
| 40,000 | 10 | 6/0 | Do. 6% Cumulative Pref. (fully paid) ..... | 17½ 18½ | 17 18 | 3 6 8 | January and July ... | 17¾ | 17½ |
| £ 00,000 | Stock | 5% | * Do. 5% Debenture Stock (red.) ..... | 131 135 | 131 135 | 3 14 11 | June and December | 131 | .. |
| 19,900 | £5 | .. | Electricity Supply Co. for Spain..... | .. .. | .. .. | .. | .. | .. | .. |
| £ 0,000 | £5 | 2/6 | Charing Cross & Strand Electricity Supply Corp. .. | 9½ 10 | 9½ 10 | 2 15 0 | .. | 10 | 9⅞ |
| £ 7,400 | £100 | 5% | Do. 5 per Cent. Debentures, 1900 ..... | .. .. | .. .. | .. | .. | .. | .. |
| 22,475 | £8 | .. | County of London & Brush Prov. Ord. (fully paid). | 8¼ 9¼ | 8¼ 9¼ | .. | .. | .. | .. |
| £10,000 | £10 | 5/4½ | Do. Pref. (fully paid) ..... | 13⅞ 14¼ | 13⅞ 14¼ | 4 4 3 | .. | 14 1/16 | .. |
| 8,322 | £5 | .. | House-to-House Electric ..... | .. .. | .. .. | .. | .. | .. | .. |
| 15,000 | £5 | .. | Kensington & Knightsbridge El. Light (fully paid). | .. .. | .. .. | .. | .. | .. | .. |
| 10,000 | £5 | 6% | Do. 1st Pref. Cumulative (fully paid)..... | .. .. | .. .. | .. | January and July .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply..... | .. 1 1¼ | .. | .. | .. | .. | .. |
| 49,900 | £10 | 4/0 | Metropolitan Electric Supply (fully paid) ..... xd | 12½ 13½ | 13 14 | 3 2 1 | .. | 13½ | 13 |
| £150,000 | Stock | 4½% | * Do. 4½% Debs. ..... | 121 124 | 121 124 | 3 13 0 | June and December | .. | .. |
| 6,452 | £10 | 4/0 | Notting Hill Electric ..... | 11⅛ 12⅛ | 1 ⅛ 12⅛ | .. | .. | .. | .. |
| .. | .. | .. | Rand Electric ..... | 1 7/16 1 9/16 | 1½ 1¾ | .. | .. | .. | .. |
| 19,980 | £5 | 2 0 | St. James and Pall Mall ..... | 11½ 12½ | 11½ 12½ | 3 2 0 | .. | .. | .. |
| 20,000 | £5 | 7% | Do. 7 per Cent. Preference..... | 10 11 | 10 11 | 3 6 8 | .. | 10⅜ | .. |
| 59,900 | 5 | 3/0 | Westminster Electric Supply (fully paid) ..... | 10½ 11½ | 10½ 11½ | 3 8 2 | .. | 11 1 | 11 |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 90,000 | 3 | 1/6 | Brush Electrical Engineering ..... | ⅞ 1⅛ | ⅞ 1⅛ | .. | .. | .. | .. |
| 90,000 | 2 | 6% | Do. 6 per Cent. Pref. Non-Cumulative ..... | 1⅛ 1⅜ | 1⅛ 1⅜ | .. | .. | .. | .. |
| £125,000 | Stock | 4½% | Do. 4½ per Cent. Debentures..... | 110 113 | 110 113 | 4 0 9 | March & September | 111 | .. |
| 28,180 | 5 | 3/0 | Crompton and Co., 7 per Cent. Cumulative Pref. | 2 2½ | 2 2½ | .. | January and July .. | .. | .. |
| 89,261 | 5 | 1/6 | Edison and Swan United ("A" Swan) (£3 paid) .. | 1¾ 2¼ | 1¾ 2¼ | 6 13 4 | February & August | .. | .. |
| £100,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock ..... | 103 106 | 103 106 | 4 6 2 | January and July .. | .. | .. |
| £20,000 | £5 | .. | Electric and General Invest. Ordinary (£1 paid) . | .. .. | .. .. | .. | .. | .. | .. |
| 110,000 | 2 | 1/0 | Electric Construction ..... | 1½ 1¾ | 1½ 1¾ | 2 17 2 | .. | 1⅝ | 1 1/16 |
| 12,845 | 2 | 2/0½ | Do. 7 per Cent. Cumulative Pref. ..... | 2½ 3 | 2½ 3 | 4 13 4 | September ..... | 2⅞ | 2¾ |
| 91,195 | 2 | 10/0 | Elmore's Patent Copper Depositing ..... | ⅛ ⅜ | ⅛ ⅜ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (fully paid) ..... | .. .. | .. .. | .. | .. | .. | .. |
| 50,000 | 10 | 5/0 | India Rubber, Gutta Percha, &c., Works ..... | 22 23 | 21½ 22½ | 4 8 11 | February & August | 22½ | 22 1/16 |
| £200,000 | 100 | 4% | * Do. 4 per Cent. Debentures ..... | 105 108 | 105 108 | 3 14 1 | March & September | 105 | .. |
| 20,000 | £5 | .. | Manchester Edison-Swan "A" (£1 10s. paid) .... | ⅜ ⅞ | ⅜ ⅞ | .. | .. | .. | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance..... | 39 42 | 39 42 | 4 5 9 | March and July | 40 | 39 |
| £150,000 | 100 | 5% | * Do. 5 per Cent. Bonds ..... | 104 107 | 104 107 | 4 14 9 | January and July | .. | .. |
| £100,000 | 10 | 6/0 | W. T. Henley's Telegraph Works Ordinary..... | 17½ 18½ | 17½ 18½ | 4 6 6 | March & September | .. | .. |
| £30,000 | 10 | 7/0 | Do. 7 per Cent. Preference ..... | 18½ 19½ | 18½ 19½ | 3 11 10 | " " | .. | .. |
| £50,000 | Stock | 4½% | Do. 4½% Mortgage Debenture Stock..... | 110 115 | 110 115 | 3 18 9 | February & August | .. | .. |
| | | | **RAILWAYS AND TRAMWAYS.** | | | | | | |
| £630,000 | Stock | 1⅝% | City and South London Railway Con. Ordy. ..... | 50 52 | 50 52 | 2 17 6 | January and July .. | 51½ | 50½ |
| 7,650 | 10 | 5% | Do. 5% Perpetual Preference ..... | 14½ 15½ | 14½ 15½ | 3 5 7 | " " | .. | .. |
| £10,171 | Stock | 4% | Do. 4% Perpetual Debenture ..... | 136 138 | 137 139 | 2 18 5 | May and November | .. | .. |
| 37,500 | £10 | 2½% | Liverpool Overhead Railway ..... | 13 7/16 13 9/16 | 13 7/16 13 9/16 | 2 4 6 | .. | .. | .. |
| 10,000 | 10 | 5% | Do. 5% Preference ..... | 16¾ 17⅛ | 16¾ 17⅛ | 2 17 9 | .. | .. | .. |
| 125,000 | Stock | 4% | Do. 4% Debenture ..... | 112½ 114½ | 112½ 114½ | 3 9 10 | January and July .. | .. | .. |

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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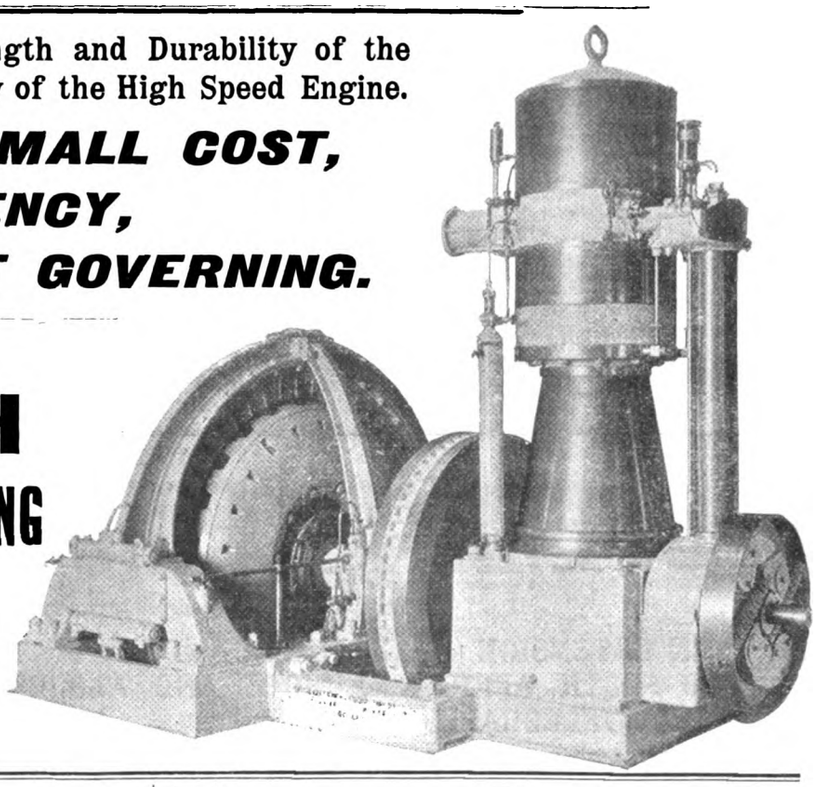

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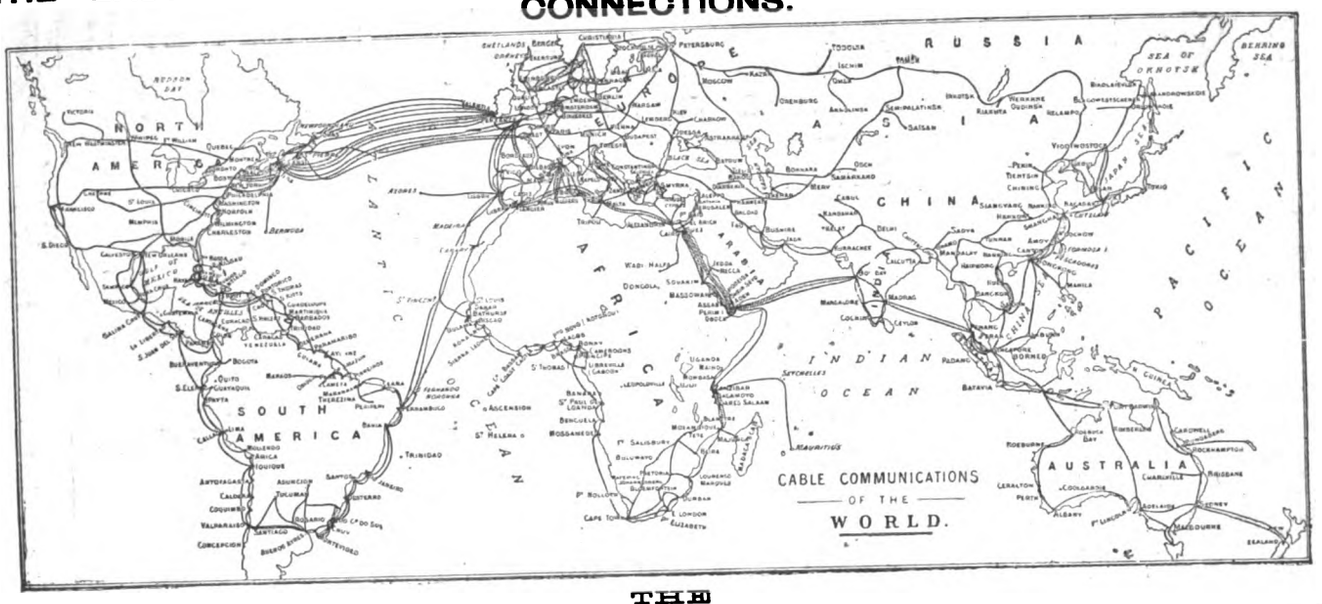
## THE EASTERN TELEGRAPH COMPANY'S SYSTEM AND ITS GENERAL CONNECTIONS.




THE

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IN CONNECTION WITH THE (LIMITED),

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**By DIRECT TRIPLICATE CABLES, to Spain, Portugal, Gibraltar, Malta, Egypt, Aden, and India.**

**By DIRECT DUPLICATE CABLE ROUTES to Madeira, St. Vincent, Brazil, Argentine Republic, Uruguay, also to Peru, Chili, and other parts of South America; and to Suakin, Perim, Penang, Malacca, Singapore, Labuan, Java, Australia, New Zealand, Tasmania, New Caledonia, Bangkok, Cambodia, Saigon, Tonquin, Hainan, China.**

**By ALTERNATIVE CABLES to Zanzibar, Mombasa, Mozambique (duplicate), Lourenço Marques (Delagoa Bay), Durban and Capetown; Bathurst, Sierra Leone, Accra, Lagos, Bonny, Bolama, Bissao, Cameroons, St. Thome, Principe, Loanda, Benguella, Mossamedes, Conakry, Grand Bassam, and Gaboon.**

**By SINGLE CABLE to the Azores, Tangier, Tripoli, Cyprus, Seychelles, Mauritius, and Manila.**

Telegrams should be sent from the Company's Stations—

**LONDON—11, OLD BROAD STREET, E.C.; 8, LEADENHALL STREET; 3, GREAT TOWER STREET; 42, PARLIAMENT STREET, S.W.; 206a, WINCHESTER HOUSE, E.C.; 37, HOLBORN VIADUCT, E.C.; FOREIGN AUCTION HALL, COVENT GARDEN MARKET, W.C., and 449, STRAND, W.C.**

**MANCHESTER—20, Brown Street.** **LIVERPOOL—K13, Exchange Buildings.**

**GLASGOW—141, BUCHANAN STREET.**

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The Company's Cables are worked by Muirhead's DUPLEX principle upon all its Main Sections.

In sending Telegrams from Postal Stations care should be taken to mark them— "VIA EASTERN," these words being signalled gratuitously by the Postal Authorities.

Books of Forms and Tariffs forwarded post free on application at the Company's Chief Offices as above, or at

**37, RUE CAUMARTIN, PARIS; and HOTEL DES POSTES ET TELEGRAPHES, MARSEILLES.**

Winchester House, 50, Old Broad Street, E.C. By Order, GEORGE DRAPER, *Secretary.*

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TELEGRAPH ADDRESS: Willcox, Southwark Street, London.

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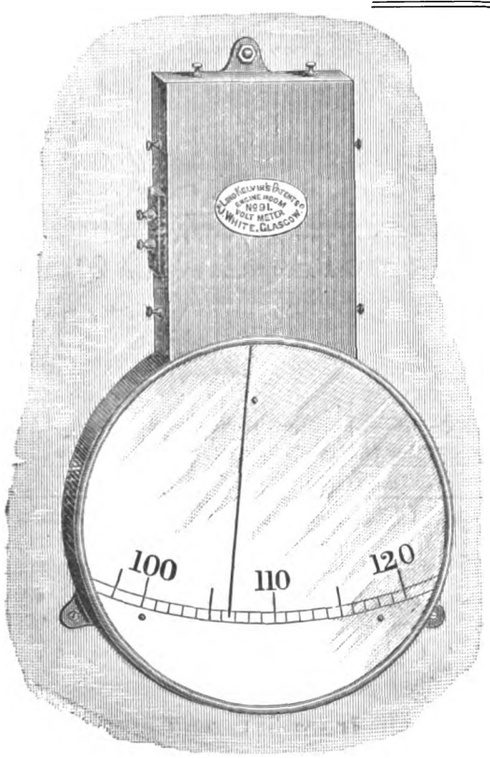

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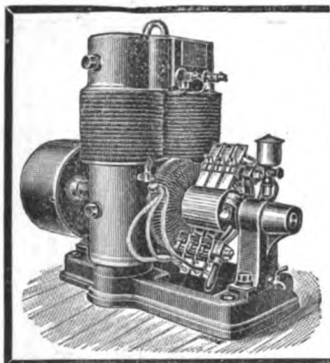

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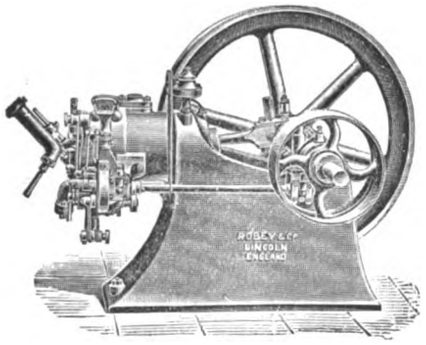

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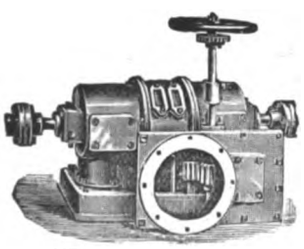

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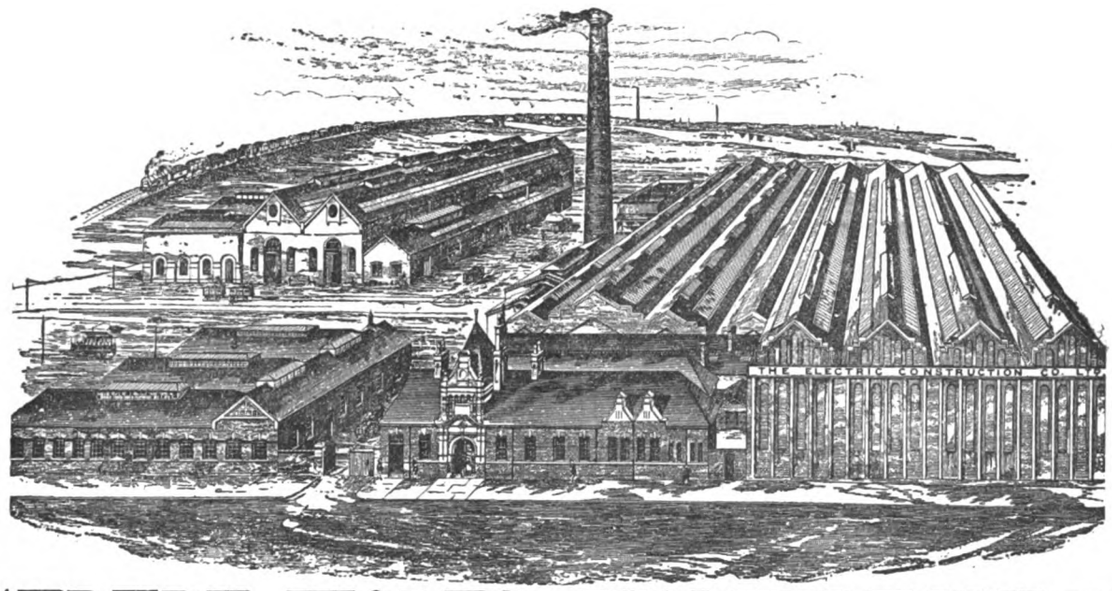

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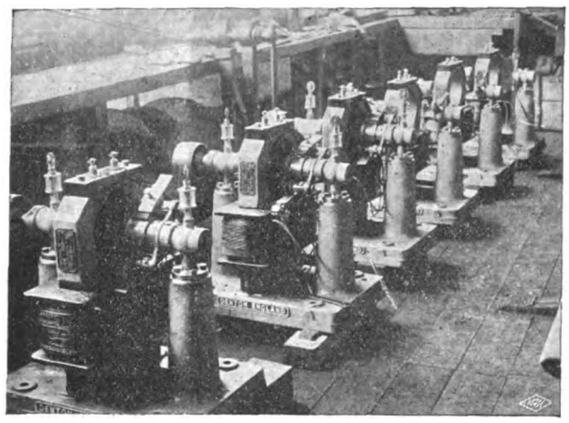

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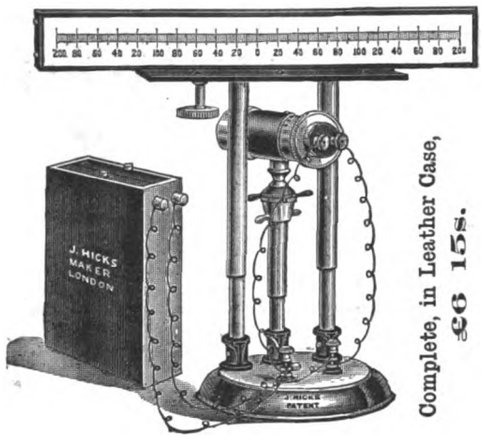

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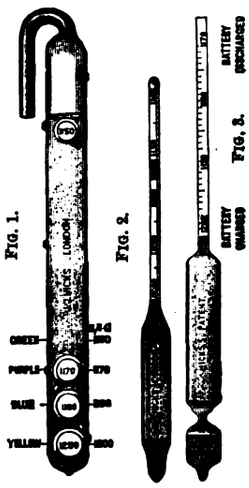


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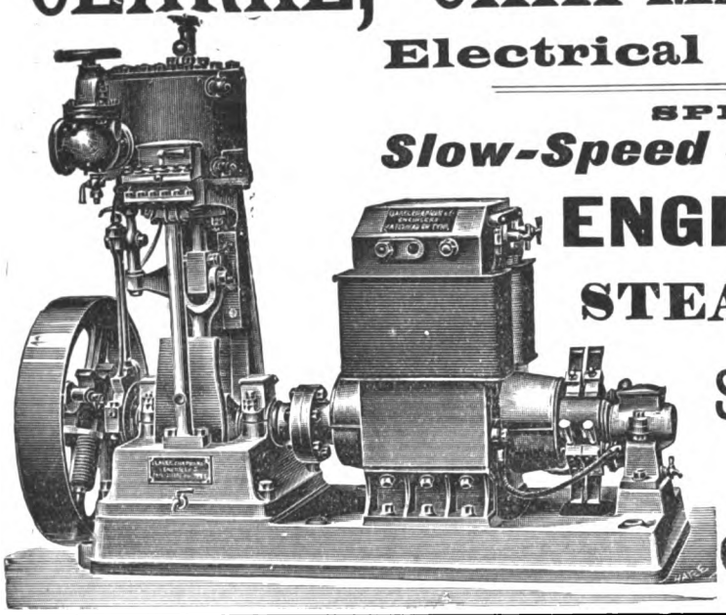

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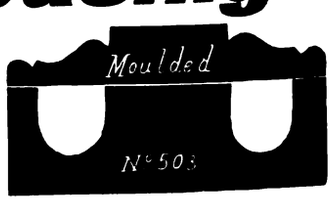


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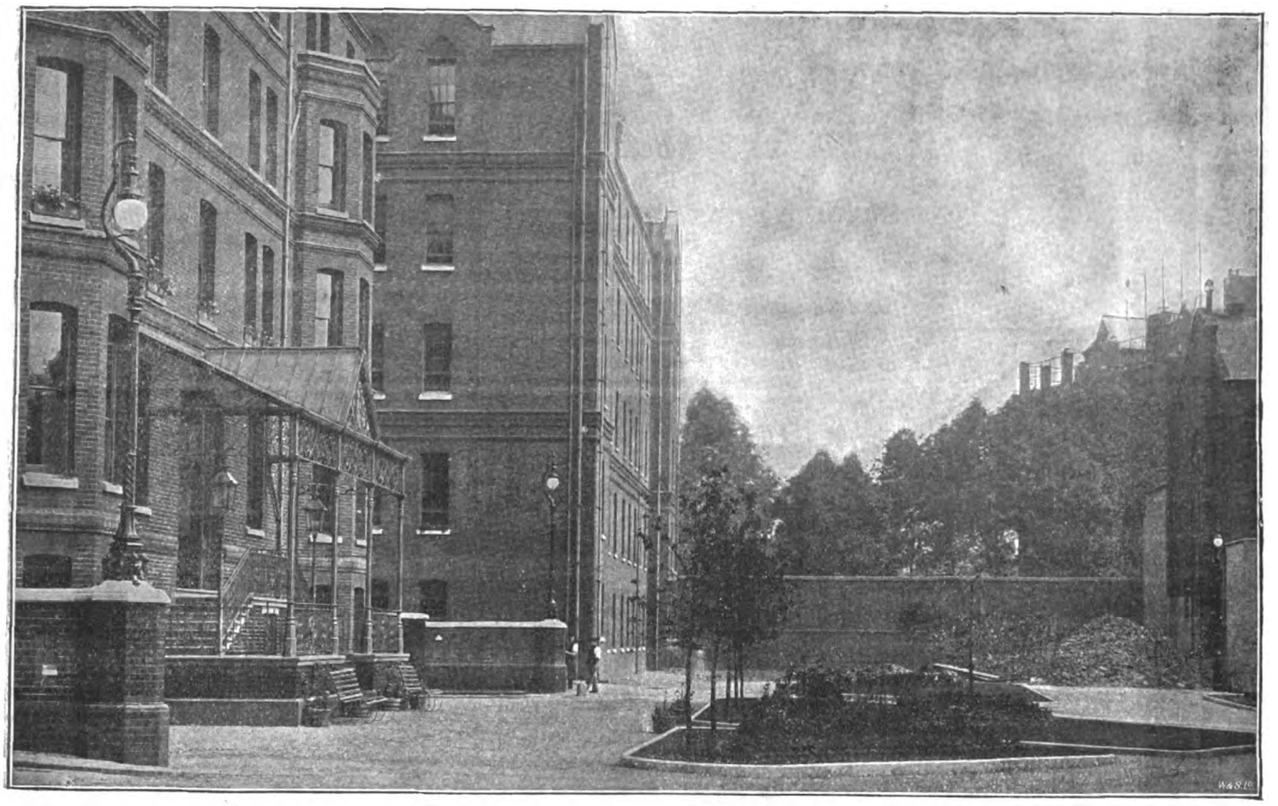

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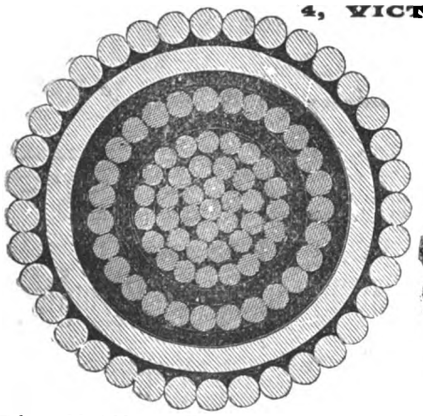

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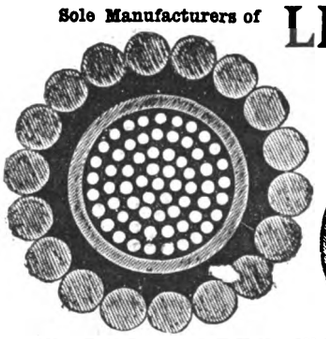

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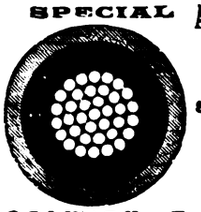

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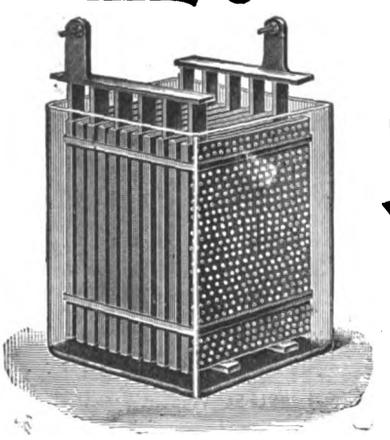

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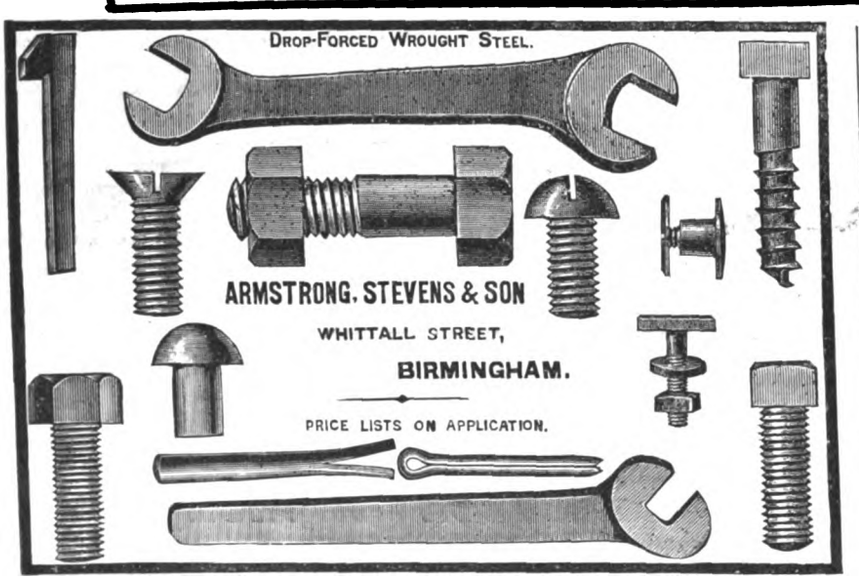


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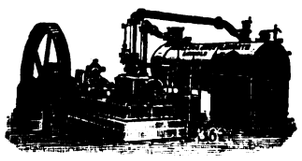

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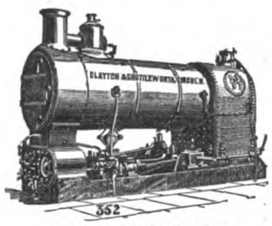

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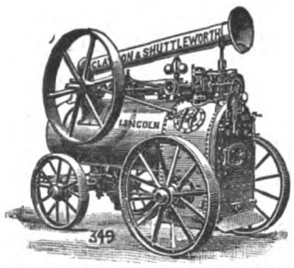

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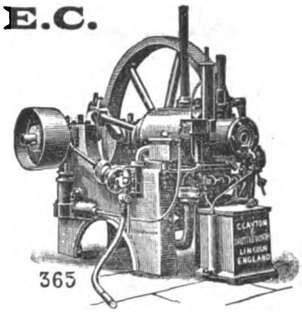

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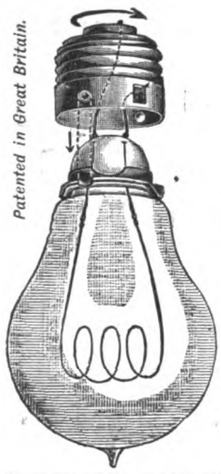

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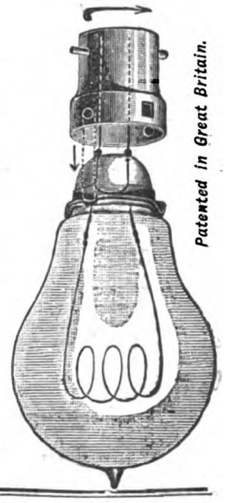

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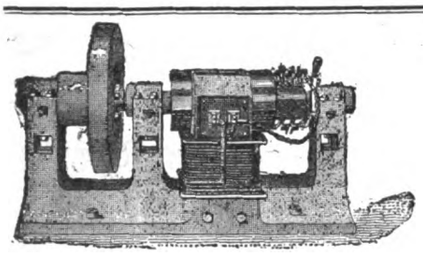

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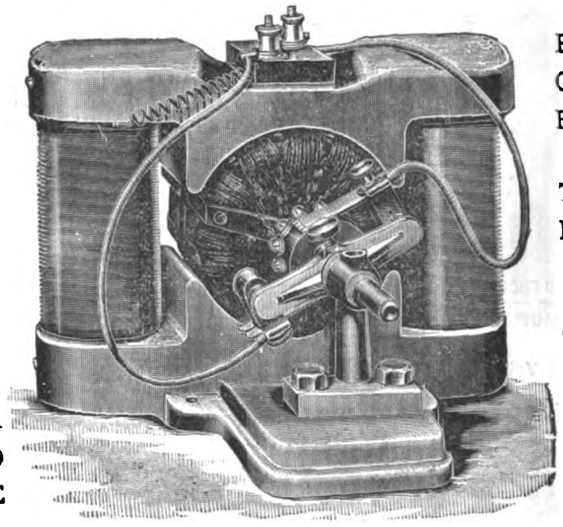

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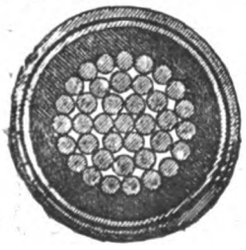

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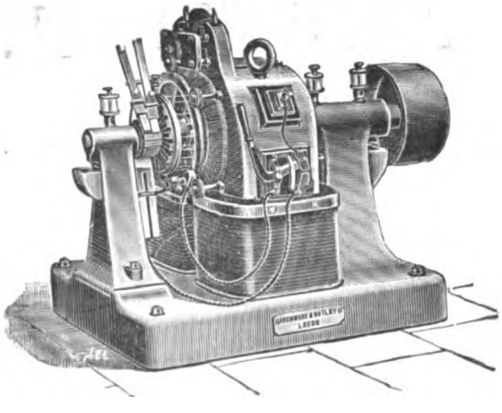

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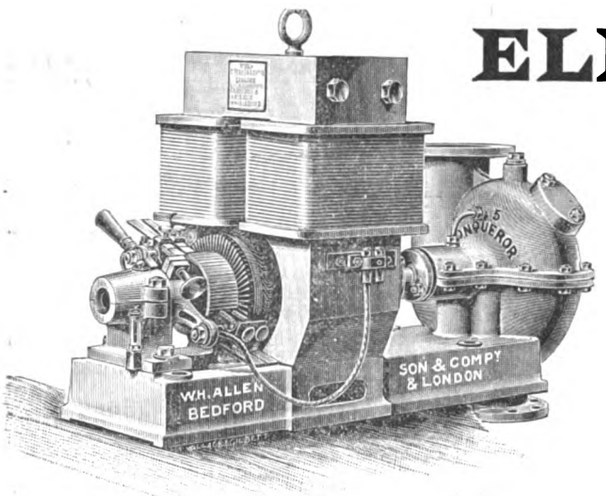


FIG. 189.—14 H.P. MOTOR AND PUMP.

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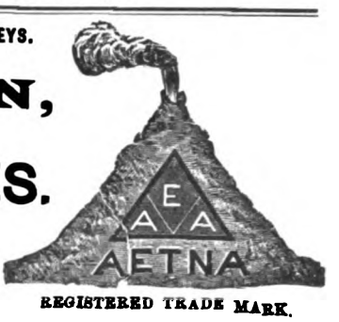


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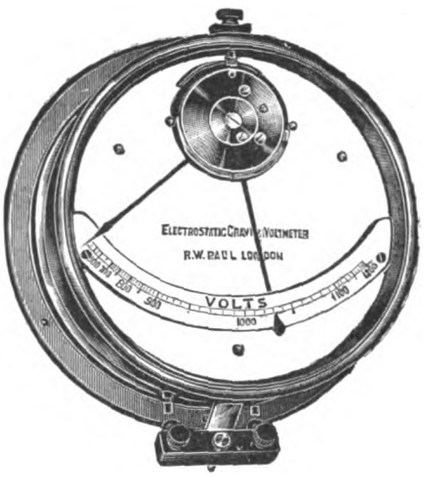


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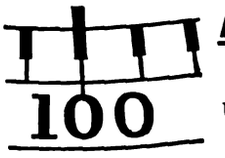


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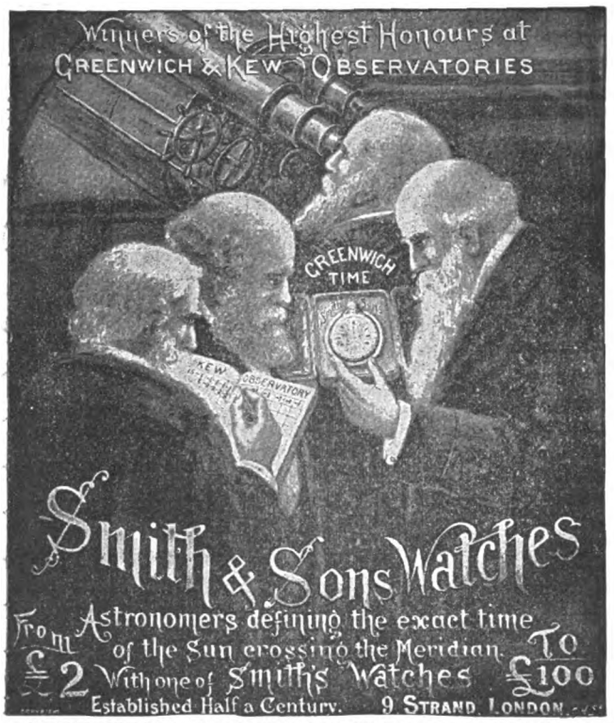


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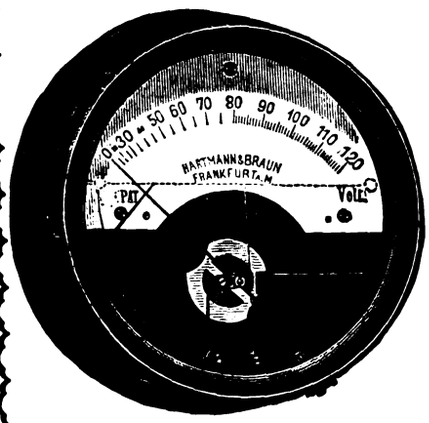


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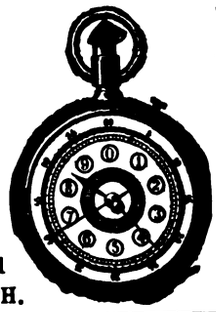

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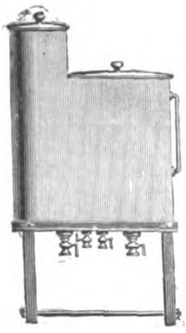

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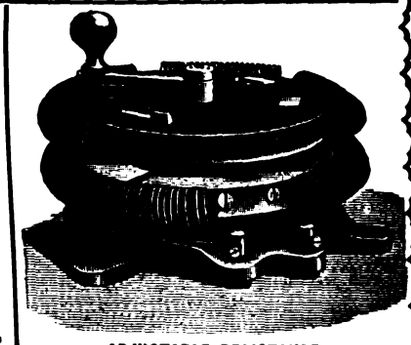

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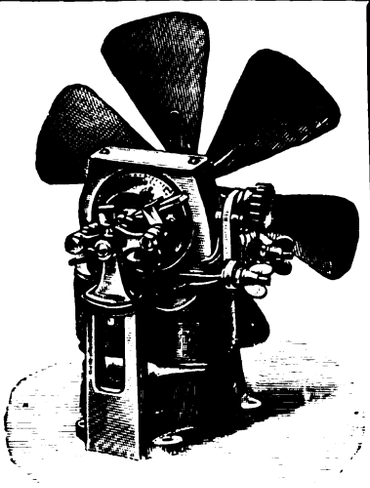

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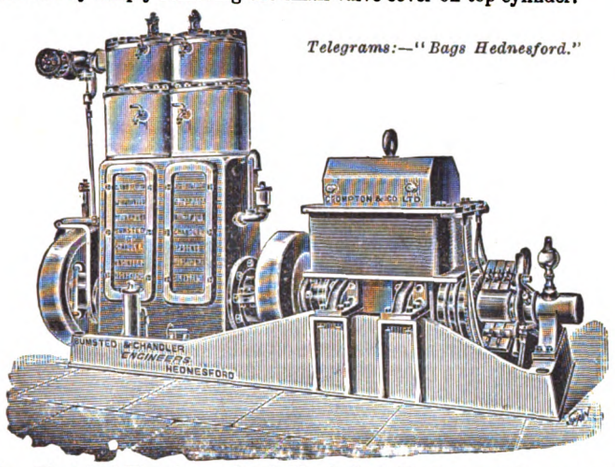


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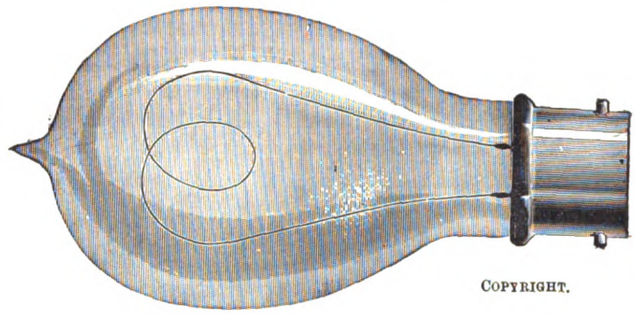

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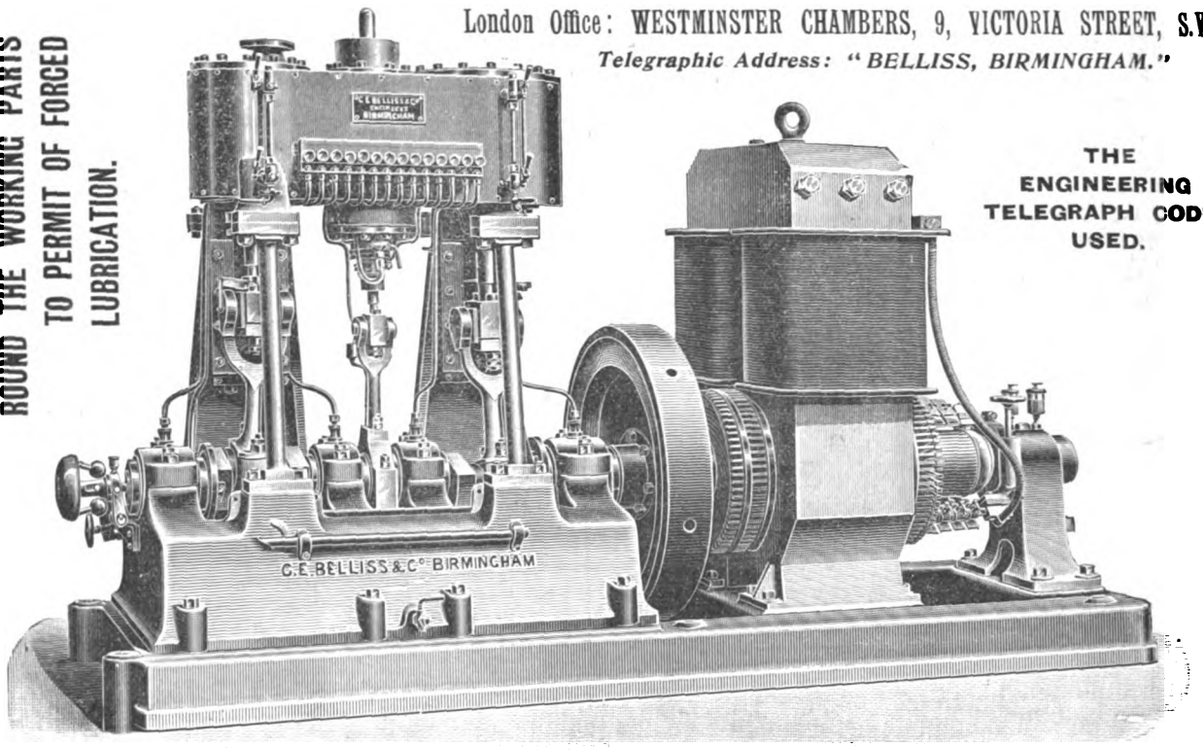


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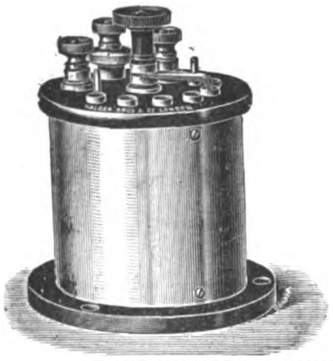

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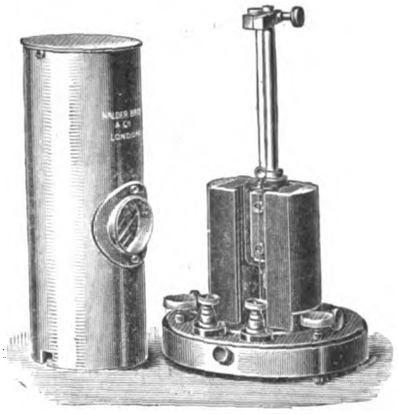

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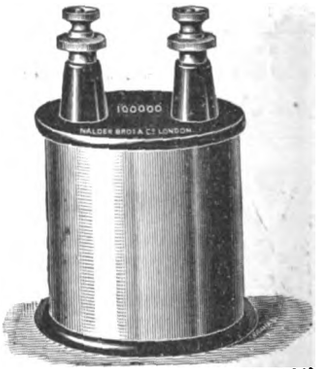


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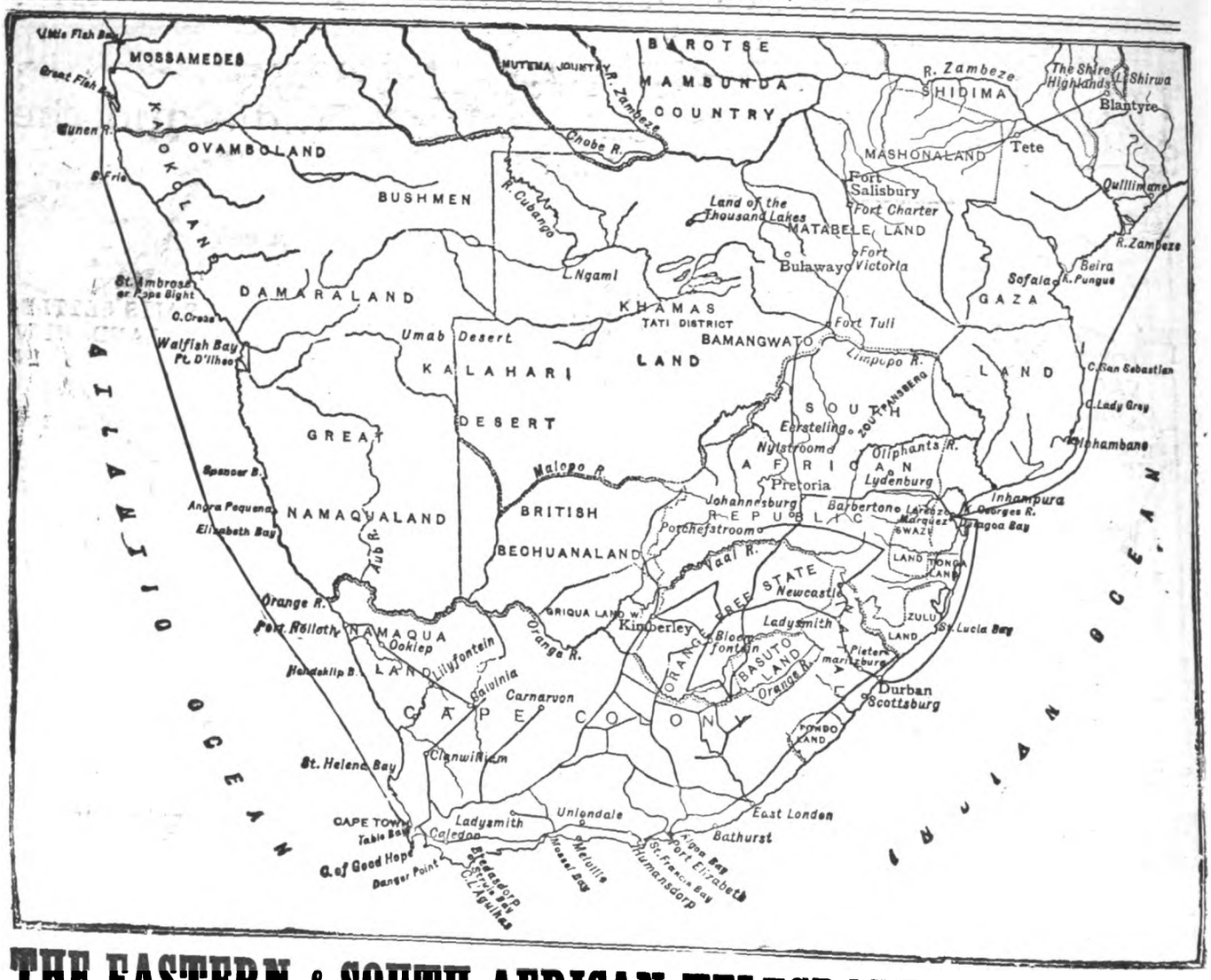


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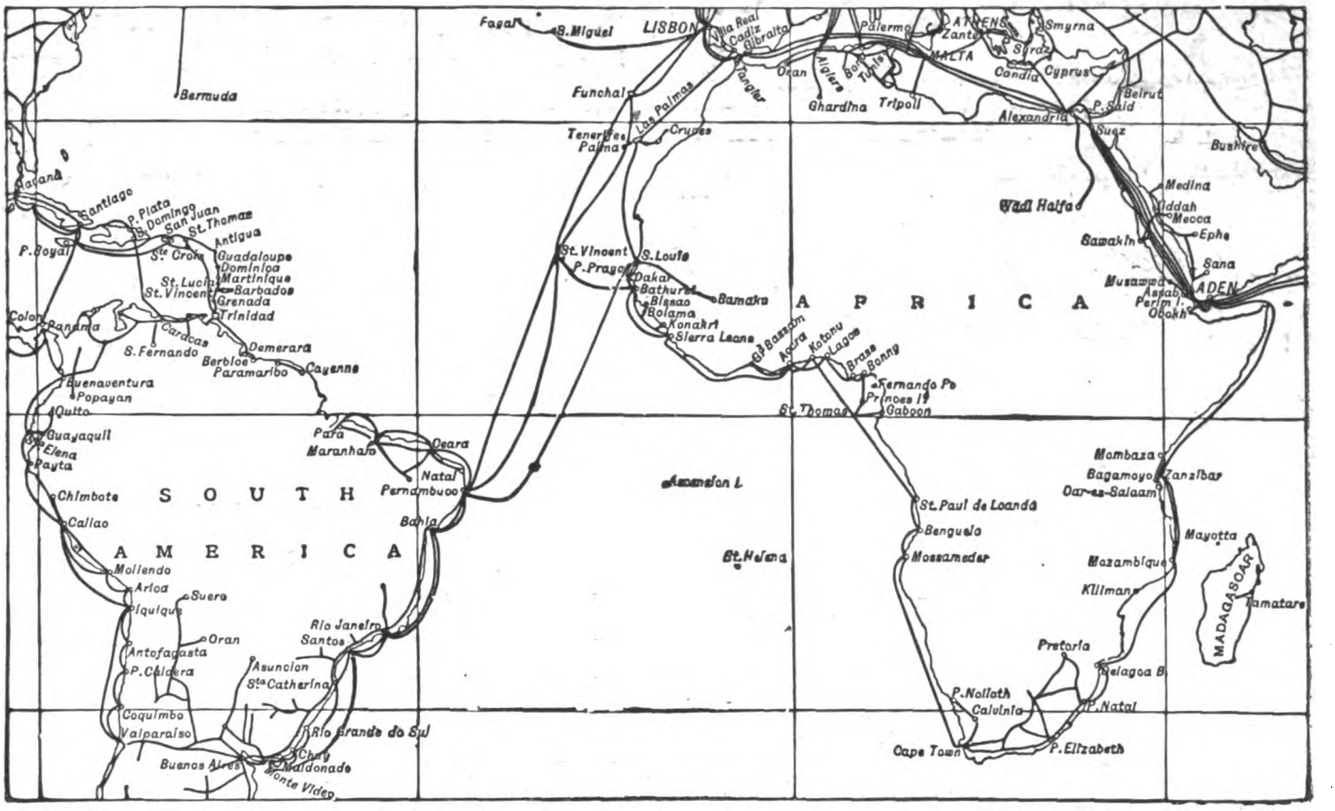


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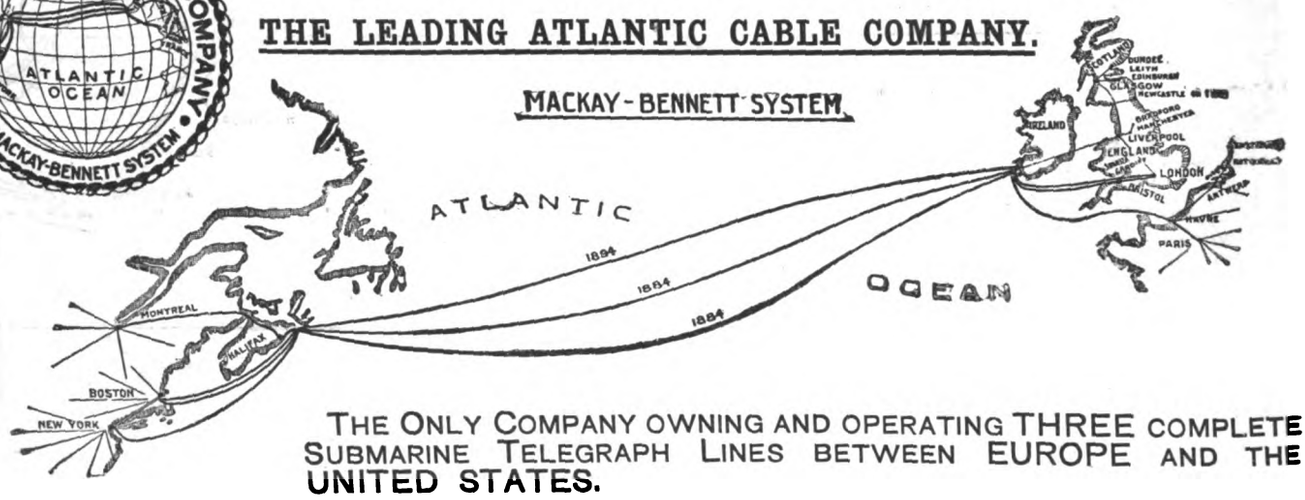


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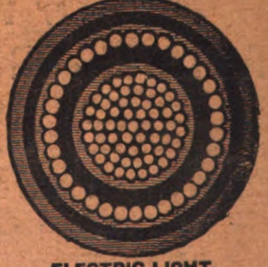

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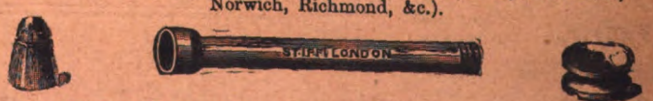


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